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A revised numerical model for parachute inflation based on ALE method

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ABSTRACT – REZUMAT

A revised numerical model for parachute inflation based on ALE method

The parachute inflation process is a typical time-varying, non-linear and fluid-structure coupling problem, especially in airdrop condition. For its complexity, numerical model of the inflation process is a big challenge, and most of the models established before still have room for improvement. There were two common problems that the first one was ignorance of inertia force of canopy and line, and the second was that took stretch speed as the initial airdrop speed in modelling. Thus, a modified finite element model for canopy inflation process based on ALE (Arbitrary Lagrange Euler) method was established that the inertia force of canopy and line was taken into consideration and the initial airdrop speed was estimated and adjusted. The opening load in finite mass situation during deployment-inflation process of C-9 type parachute was calculated. The result was compared to experimental data and calculated data of unmodified models. It was indicated that the opening load and peak time of modified model was the closest to experiment and the snatch load was also calculated and confirmed, so that the correctness and rationality of the model was verified. Then the factor influence of inertia force and initial airdrop speed was analysed, which provided a reference for parachute numerical modelling.

Keywords: *ALE, parachute, inflation, finite mass, finite element model*

Un model numeric revizuit pentru umflarea parașutelor bazat pe metoda ALE

Procesul de umflare a parașutei este o problemă tipică de cuplare neliniară și cu structură fluid, care variază în timp, în special în momentul deschiderii parașutei. Prin complexitatea sa, modelul numeric al procesului de umflare reprezintă o provocare, iar majoritatea modelelor stabilite anterior pot fi încă îmbunătățite. Au existat două probleme: prima a fost ignorarea forței de inerție a voalurii și a suspantelor, iar a doua a fost aceea că viteza de întindere a fost considerată, în modelare, ca viteză inițială de lansare. Astfel, a fost stabilit un model de element finit modificat pentru procesul de umflare a voalurii bazat pe metoda ALE (Arbitrary Lagrange Euler), care ia în considerare forța de inerție a voalurii și a suspantelor, iar viteza de lansare inițială a fost estimată și ajustată. S-au calculat solicitările la deschidere, în situația de masă finită, din timpul procesului de desfășurare-umflare pentru o parașută de tip C-9. Rezultatul a fost comparat cu datele experimentale și datele calculate ale modelelor nemodificate. Se indică solicitarea la deschidere și timpul maxim pentru modelul modificat ca fiind cele mai apropiate de datele experimentale, iar solicitarea la aterizare a fost, de asemenea, calculată și confirmată, astfel încât corectitudinea și raționalitatea modelului au fost verificate. Apoi a fost analizată influența factorului forței de inerție și a vitezei de lansare inițiale, care a furnizat o referință pentru modelarea numerică a parașutei.

Cuvinte-cheie: *ALE, parașută, umflare, masă finită, model cu element finit*

INTRODUCTION

The parachute numerical inflation model of airdrop situation has long been focused. However, the inflow and canopy structure changes sharply in a short time which is a complex non-linear problem and the fluid-structure coupling model also couples with the ballistic equation of the parachute system, which was difficult to solve. Tutt first established a deployment-inflation airdrop model by finite mass and dynamic mesh method [1], which was verified through experimental comparison. Gao established a slotted parachute model by ALE method [2] and the adaptive mesh technology in airdrop situation, calculated the drag coefficients and analysed the influence of initial airdrop speed. Cheng calculated the opening process in a finite mass situation [3–5], and analysed the interrelation between dangerous section, overload and canopy shape.

The above researches laid a solid foundation for numerical calculation of parachute airdrop FSI (Fluid Structure Interaction) problem. However, most of the calculation models still have room for improvement, such as models neglected fabric porosity and using infinite mass method to calculate airdrop situation. Two more common problems are: first, assumed that the canopy was initially straightened and the stretch speed was the initial airdrop speed. Yet actually, there is no initial stress on line. Second, most studies ignored the gravity of canopy and line. However, the inertia force caused by canopy and line is not negligible.

In order to improve the accuracy of numerical calculation, a finite element model of parachute inflation, which fabric permeability considered, inertia force of canopy and line calculated and initial airdrop speed modified, was established based on ALE method.

The opening load of C-9 parachute was calculated in infinite mass situation, which was compared to experiment and unmodified model data.

MATHEMATICS MODEL

Governing equations

ALE equation was used to solve free interface flow and typical fluid-solid coupling problems. The structure and flow field were coupled by penalty function. While Ω^s denotes the canopy structural domain and $\partial\Omega^s$ is the solid boundary, the governing equation is [6]:

$$\rho^s\left(\frac{d^2\boldsymbol{y}}{dt^2} - \boldsymbol{f}\right) - \operatorname{div}\sigma^s = 0 \quad \text{on } \partial\Omega^s \tag{1}$$

where $\boldsymbol{y}$ is displacement, ρ^s – density of structure, $\boldsymbol{f}$ – volume force acting on structure, σ^s – Cauchy stress, t – integral time.

The compressibility of air was neglected for the dropping velocity was less than 0.3 Ma. The time-varying unsteady incompressible N-S equations under reference coordinates are:

$$\frac{\partial\rho^f}{\partial t} + \rho^f \cdot \operatorname{div}\boldsymbol{u} + (\boldsymbol{u} - \boldsymbol{w})\operatorname{grad}\rho^f = 0 \tag{2}$$

$$\rho^f\frac{\partial\boldsymbol{u}}{\partial t} + \rho^f(\boldsymbol{u} - \boldsymbol{w})\operatorname{grad}\boldsymbol{u} = \operatorname{div}\sigma^f + \boldsymbol{f} \tag{3}$$

$$\rho^f\frac{\partial e}{\partial t} + \rho^f(\boldsymbol{u} - \boldsymbol{w})\operatorname{grad} e = \sigma^f \cdot \operatorname{grad}\mathbf{u} + \boldsymbol{f}\cdot\boldsymbol{u} \tag{4}$$

where $\boldsymbol{u}$ is particle velocity, $\boldsymbol{w}$ – mesh velocity of reference coordinate, ρ^f – the density of fluid, e – the internal energy of material.

The Dirichlet and Neumann boundary conditions are:

$$\boldsymbol{u} = g(t) \ \text{on} \ \partial\Omega_1^f \ \text{and} \ \tau^f\cdot\sigma^f = \boldsymbol{h}(t) \ \text{on} \ \partial\Omega_2^f \tag{5}$$

where $\partial\Omega_1^f$ is the boundary of fluid, $g(t)$ – the function of boundary inflow velocity, $\partial\Omega_2^f$ – the traction boundary and τ^f – its unit normal, $\boldsymbol{h}(t)$ – the stress potential function.

Initial airdrop speed

During deployment, when the relative velocity of canopy and payload is zero, the viscoelastic deformation of line absorbed all the kinetic energy and whose instantaneous axial tension load reaches peak, that is, the snatch load, and the corresponding speed of canopy/payload is the stretch speed. Which obviously, not equal to initial airdrop speed.

The initial airdrop speed can be estimated based on Wolf's experience method [7]:

$$\frac{\Delta v_{max}}{v_0} = f\cdot\left[\frac{\rho(C_D S)_p l_1}{2m_p}\right] \tag{6}$$

$$m_p = m_c + \frac{m_1}{2} \tag{7}$$

$$K_b = \frac{l_1 g}{v_0^2} - \frac{\rho C_D A l_1}{2m_b}\cdot\left(\frac{v_b}{v_0}\right)^2 \tag{8}$$

where v_0, v_b, Δv are the speed of initial airdrop, payload at the line stretched, and relative speed of canopy and payload, f – the slope of fitting curve, ρ – density of air, $(C_D S)_p$ – the resistance area of canopy, l_1 – the initial length of line, m_p, m_c, m_1, m_b – the mass of parachute, canopy, line and payload, K_b – a working conditions coefficient, $C_D A$ – the resistance area of payload.

The initial airdrop velocity estimated may slightly deviated due to factors like parachute type, strop and mass distribution.

COMPUTATION MODEL SETUP

The full-scale numerical model of C-9 parachute was established and the airdrop-deployment-inflation process calculated. The model parameters were shown in table 1.

The packed model mesh was shown in figure 1. The canopy was discretized by two-dimension unstructured shell grid, and structured for payload [2]. The line was not fully straightened, while no initial stress. The fluid domain, shown in figure 1, was established for airdrop process in finite mass situation. The mesh nearby canopy was densified for efficiency.

Working conditions in still air: The airdrop angle was 90°, the stretch speed was 76.2 m/s, the stretch altitude was 3962.4 m, and mass of payload was 98.88 kg.

Four calculation models (table 2) were established and calculated for comparison.

Second-order Van Leer MUSCL advection algorithm was adopted to solve the governing equations with permeability calculated [8, 9] based on explicit finite element method.

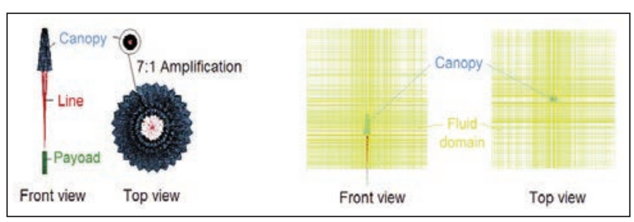

Fig. 1. 3D mesh model of initial packed parachute and its fluid mesh domain

Table 1

MODEL PARAMETERS OF C-9 PARACHUTE							
Canopy gore	**Nominal diameter (m)**	**Vent diameter (m)**	**Line length (m)**	**Canopy elastic modulus (Pa)**	**Canopy thickness (m)**	**Line elastic modulus (Pa)**	**Parachute mass (kg)**
28	8.5	0.85	7	4.38e8	1e-4	9.7e10	5.126

Table 2

PARAMETERS OF CALCULATION MODELS		
Model	**Initial airdrop speed (v_0/m/s)**	**Gravity of canopy and line**
Model1	80	Calculated
Model2	80	Not calculated
Model3	76.2	Calculated
Model4	76.2	Not calculated

Table 3

RELATIVE ERRORS OF PEAK TIME AND PEAK VALUES				
Model	**1st peak time (%)**	**1st peak value (%)**	**2nd peak time (%)**	**2nd peak value (%)**
Model1	7.69	10.43	2.34	10.22
Model2	21.76	27.83	7.96	13.98
Model3	18.24	42.61	3.72	5.38
Model4	18.68	5.22	3.08	2.15

COMPARASION AND ANALYZE

The opening load of the calculated and airdrop experimental data [7] were shown in figure 2. F denoted the opening load, W_b was gravity of payload, t_f was canopy inflation time.

Seen from figure 2, the calculated curves were mainly in good agreement with experiment: The shape of curves was similar; the opening time was almost the same; the load curve had two peaks, whose occurrence time (peak time) nearly identical. However, due to omission of damping dissipation and friction of canopy, the calculated loads were larger and peak time ahead of experiment. The relative errors were shown in table 3.

In case of Model1 and Model2, v_0 was 80 m/s, Model1 calculated gravity (inertia force) of canopy and line while Model2 did not. Affected by inertia force and interaction among canopy, line and payload, the load curve of Model1 fluctuated. And the opening shape of canopy changed: the two peak values of opening load (10.43% and 10.22% larger) were less than Model2 (27.83% and 13.98% larger) and the peak time delayed, which was more accurate.

In case of Model1 and Model3, the inertia force was calculated. v_0 of Model1 was 80 m/s while 76.2 m/s of Model3, which was, took stretch speed as v_0 by traditional modelling method. The stretch time and load were the same of the two models. For Model1 after stretching, the airflow speed was lager and incensement of opening load faster due to higher initial velocity. Because of associated air mass and formation of apex vortexes, the 1st peak fluctuated several times and appeared later, only 7.69% ahead while 18.24% of Model3. With larger initial kinetic energy, the 2nd peak of Model1 was larger than Model3 while the peak time was similar.

In case of Model2 and Model4, the inertia force was omitted. v_0 of Model2 was 80 m/s, while 76.2 m/s for Model4. Due to larger initial speed and neglect of inertia force, two peaks of Model2 were obviously ahead of experiment and Model4. For larger kinetic energy, two peaks of Model2 were also larger, while Model4 was more realistic relatively.

In case of Model3 and Model4, v_0 was 76.2 m/s, Model3 calculated inertia force while Model4 did not. Due to influence of inertia force, the two curves differed greatly at the 1st peak and then tended to be

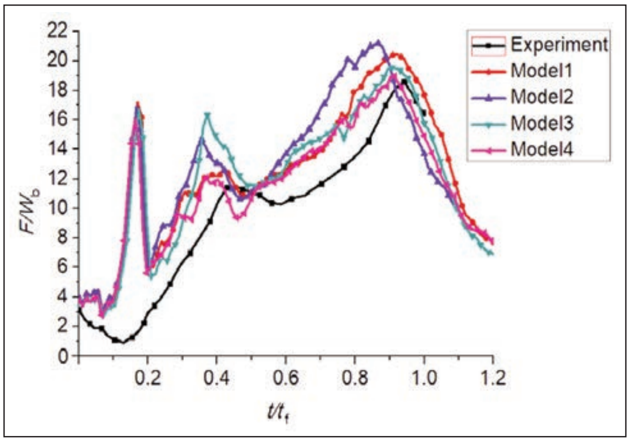

Fig. 2. Curves of opening load

similar. After deployment, the incensement of opening load of Model3 was faster and the 1st peak larger while the peak time was slightly delayed compared to Model4. And then the changing trend of curves were almost the same, that was, similar 2nd peak time while peak value of Model3 was slightly larger.

To sum up, neither the initial airdrop speed v_0 nor the inertia force affected the law of opening load alone, but the combination made a certain impact. When v_0 increased (higher than stretch speed) and inertia force calculated (Model1), the law of opening load was the closest to experiment that with similar curve shape and accurate peak time, although the peak value was larger. When the stretch speed was taken as v_0 and inertia force ignored (Model4), the peak time was much earlier but the value closer to experiment. Increasing v_0 (Model2) or calculated inertia force alone (Model3) tended to cause a stronger single factor influence, that led to larger opening force, earlier peak time and low accuracy than the former two models.

In addition, there was an obvious difference between the calculated and experimental curves: At the moment t/t_f = 0.17, an obvious impact load acted on the calculated curves while the experimental one without. This was just the calculation of snatch load. For a finished parachute, pilot parachutes or bags had been designed to counteract the violent impact of stretching, yet was omitted in numerical modelling. In another experiment (experiment1) [7], the curve of opening load with snatch load included was given in figure 3. For the unclearness of experimental condition,

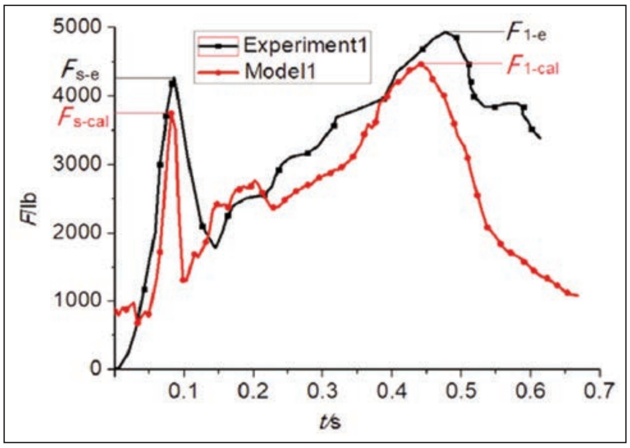

Fig. 3. Curve of snatch and opening load

only the changing trend and peak value was to be referenced.

From figure 3, F_{s-e}/F_{1-e} = 0.86 in experiment1 while F_{s-cal}/F_{1-cal} = 0.84 in calculation, the relative error was only 3.49%. This also helped to prove the correctness of snatch load and opening load in modelling and calculation.

CONCLUSIONS

A revised deployment-inflation finite element model of parachute based on ALE method in finite mass situation was built. C-9 parachute was taken as an example to validate the accuracy and reliability of the model compared to traditional ones by opening load of canopy. And the following conclusions were drawn:

- The modified model was able to predict the opening process accurately. The changing curve of opening load was the closet to experiment that the peak time was accurate but the value larger, however, met the engineering accuracy requirements.
- Neither the inertia force of canopy and line nor the initial airdrop speed affected the changing law of opening force alone. When the stretch speed was taken as initial airdrop speed while inertia force neglected, the peak time was much advanced but value closest to experiment. Relatively, increasing the initial airdrop speed or calculated inertia force alone tended to gain low accuracy.
- The initial airdrop speed and inertia force had little effect on the deployment process that the stretch time and load were almost independent of these two factors.

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Determinants of supply chain effectiveness during economic slowdown – an exploratory study of the Indian Textiles Cluster

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ABSTRACT – REZUMAT

Determinants of supply chain effectiveness during economic slowdown – an exploratory study of the Indian Textiles Cluster

This paper aims at studying the functioning of the supply chain in the garment cluster. It identifies key factors that contribute to the effective functioning of supply chain network and practices undertaken to can withstand adverse economic situations. Moreover, it was analysed the payment of dividends to the industry in terms of better business performance. This paper uses a case based exploratory research methodology, which aims to understand the cause and effect relationship between the variables influencing the supply chain network. A comprehensive literature review was undertaken and logical reasoning was applied to propose the hypotheses and the conceptual model. Case studies from various developing nations were considered and a wide variety of supply chain models have been carefully studied to propose the constructs. This has led to the development of a model which is flexible to with stand economic crisis and at the same time effective and more robust enough to support the functioning of the various nodes in the garment supply chain network. This study to the best of author's knowledge have not been undertaken in the garment cluster in a developing nation. The implications of this study is bound to give much needed support and leverage to the frail and underperforming garment cluster which is a major contributor of Gross Domestic Product and employment generator for the growing middle class in these developing nations.

Keywords: *supply chain management, supply chain effectiveness, Indian Textile Cluster, economic slowdown, integration, organizational performance, information sharing*

Factorii determinanți ai eficienței lanțului de aprovizionare în timpul încetinirii economice – un studiu exploratoriu al Clusterului Textil Indian

Această lucrare are ca scop studierea funcționării lanțului de aprovizionare în clusterul din sectorul de îmbrăcăminte. Sunt identificați factorii cheie care contribuie la funcționarea eficientă a rețelei lanțului de aprovizionare și practicile întreprinse pentru a rezista situațiilor economice dificile. În plus, s-a analizat modalitatea de plată a dividendelor industriei în condițiile de performanță a afacerii. Această lucrare folosește o metodologie de cercetare exploratorie bazată pe studii de caz, care își propune să înțeleagă relația cauză-efect dintre variabilele care influențează rețeaua lanțului de aprovizionare. S-a efectuat un studiu amplu și s-a aplicat un raționament logic, pentru stabilirea ipotezelor și a modelului conceptual. Au fost luate în considerare studii de caz din diferite țări în curs de dezvoltare și o varietate de modele de lanț de aprovizionare au fost studiate cu atenție pentru a propune modelele. Aceasta a condus la dezvoltarea unui model flexibil, pentru a rezista la criza economică și, în același timp, suficient de eficient și robust pentru a sprijini funcționarea diferitelor noduri din rețeaua lanțului de aprovizionare din sectorul de îmbrăcăminte. Acest studiu, după cunoștințele autorului, nu a fost întreprins într-un cluster din sectorul de îmbrăcăminte dintr-o țară în curs de dezvoltare. Concluziile acestui studiu vor oferi suportul necesar clusterului din sectorul îmbrăcăminte, un sector fragil și slab performant, dar contribuitor major al produsului intern brut și generator de locuri de muncă pentru clasa de mijloc în creștere în țări în curs de dezvoltare.

Cuvnte-cheie*: managementul lanțului de aprovizionare, eficiența lanțului de aprovizionare, Clusterul Textil Indian, încetinirea creșterii economice, integrare, performanță organizațională, schimb de informații*

INTRODUCTION

Growth of Indian economy

India since independence understood the primitive role of the manufacturing sector in realizing the dreams of setting up the "socialistic pattern of the society". Thus after gaining independence in 1947, a number of industrial policies were taken up to foster the growth of manufacturing sector in India. Out of those, two important policies which were taken up immediately after the independence were Industrial Policy Resolution of 1948 and Industrial Policy Resolution of 1956. These two policy resolutions helped the development of the industries to a great extent, but on account of the excessive regulatory interference, red tapes, protocols, cap on foreign investment, adverse tax law provisions and excessive government control the anticipated growth rate could not be achieved. In the initial years of planning, the thrust was to develop the manufacturing base by setting up heavy industry, towards which the organized manufacturing sector was mainly producing basic intermediate goods and machinery. The 1980s saw a clear departure from this strategy with partial liberalisation, as consumer goods became the dominant industry. The introduction of economic reforms in the 1990s led to growth of the consumer durables industry and export-dependent growth. Both these strategies made growth more volatile since demand for consumer durables is income-elastic and export growth is based on international demand [1]. During the month of January 2019, 11 out of the 23 industry groups (as per 2-digit NIC-2008) in the manufacturing sector had shown growth, as compared to January 2018.

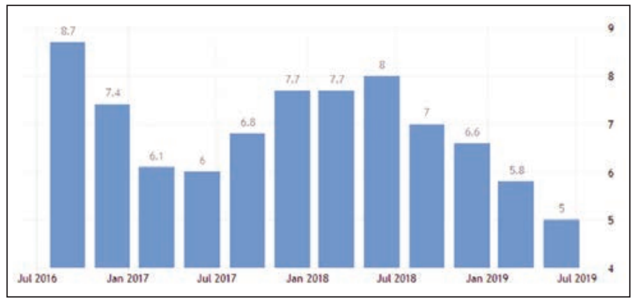

Fig. 1. GDP growth rate (2016–2019) [5]

Contribution of textile industry to the growth of the Indian economy

India is one of the world's huge manufacturers of garments and textiles oriented products. Today the Indian textile industry is one of the most important and vital industry of the economy not only in terms of output but also in terms of foreign exchange earnings and employment generation [2].

Indian textile industry has suffered in the past from low productivity at both ends of the supply chain – low farm yields affecting cotton production and inefficiency in garment sector due to restriction of size and reservation [3]. Cotton is an important fiber and cash crop, which plays a dominant role in the industrial and agricultural economy of India. India is placed at the number two position for production of cotton in the world market and is among the preferred sourcing sites for various international textile brands and retailers. As per the latest international reports, for the year 2018–2019, India is about to lose its "top cotton producer" tag to China, which has shown improved yields with better farming practices [4].

Economic slowdown

India had faced a few recession phases in the past 10 years. During the period of 1958–1959 recession, India went through a foreign exchange crisis. In the year 1966 recession the railways and defence were major customers and the monsoon failures of the year 1966 and 1967 had reduced their budget allocations. The recession of 1973 was triggered by the oil crisis. India was still a substantially closed economy and so was less affected by the global recession, under which the US, Europe and Japan were reeling. However, India could not escape the costs of high dependence on imported crude oil. The recession of 1981 led more Indian companies to take interest in Japanese management techniques like Kaizen, Kanban, Just in Time (JIT). During the recession of 1996 the RBI over-reached itself in controlling inflation, touching 2%, though 4% was a more sustainable rate for a high growth economy. Except petroleum and rubber goods, most of the other industries like mining and quarrying, heavy inorganic chemicals, cement, basic metals, iron and steel, aluminium, electrical goods show a decline in growth rate until 1966.

The development of the Indian economy during 80's and 90's depended heavily on the import of oil; this development curve took a serious hit during 1973 because of the oil crisis which was brought about by the Iran-Iraq war. The global recession during the 1980's stifled the Indian exports which led to India facing a Balance of Payment (BoP) crisis. India found itself facing macro-economic crisis during 1990's with acceleration of inflation, unsustainable fiscal deficit and a very fragile Balance of Payment situation.

Therefore, it's evident that India has faced recession the years: 1958 – foreign exchange crisis, 1966 – railways and defence were major customers and the monsoon failures of the year had reduced their budget allocations; 1973 – oil crisis; 1980 – India's exports suffered during this time; 1991 – 'balance of payment' crisis; 1997 – Asian crisis (currency crisis/financial crisis) [6], 2000–2001 – dot com crash [7]; 2008 – IT, automobiles, industry and export-oriented firms.

Presently the Indian economy is experiencing slow down. The GDP growth rate had slowed down considerably to a meagre 5% during April – June quarter of 2019–2020 which had a domino effect on the job market, where the unemployment rate dropped to 3.4% [7].

Fig. 2. GDP growth of India (1951 – 2014) [9]

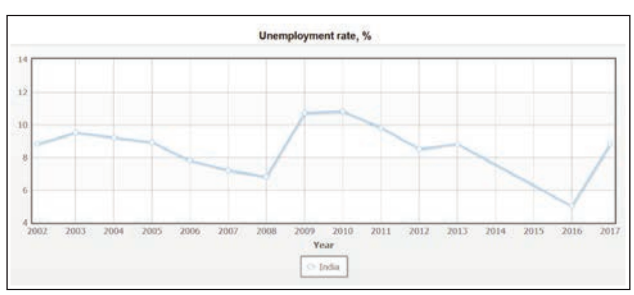

Fig. 3. Unemployment rate (%) [10]

Table 1

RECESSION DRIVING VARIABLES AND GDP GROWTH RATE DURING CORRESPONDING YEARS [8]						
Driving variable	**Recession**	**From**	**To**	**GDP before recession (%)**	**GDP during recession (%)**	**GDP after recession (%)**
Foreign Exchange Crisis	1	1958	1959	3.6	76.78 USD	3.7
Railways and Defence	2	1965	1966	7.5	-0.1	7.8
Oil Crisis	3	1972	1973	1.6	-0.6	1.2
Exports	4	1979	1983	5.7	-5.2	3.8
"Balance of Payment" Crisis	5	1990	1991	5.9	1.1	5.5
Asian Crisis (Currency Crisis/Financial Crisis)	6	1996	1997	7.5	4.0	6.1
Dot com Crash	7	2000	2001	8.8	3.8	4.8
IT, Automobiles, Banking and Financial sector, Industry and Export-oriented Firms	8	2007	2009	9.3	3.9	10.3

Table 2

UNEMPLOYMENT RATE [10]														
Country	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2016**	**2017**
India	8.8	9.5	9.2	8.9	7.8	7.2	6.8	10.7	10.8	9.8	8.5	8.8	5	8.8

Textiles industry today in slowdown situation

The Director General of Commercial Intelligence of Statistics recorded an average fall of 34.6% in the cotton yarn exports from India during April 2019. The economic slowdown saw textiles spinning mills which were once running round the clock, limit their operations and functioned only to their half capacity.

India has around 4,500 ginning units, of which 2,100 are non-operational. Gujarat has 1,300 ginning units, comprising 700 operational and 600 non-operational units. Maharashtra has 1,200 units (700 operational and 500 non-operational), South India has 1,000 units (500 operational and 500 non-operational), North India has 600 units (300 operational and 300 non-operational) (Ginning mills status in 2015). Knitting factory in India is providing huge collection of Knitted fabric, which are accessible in different styles and textures. There are lots of dependable manufacturer, exporter as well as supplier of knitted fabrics in India. The Northern India Textile Mills Association (NITMA) has claimed that the cotton and blends spinning industry is witnessing the biggest crisis in the past nine years. Their estimates reveal that 50 lakh job cuts owing to the economic slowdown in India.

Significance of effective supply chain in garment industry

Supply chain management is becoming a crucial part of textiles and apparel business. In addition to the traditional concepts on improving the production efficiency, quality control, and product design, supply chain management focuses on enhancing the collaboration and cooperation among all companies in the supply chain with a goal of satisfying market requirements [11]. In the era of global supply chains, the management of sourcing, production, and distribution in partnerships with suppliers and distributors, has become a top priority for manufacturing firms to gain competitive advantages in the marketplace [12]. It has been observed that firms do not compete individually but their supply chains do [13, 14]. Necessity to have an effective supply chain has become vital for survival essentially at the time of economic slowdown. Effective SCM implementation requires shared goals setting, collaborative planning, shared risk and reward sharing, and information sharing [15–20]. Therefore, this paper focuses on understanding the necessity of having an effective supply chain to withstand situations like economic slowdown/recession.

STATEMENT OF THE PROBLEM

Businesses in the under developed and developing countries are not able to withstand competition. This is because of rising cost of raw materials, as there are no raw material suppliers within the country who are able to meet the demand of the businesses at the rate they quote. Therefore, customer expectations are not being met within the time promised. India being a cash based economy faces financial pressure within the members of supply chain because of the changes brought in the government policies to adopt digital currency and electronic payment methods. This has led to cash crisis and strangling the supply chain network. Since, there are no steady supply of raw materials within the nation, the business units are forced to depend on other nations for raw material supply. High import duties and trade restrictions hamper easy flow of material, information and money through the supply chain network. High employment generating garment sector today is facing the problem of non-availability of skilled work force forcing manufacturing units to consider shifting operations to other developing nations like Vietnam and Bangladesh.

REVIEW OF LITERATURE

Talavera had pointed out that an effective Supply Chain Management implementation involves shared goals setting [21], collaborative planning, shared risk and reward sharing, information sharing, and supply chain integration [15–20].

Collin and Lorenzin [16], had indicated that an effective supply chain must be responsive to customer requirements and flexible to demand-and-supply challenges.

The supply chain efficiency can be evaluated by improving firm's capability to reduce its supply chain costs [20, 22–24].

Hwang and Lu [20] had proposed that quicker time-to-market, minimal costs, maximum responsiveness and superior service quality, are crucial to integrate the value chain.

Ponomarov and Holcomb [25] had pinpointed that the supply chains should have preparedness plan at the time of the economic slowdown to reduce the likelihood of disruptive events.

Bigelow and Chan [26] had indicated that an important step to be remembered during an economic slowdown is to have strong handling efforts.

An organization's initial conditions in terms of its current stocks of resources and capabilities [27], during the economic slowdown/recession, will mitigate or accentuate recessionary pressures and subsequently influence firms' short-term response and performance

Dierickx and Cool [27] had drawn attention to the point that an organization's initial conditions in terms of its current stocks of resources and capabilities during the economic slowdown/recession, will accentuate recessionary pressures and influence firms' short-term response and performance. Hence, bringing in changes in organizational performance during recession helps in withstanding the tide.

Tan and Kannan [28] had pointed out the importance of adapting business models in the strategy of firms is imperative as well as the need. Bringing in changes in business procedures with trading partners during economic slowdowns will help in reducing the credit-risk levels.

RESEARCH METHODOLOGY

This study adopts an exploratory case based approach. A detailed literature study was conducted and fact statements from peer reviewed journals of the highest category were drawn on various scenarios on the subject of study. These fact statements were carefully compared and contracted to identify the research gaps. Historical data from various companies were carefully studied and common threats to surviving companies were identified and measures taken by these companies to withstand changes in the market and defend against threats were analyzed. A sequence of historical events and economic slowdown scenarios from various developing nations were studied. Careful observation of literature has led the researchers to propose robust hypotheses. Statistical proof of economic slowdowns were drawn from authenticated and credible secondary sources such as the World Bank report [8], Planning Commission – Government of India [9], CIA World Factbook [10], etc. Drivers of an effective supply chain under conditions of economic slowdown are laid down after an in-depth study of literature. This paper seeks to propose and validate suitable model for an effective supply chain under a situation of economic recession.

NOTABLE COMPANIES OF THE WORLD THAT PERFORMED DURING ECONOMIC CRUNCH

United Technologies Corporation (UTX) and The Boeing Company (BA) were top performers during 1973 recession. Toyota was one such automobile manufacturing firm, which was able to withstand the tide. After the 1973 oil crisis, oil and gas companies owned by Saudi Arabia, Russia, China, Venezuela, Brazil and Malaysia which created world class brands like Aramco, Gazprom, Petrobras, etc. established their dominance in this industry [29, 30].

Wal-Mart (WMT), American Express (AXP) and McDonald's (MCD), were the companies which all jumped over 100% during 1980 recession.

Bungie (game developer for the Mac platform) is a successful tech companies to emerge out of the recession of 1990 and 1991. UnitedHealth Group (UNH), Cisco (CSCO), and Home Depot (HD) were all top performers during 1990 recession.

The companies Infosys, Wipro, Satyam [7], HP, IBM, Dell, Amazon.com, eBay, Priceline.com, Shutterfly (internet-based personal publishing), Coupons.com, Microsoft were able to picking up new clients and were hoping to increase business even during 2000 – 2001 recession.

The companies which thrived during the great recession between the year 2007–2009 were Amazon (online shopping), Ford (automobile), Domino's (fast food), Snuggie (blankets), Intel (IT), Lego (toy manufacturing), Groupon (which sends out daily email discounts), Wells Fargo (selling of financial products), ETrade (online brokerage firm), Netflix (ideo-on-demand services), Citigroup (investment bank and financial services), Walmart. They grew a profit, despite the bad economic climate. The multinational investment bank and financial services company, which withstood the tide of 2008 financial crisis, was Goldman Sachs.

LESSONS FROM DEVELOPING NATIONS ON HANDLING EFFECTIVE SUPPLY CHAIN DURING ECONOMIC CRISIS

Case 1: Japan

The success of the Japanese automotive and electronic sector depended heavily on the strength of the relationship between the supply chain partners. The mounting pressure by the industrial customers led them to search for technical and managerial solutions that would be commercially viable and flexible enough to face growing world competition [31].

Japan had faced recession during Quarter 2 in 2008 until Quarter 1in 2009 (12 months), Quarter 4 in 2010 until Quarter 2 in 2011 (9 months) and Quarter 2 in 2012 until Quarter 3 in 2012 (6 months), considering the period between 2006 and 2013.

During recession, the long-term relationships between Japanese firms and their first-tier suppliers were balanced by managing the core things. The primary pressure were laid on the suppliers for reducing costs with their own initiatives; the supply of materials were 'rationalized'; customer's cross functional teams rarely involved suppliers; buyers preferred to re-source; suppliers were encouraged to deal with the parent company's competitors as well; the first tier suppliers were expected to manage the second tier relationships. Set of companies with interlocking business relationships appeared to be weakening. Relationship with the overseas suppliers was managed by bringing in changes in their sourcing strategies. No sign of Japanese firms repatriating business from overseas; businesses were switched from the West to East Asia; East Asian firms developing capabilities: import reliance on Japan may lessen, new offshore sourcing by Japanese companies is likely but only in East Asia; re-sourcing preferred where 20% saving is possible (25% for new non-Japanese source) [31].

Case 2: Vietnam

The 20 year old Vietnam War which ended during 1975 brought the economy to its knees by mid-1980's, the per capita GDP plunged to less than $300. During 1986 the government of Vietnam introduced a series of economic and political reforms called "Doi Moi" to steer the country towards a socialist market economy. These reforms were instrumental in pulling up the economy even after the wake of global recession which hit during the 2000's [32].

Vietnam faced several weaknesses and macroeconomic risks in their economy, which were hidden until 2007 by a relatively high economic growth [33]. They predicted that the global crisis will affect Vietnam's macro economy in five ways. Demand for some Vietnamese exports will weaken, foreign investment will fall over the short to medium term, tourist arrivals are also likely to fall, remittances from overseas could fall and finally the fall in commodity prices will result in a shortfall in government revenues [34].

The sustained growth of the Vietnamese economy was largely due to trade liberalization, domestic reforms through deregulation and providing investment support for new businesses [32].

Case 3: Cambodia

Cambodia's clothing industry grew adversely during the decade 1995–2005. From a very low base in the early 1990s the growth rate averaged 60% per annum between 1995 and 2000, dipping a little during the years of political crisis in 1997–1998. From 2001 to 2005 it grew at a steadier rate of 20% per annum. As a result, its share of GDP rose from less than 1% in 1993 to over 15% in 2005, while its share of manufacturing industry rose from 9% to 77%. No other sector has been able to increase its share of the economy in this manner [35]. The recent development of the Cambodian economy has been heavily dependent on the increase of garment export industry [36].

The garment industry in Cambodia in the past depended largely on the import of yarn, finished woven's and knitted fabrics, but the principle of cut-make-trim model coupled with assembly of products has proved to be profitable for Cambodia's garment industry [37].

SUPPLY CHAIN MODELS

Kai Hoberg and Knut Alicke [38] had proposed five action areas that must be considered in parallel, which will cause exceptional challenges for supply chain managers while also dealing with all types of operational glitches. They believed that firms should begin to prepare as early as possible for difficult times ahead. So that they will not only benefit in the crisis but actions are also beneficial to the business from a long-term perspective.

Tom Holland and Jeff Katzin [39] model demonstrates that all companies fall into anyone of the four basic quadrants which will determine cost program, supplier strategies and financial positions needed for sustainable growth.

Christopler et al. [40] in their model, they had structured the horizontal axis in such a way that it shows the demand characteristics in terms of "predictability". This is likely to be determined by the variability of demand, hence measures such as the Coefficient of Variation could be used to position products on that axis. The vertical axis reflects the replenishment lead

	Action Area	Key Actions
1	Understanding True Demand	• Identify reliable information • Communicate with customers • Develop demand scenarios
2	Monitoring and Safeguarding Supply	• Identify supplier criticality • Monitor supplier health and lead times • Ensure the survival of critical suppliers
3	Creating Flexible, Breathing Supply Chains	• Understand the effects of demand fluctuations • Convert fixed costs into variable costs • Define smart contracts
4	Aligning Inventories to Free Up Cash	• Avoid surplus-inventory intake • Align inventory policies • Streamline service offerings
5	Preparing for Upswing	• Retain and develop talent • Prepare long-term projects • Provide upside capacity

Fig. 4. Action areas for Supply Chain Management during periods of economic crisis [38]

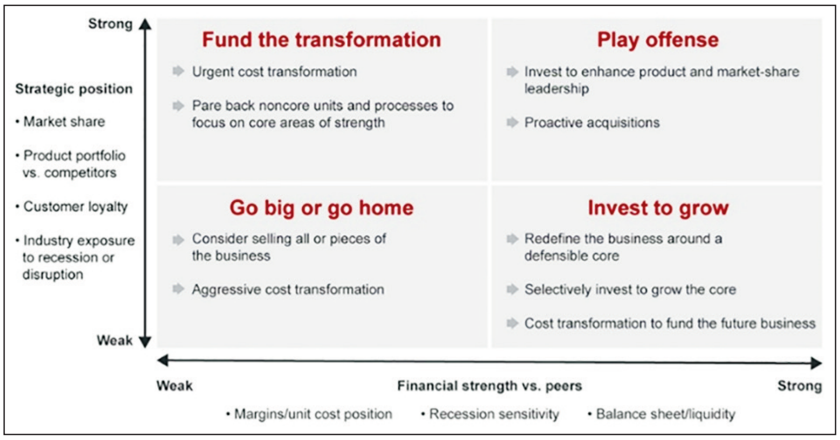

Fig. 5. Taking advantage of a downturn starts with a realistic assessment of a company's strategic and financial starting positions [39]

Scott Latham [41] model comprises five distinct constructs form the literature which additionally includes seven distinct linkages within the model representing the dynamics between constructs – and the bases for their propositions. The first contention is, that an organization's initial conditions in terms of its current stocks of resources and capabilities at the onset of the economic recession, will mitigate or accentuate recessionary pressures and subsequently influence firms' short-term response and performance (i.e. intra-recessionary) performance (Proposition 1).

times for the same product. Effectively this is measuring the time it would take the system to respond to an increase in demand if materials etc. had to be sourced or manufactured. If this elapsed time is measured in months rather than days then that product could be regarded as having a long re-supply lead time.

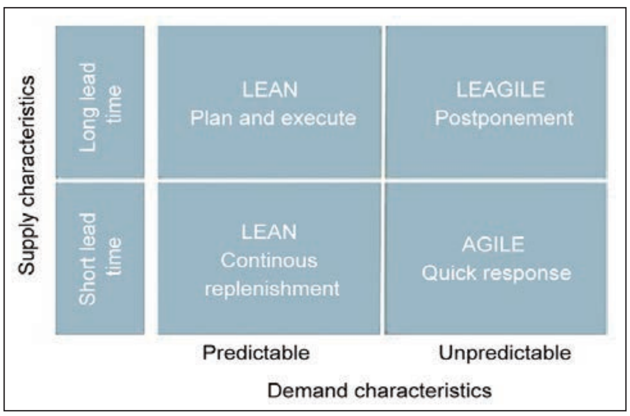

Fig. 6. Demand and supply characteristics and pipeline selection strategy [40]

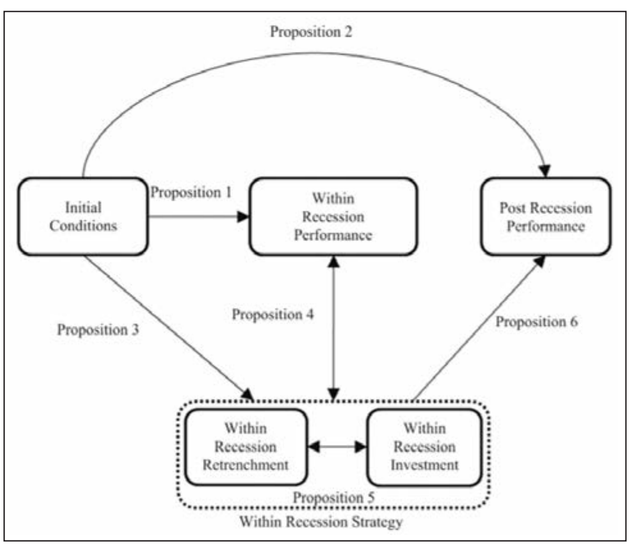

Fig. 7. An integrated framework for understanding firm level dynamics during recession [41]

Furthermore, they expect initial conditions to partially determine the firm's long-term performance, including survivability and competitive advantage, once the recession ends (Proposition 2). Given the detrimental nature of recessions on firms' short and long-term viability, and in keeping with the majority of extant literature on firm strategies during economic downturns they attend to the performance construct in terms of accounting-based performance metrics (e.g. sales, ROA, ROS, etc.). Their third proposition holds that organizations' initial conditions, which more often than not are a by-product of past decisions, will dictate firms' strategic decision-making in response to recessions (Proposition 3). The next phase of the model deals with the unique interplay between within-recession performance and within-recession strategy (Proposition 4 and 5). The interactions as discussed has significant repercussions for firms' post-recessionary performance (Proposition 6). Their final proposition demonstrates the effect of the recurring nature of recessions on firms' competitiveness and subsequent performance over multiple business cycles (i.e. economic growth and retraction) (Proposition 7).

CONSTRUCTS IDENTIFICATION

Careful study of the literature and various supply chain models had paved way to identify the following constructs.

- Shared goal setting
- Collaborative planning
- Risk and Reward sharing
- Information sharing
- Supply Chain Integration
- Flexibility to demand and supply challenges
- Supply Chain cost
- Responsiveness to the economic environment
- Recession preparedness plan
- Recession handling effort
- Change in organizational performance during recession
- Change in business procedures with trading partners

HYPOTHESES DEVELOPMENT FOR EFFECTIVE SUPPLY CHAIN DURING ECONOMIC CRISIS

Shared goal setting

From a study conducted by John W. Haas, Beverly D.S. and Sypher H.E. [42], it was evident that perception of shared goals among organizational members are positively related to important organizational outcomes, such as commitment, job satisfaction and communication satisfaction.

H1: Goal setting process in surviving supply chain is clearer and more accurate than other supply chains.

Collaborative planning

Forecasting is challenging and there are only a handful of customers who are really committed to accurate forecasts. That's the reason behind, why true process collaboration with all stakeholders is so crucially important. The consolidated demand plan is shared in a continuous manner with all the organizations contributing to its fulfilment. Continuous planning is practically the only way to make supply chain for effective and efficient. Therefore, the key point is that collaborative planning should be seen as a process of continuous development that will systematically improve itself in the course of time [16].

H2: Collaboration is more efficient and robust in surviving supply chain than other supply chains.

Risk and Reward sharing

Cooper [16, 43] highlighted that efficient management of supply chain depends upon sharing risk and reward among the supply chain network partners. The risk and reward sharing capability of firms in supply chain network will evenly spread and level out the potential risks and returns between strategic partners [43, 45].

H3: Reward and risk sharing is more transparent in surviving supply chain than other supply chains.

Information sharing

Modularization and reconfiguration of business processes as well as ease of information sharing with customers, suppliers and other business partners [46, 47] becomes primarily important to maintain an effective supply chain.

H4: Information sharing is much more dynamic in surviving supply chains than other supply chains.

Supply Chain Integration

New argued that integration can be understood in three ways: operational integration (coordinating inventory, scheduling, transport, new product development), functional integration (managing different managerial functions such as purchasing and inventory management), and relational integration (improving boundary relations). Supply chain integration increases performance if supply complexity is high, while a very limited or no influence of supply chain integration can be detected in case of low supply complexity [48].

H5: Supply chain integration ensures performance in an effective supply chain than other supply chains.

Flexibility to demand and supply challenges

Mature supply chain firms have developed the ability to adapt to uncertainty in the environment through creating flexible policies and procedures and by minimizing the rules for significant performance in the market [49, 50].

H6: Surviving supply chains react better to change in market conditions than other supply chains.

Supply Chain cost

Supply chain costs are complex because there are so many variables. Thus, the costs should be considered as aggregate and not as individual costs. There seems to exist considerable advantage when it comes to variable cost supply chain operations than performing with the traditional cost model. This variable cost structure has a favorable impact on the growth prospects of the firms compared to that of the traditional fixed cost structure. One of the most appropriate time to consider a variable cost structure in the supply chain functioning is during the time of recession and economic slowdown. This variable cost approach has proved to be a risk minimizing factor for enterprises performing under economic slowdown [51].

H7: Effective supply chains are able to scale up operations during varied cost structures than other supply chains.

Responsiveness to the economic environment

To achieve shorter time-to-market, lower costs, higher responsiveness and better service quality, it is critical to integrate the value chain of semiconductor industry [20].

H8: Surviving supply chains respond better to adverse economic environment compared to other supply chains.

Recession preparedness plan

From Ponomarov and Holcomb [25] research it's evident that supply chains should have required level of readiness/preparedness at the time of the economic slowdown to reduce the likelihood of disruptive events or recession. They have also pointed out that failure to develop required readiness, response and recovery abilities makes the supply chain vulnerable, which adversely affects both revenue and cost of the whole chain. It is worth noting that supply chain readiness, response and recovery are interdependent to each other as preparedness of supply chains accelerates a quicker response and recovery from the crisis [52, 53]. Any event, which disturbs a supply chain, can lead into a supply chain crisis due to the propagation of disturbance along the supply chain network [54]. Richey [55] mentions "preparedness" and "recovery", and Natarajarathinam et al. [56] state the need for avoiding crisis and overcoming it.

H9: Surviving supply chains have a clearer recession preparedness plan than other supply chains.

Recession handling effort

Traditional methods of dealing with a recession (e.g. layoffs and reduced expenditures in maintenance, research and development (RandD), advertising, process improvements and product improvements) are no longer viable options for all companies. The first key to successful downsizing lies in the handling of the people. The important step in handling an effective downsizing operation at the time of recession is to reduce the workload [26]. The saying "the best defence is a well thought-out offence" applies to management in at terrible times such as recession. The appropriate way for a firm to handle such times is to plan for them ahead of time. A management team that is adroit at planning and implementing recession strategies can sometimes use the circumstances of a recession to expand market share. Recessions are part of the normal cycle of business – it is certain that they will sooner or later occur. Therefore, it makes just as much sense to plan for recessions or downturns as it does to plan for good, economic times [26].

H10: Surviving supply chains have appropriate recession handling efforts compared to other supply chains.

Change in organizational performance during recession

Recession emerge in an unexpected fashion with no present time frame. Therefore it's vital for any organisation to be prepared for bringing in changes in their performance for bearing the crisis situation. An organization's initial conditions in terms of its current stocks of resources and capabilities [27], during the economic slowdown/recession, will mitigate or accentuate recessionary pressures and subsequently influence firms' short-term response and performance [41].

H11: Surviving supply chains have an adaptive organizational performance than other supply chains.

Change in business procedures with trading partners

Changes are inevitable for businesses whose leaders seek to achieve the mission, vision, and objectives of the organization [57]. Supply chain partners also make strategic choices in terms of supplier partnering, cross-functional teams, and closer customer relationships in order to achieve integration [58]. The importance of adapting business models in the strategy of firms is imperative as well as the need for new designs of inter-firm networks. Because of the fact that supply chain management has a significant impact on overall business performance [28].

H12: Transaction procedures are more adaptable in a surviving supply chain than other supply chains.

DISCUSSIONS

Proposed conceptual model for supply chain effectiveness during economic slowdown

Before outlining the implications of the study's findings certain limitations needs attention. Out of the three cases cited here, the timing of the recession in two cases namely Vietnam and Cambodia happened fairly long time ago. Japan's case scenario was recent enough to give insights in to the current economic crisis facing the industries in the developing nations. The actual data availability on the performance of the supply chains in the garment cluster in these nations was difficult to obtain. While coming to the implications and observations of the study, the paper high lights the significance of how economic recessions represent an enduring environmental force which results in large-scale changes across

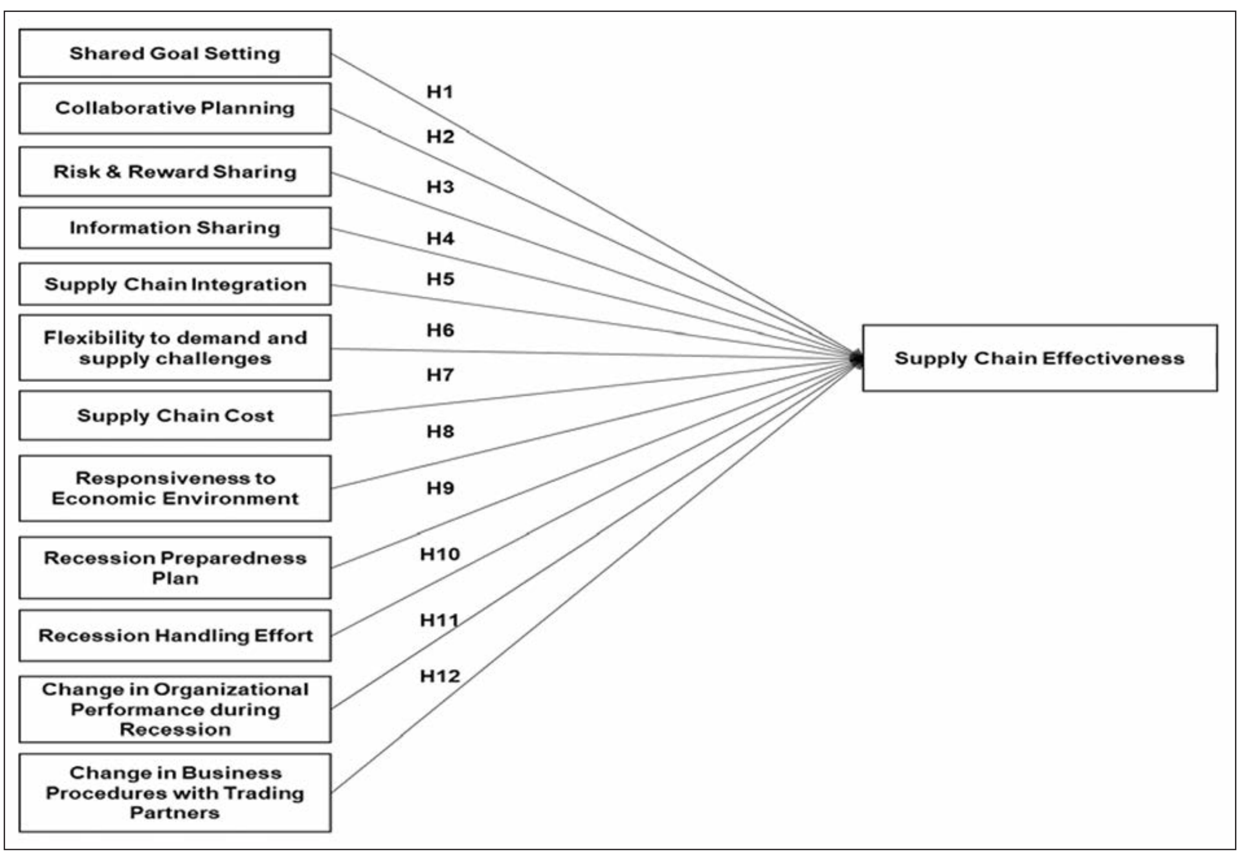

Fig. 8. Proposed Model

markets, industries, and firms. It is observed that certain notable companies of the world have sailed through the current of recession smoothly to emerge with a more mature and robust supply chain than others who have vanished from the market. These companies today make it into the top fortune 500 company list due to their seem less performance and their ability to manoeuvre through economic crisis and prove to be role models for other underperforming firms. The supply chain model 1 which has been included in the paper as figure 4 discusses the five main action areas such as understanding demand, safe guarding supply, creating flexible supply chain, aligning inventories and preparation for up scaling the entire network as the focus areas to ensure free flow of material, money and information. The model shown in figure 5 discusses the strategies and position that the network partners of the supply chain take in terms of strategic positions taken by the firms during recession to avoid financial crisis. The model proposed by Christopher et al. [40] (figure 6) discusses shortening the time lag to respond to variable demand and sourcing of materials. This model looks at the supply chain from a lean perspective thereby capturing and processing demand within the stipulated time. Latham and Braun [41] model shown in figure 7 proposes five distinct constructs such as holding adequate stock of resources to relieve recessionary pressure. The model highlights the importance of a healthy initial condition which arises out of strategic decision making and unique inter play between the supply chain members to withstand competition and perform better over the economic cycle. Based on the careful study of various supply chain models, the study proposes twelve independent constructs which can be seen in figure 8 as independent drivers for an effective supply chain to function in an adverse economic scenario. The textile cluster depends on each one of these drivers to overcome economic and environmental challenges that is bound to arise during the various phases of a business cycle.

CONCLUSION

In conclusion, this study sought to improve the understanding on the key drivers that propel firms in the textile cluster through cyclic and erratic economic conditions. By observing cases from developing nations and by meticulous analysis of various supply chain models under recessionary conditions, the study has arrived at a robust model that would prove to be efficient in managing the supply chain network.

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Analyses of body measurement with depth image data using motion capture sensor

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ABSTRACT – REZUMAT

Analyses of body measurement with depth image data using motion capture sensor

Sensors can capture and scan many objects in real time for military, security, health and industrial applications. Sensors can be made smaller, cheaper and more energy efficient due to rapid changes in technology. Low-cost sensors are attractive alternatives to high cost laser scanners in recent years. The Kinect sensor can measure depth data with low cost and high resolution by scanning the environment. In this study, this sensor collected data on users in front of a scanner, and the depth data results were tested. The process was repeated with four different body positions, and the results were analysed. The sensor data was reliable versus real measurements. When compared the depth data taken by the sensor with the real measures, the reliability rate is found significance. The difference between the depth image data of different users, different positions and different body measures and real data is 0.35 to 1.15 cm. This shows that the sensor's results are close to real data. When the accuracy of the sensor against real measurements is examined, it is seen that these values are between 98.46 % and 99.6 %. Thus, this depth image sensor is reliable and can be used as an alternative and cheaper way for body measurements.

Keywords: *anthropometry, gesture based sensors, image processing, measurements, depth image*

Analize ale măsurării corpului cu date de imagine de profunzime folosind senzorul de captare a mișcării

Senzorii pot captura și scana multe obiecte în timp real pentru aplicații militare, de securitate, sănătate și industriale. Senzorii pot avea dimensiuni mai reduse, preț mai scăzut și eficiență din punct de vedere energetic datorită schimbărilor rapide ale tehnologiei. Senzorii cu prețuri reduse sunt alternative atractive față de scanerele laser cu prețuri ridicate. Senzorul Kinect poate măsura datele de profunzime cu un cost redus și o rezoluție ridicată prin scanarea mediului. În acest studiu, acest senzor a colectat date despre utilizatori aflați în fața unui scaner, iar rezultatele datelor de profunzime au fost testate. Procesul a fost repetat cu patru poziții diferite ale corpului, iar rezultatele au fost analizate. Datele preluate de senzori au fost fiabile comparativ cu dimensiunile reale. Când se compară datele de profunzime preluate de senzor cu dimensiunile reale, fiabilitatea este semnificativă. Diferența dintre datele de imagine de profunzime ale diferiților utilizatori, pozițiile diferite și dimeniunile corpului și date reale este de 0,35–1,15 cm. Aceasta arată că rezultatele senzorului sunt apropiate de datele reale. Când se examinează acuratețea senzorului față de dimeniunile reale, se observă că aceste valori sunt între 98,46% și 99,6%. Prin urmare, acest senzor de imagine de profunzime este fiabil și poate fi folosit ca o modalitate alternativă mai ieftină pentru măsurători ale corpului.

Cuvinte-cheie*: antropometrie, senzori bazați pe gesturi, procesare de imagini, măsurători, imagine de profunzime*

INTRODUCTION

Many studies have described the human body accurately in 3D environments and with different body measurement methods. These include multiple probe, linear and body forms [1]. Anthropometry and body scanners have been used to accurately to describe the body, but this is complicated because of the complexity of the human body [2].

A variety of angles, poses and linear measurements from the width, height and circumference data can be easily counted with body scanners. The shape, surface, point, line and volume of the body can be determined from the scanned data. Versus standard linear methods, these new methods are more accurate, faster and less invasive [2].

Many researchers have tested the accuracy and reliability of body scans. As an example, Yu, Lo and Chiou tested the body surface measures with 3D scanners and proved that it easily and quickly makes accurate measurements [3]. Heuberger, Domina and MacGillivray reported no significant difference between body scanner data and manually collected measurements [4]. Although Choi and Ashdown found that the circumferences were a little larger in the scanned measurements than in traditional measures [5], the two measurements did not have a significant difference [6]. Via proper calibration and control, data from 3D body scanners are more accurate and practical than manual measurements. It is also possible to get complicated body shape data with this three-dimensional scanning technology [5]. Wang, Xu and Wang stated that there has been a remarkable increase in the studies of taking anthropometric body measurements of a target population to organize product process and meet different customers' desire [7]. In order to make a tool to increase the ergonomic suitability and the comfort of the collar part of the clothing, it is aimed to create a 3D model of the collar part of Chinese young male office workers.

Today, the developing of the body scanning software will make the body measurement counting more functional. Although researchers have proved the accuracy and the reliability of body measurement with 3D body scanners, they have limited utility because of their high-cost.

Low-cost range sensors are an attractive alternative to high cost laser scanners in indoor surveillance, mapping, forensics and robotics. Microsoft's Kinect Sensor is one recent development in consumer grade range sensing technology. Kinect has an RGB camera, a depth sensor and a four microphone arrays that provide voice recognition, full-body facial recognition and 3D motion capture capabilities. The Kinect camera captures colour and depth images at 30 frames per second (fps) to produce a cloud of three-dimensional points from an infrared pattern and projected on the scene.

This was primarily designed for natural interaction in a computer game environment [8]. The sensor is not only popular in the gaming industry, but also in electronic and computer science. Robotics researchers have used it to develop creative new ways to interact with machines and perform other tasks [9–11]. Researchers have also used the characteristics of the data captured by Kinect in the field of mapping [12, 13] and 3D modelling [14, 15].

This paper is organized as follows. In section 2, body measurements with depth data were searched for literature. In section 3, material and method used in application are described detail. In section 4, the developed method is stated with the application principles. In section 5, the results of the application are tested experientially and they are argued. In section 6, the results are evaluated generally and the proposals for the future studies are mentioned.

LITERATURE REVIEW

The Kinect Software Development Kit (SDK) features real-time tracking of human joints for gesture-based interactions. Several studies have used Kinect to capture colour and depth data. For example, Khoshelham conducted a research of geometric quality of depth data taken by the Kinect sensor [16]. According to the results of the study, it has been found that the accuracy of data is influenced by the low resolution of the depth measurements [17]. Chen, Lin and Li proposed tools to characterize Kinect depth image quality they detected wrong depth values and removed them [18]. They filled the holes using bilateral filters. As a result, the proposed method has a positive effect on the quality of the depth image. Haggag et al. compares the detection capacity and depth accuracy of Microsoft Kinect and Asus Xtion sensors under different conditions [19]. Tests and analyses made It has been observed that the accuracy of the depth sensor decreases with the increase of the measurement distance for the 2 sensors. However, it has been shown that the Microsoft Kinect sensor has higher sensing accuracy and depth accuracy than other sensors. Özbay and Çınar matched the RGB images with point clouds obtained from depth images. Using the depth data of the RGB images as 3D objects, they successfully managed their modelling process [20].

Peng et al. introduced a unified depth modification model has been to improve Kinect depth and accuracy by recording colour and depth images in a recursive way [21]. In particular, at each iteration, a structure based primarily on the property descriptor of the canny edge was established, and then an estimator called the nonparametric L2E was established. The accuracy of colour and depth images, the depth data, as well as 3D measurement errors has been tested with the applied method. Test results show that the applied approach greatly improves depth accuracy.

In a study, it is compared the performance of the Kinect depth data with the Kinect skeletal data while capturing various gait parameters. According to the results of the study, the depth data analysis has remarkably low percentile errors in comparison with the skeletal data analysis in terms of providing stride length and stride time measures [22]. Rumambi et al. respectively used image acquisition method, RGB and depth image algorithm and to detect Straight Leg Raise, skeleton tracking and feature extraction is made [23]. In order to estimate triangulation angle Straight Leg Raise, Kinect provided a method with the proposal of the algorithm. It is observed that the proposed method results were all positive.

Most of the validity studies of Kinect were performed for postural and balance analyses. According to these studies, it was observed that validity reliability tests could be performed on capture or on volunteer subjects and Kinect had the competitive results. With a low cost advantage, Kinect's reliability and validity results show that it can be used instead of 3D motion systems [24–27].

In this paper, we presented depth data and analysed the accuracy and reliability of the data taken by the Kinect sensor. This work provides an insight into the quality of the Kinect depth data with an analysis of the accuracy of the body measurement parts. The colour and depth images can capture the user in front of the sensor. The captured user's width and height measurements are computed in real time on the scene. The computing accuracy is analysed by comparing the data provided from the depth maps with the real data.

MATERIAL & METHOD

The Kinect sensor has an RGB camera, a 3D depth sensor (infrared (IR) or depth camera) and four microphones. There is a tilt motor in the underside that enables the sensor to move up and down.

Like any kind of camera, the IR or depth camera has a field-of-view. As seen in figure 1, the sensor's field-of-view is restricted. Originally, the sensor was used to play videos within the boundaries of the scene. The depth vision differs from around 800 mm to just

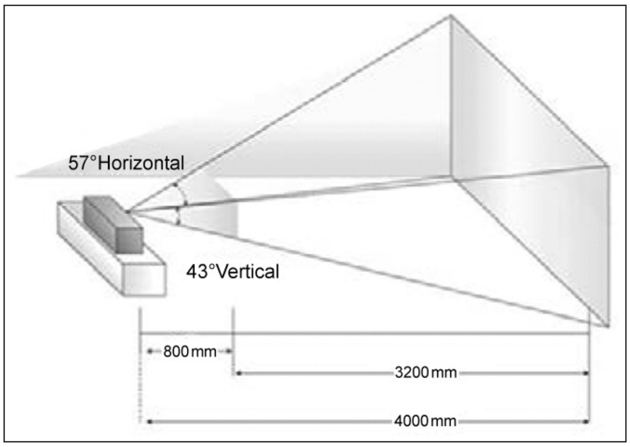

Fig. 1. The field of view of Kinect sensor

over 4000 mm [28]. This range offers the most reliable depth data.

The depth camera's field-of-view is shaped like a pyramid as in any camera. If an object is farther away from the camera, then its lateral range will be greater when compared to an object nearer the camera. Thus, the height and width pixel dimensions, e.g., 1920*1080 pixels, do not have a correlation with a physical location in the camera's field-of-view. The depth value of each pixel does map to a physical distance in the camera's field-of-view. Each pixel in a depth frame is 16 bits and has only 13 of the 16 bits of depth value.

In this study, Kinect v2 model was used in the application software developed. Primarily, Kinect v2 seems a more refined version of Kinect v1, but its defect is that it is bigger and has lots of annoying cables and power converters, while Kinect v1 is surely more lightweight and easy to carry and to install. Kinect v2 performs awesomely better than Kinect v1: increase in resolution has been impressive, with the v2 reaching the full-HD res. Even the field of view has been greatly increased: The Kinect v2 is awesome on how big is its FOV: if you move in front of it, it always catches you, while Kinect v1 loses you if you move too much on a side. So, The Kinect v2 is powered by hardware and software than Kinect v1. Table 1 shows the comparison of basic features between Kinect v1 and Kinect v2.

Table 1

FEATURES OF THE KINECT V1 AND KINECT V2		
Feature	**Kinect v1**	**Kinect v2**
Color camera	640*480 @30 fps	1920*1080 @90 fps
Depth camera	320*240	512*424
Max depth camera (m)	4.5 M	4.5 M
Min depth camera (cm)	40 in near mode	50
Horizontal field of view (degree)	57	70
Vertical field of view (degree)	43	60
Tilt motor	Yes	No
Skeletons joints defined (joints)	20	26
Full skeletons tracked	2	6
USB standard	2.0	3.0
Supported OS	Win 7,8	Win 8, 10

Mathematical model of measuring depth data

We aimed to measure the pixels of the user in this work. The actual width or height measurements cannot be coordinated with X and Y positions of the pixels, but it is possible to compute them. Each camera has a field-of-view. The angles of the field can be estimated by the focal length and the size of the camera's sensor. According to the sensor's SDK, the view angles are 57° horizontal and 43° vertical. Using knowledge of the depth values, the width and height measures of a user can be estimated by using triangulation, as shown in figure 2. Here, a user's width is computed. The results are sufficiently accurate for many of users.

$$d = h \tan(\alpha) \quad (1)$$

$$\frac{W_p}{320} = \frac{W_r}{2d} \quad (2)$$

$$W_r = \frac{2d(W_p)}{320} \quad (3)$$

Figure 2 shows that the angle of view of the camera is an isosceles triangle with the player's depth position this forms the base. The real depth value is the height of the triangle. To create the two right triangles used to calculate the width of the base, the triangle is divided in half. Using the knowledge of the width of the base, pixel widths are transferred into the real widths measurements computed by equations 1, 2 and 3. The user's depth measures and the number of pixels that the user spans are needed for calculations. The averages of the depth measurements for each of the user's pixels are taken. This makes the

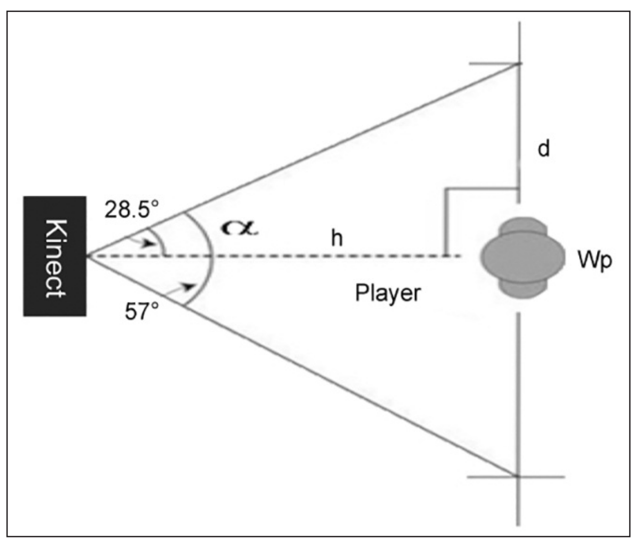

Fig. 2. Schematic representation of Kinect sensor' depth data: *d* – scene; *h* – depth; *Wp* – user pixel width; *Wr* – user real width; α – sensor' horizontal angel

depth measurement normal because no person is completely flat. For the user's height, the same computing procedure is used but different angles and different image dimensions are employed.

Calibration of the sensor

The Kinect Sensor consists of a multi-view system that provides three outputs: an infrared, a depth, and an RGB image for every sensor. Figure 3 shows that, there is a distance between the RGB camera of the sensor and its infrared image on the horizontal platform. In addition, the width of the vision of the RGB camera is bigger than the infrared image. Thus, the point in the color images and the point in the same coordinate in the depth image are not the same. The sensor must be calibrated to capture the colour and depth images on the same platform.

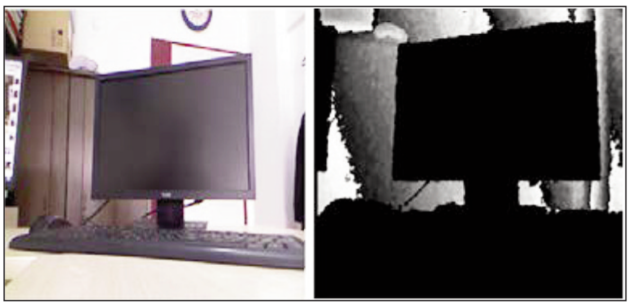

Fig. 3. Color and depth image difference

Many different applications and methods are used for sensor calibration [17, 29–34]. Here we chosen the calibration method offered by Nicolas Burrus. The primary reason for this is the open source software library, which is written in Open Cv. It was also an important factor that the distance obtained as the result of the calibration was low. These calibration tools were used to calibrate, the infrared and RGB cameras. The calibration distance is approximately 0.322 pixels.

Overview

The Kinect sensor is used in many different applications including body biometrics, human-activity recognition, 3D surface reconstruction, hand-gesture recognition and healthcare applications. Here, we used application software to compute, the user's depth measurements and compared the accuracy of the real measures and the captured depth data.

A calibration method is used to capture the depth images. Using this calibration method, the depth images are better approximate the RGB images. The capture of depth data and user motion is a feature of the sensor's SDK. The sensor can recognize six users at a time. For each tracked user, a number is assigned by SDK. There is a number or user index for the first three bits of the depth pixel data. The other thirteen bits (3 to 15) hold the depth value.

Proposed method

In this study, the user's width and height are computed with the sensor's depth data. Data from 30 men and 30 women with different body sizes and are between the ages of 20–45 were taken. Body measures of these 60 users in 4 different positions were collected (figure 4; order by position 1, position 2, position3 and position 4).

Fig. 4. The sequence of 4 different positions of the users

The aim of the 4 different positions is to increase the validity and reliability of the measurements taken by the Kinect sensor. These measurements are in different positions and positively affect the accuracy of the sensor's data. The measurements in the 4 positions are presented in table 2.

Depth data was collected as follows:

- The calibration method was used to match the RGB images and depth images taken by the sensor.
- After calibration, the sensor is placed 500 mm from the ground, 1800 mm farther from the user [35].

Table 2

BODY MEASURES OF 4 DIFFERENT POSITIONS AND THEIR EXPLANATION		
Measures		**Explanation**
Horizontal measures	Shoulder width (S)	The measure of the end points of two shoulders (position 1)
	Bust width (B)	The measure between the back and nipple (position 2)
	Arm open width (AO)	The measure between the two arms opened parallel to the ground (position 4)
Vertical measures	Height (H)	The measure of the height (position 1)
	Hands up height (HU)	The measures between top point and bottom point of the body in hands up position (position 3)

- While the sensor can capture 6 people in real time, in this study, users were scanned individually.
- For each position, the user must stay in front of the sensor for 5 seconds to get the data.
- The vertical and horizontal measurement processes in Table 1 is repeated 2 times for each user.

Data analysis

Two ways is used to collect the quantitative data, one of them is the measurements taken from the sensor (table 3) and the other one is manual taken measurements. The data were analyzed with SPSS 20 (Statistical Package for Social Studies).

The measurement process was repeated twice using the sensor system to compute the variation between the two measurements [2]. Intra class correlation (ICC) was used to measure inter-rater reliability for the two measures. To determine whether there were significant differences between the depth data of the sensor system and the manual measurement, descriptive analyses and the paired t-tests were used.

Table 3

PARTICIPANTS' MEASUREMENTS FROM THE SENSOR SYSTEM							
Measures		**n**	**Min**	**Max**	**$\overline{X}$**	**SD**
Horizontal measurements	Shoulder width (S)	60	35.5	44.5	40	2.75
	Bust width (B)	60	24.5	33	28.65	2.86
	Arm open width (AO)	60	160	180	171.2	6.26
Vertical measurements	Height (H)	60	161	180	172.6	6.39
	Hands up height (HU)	60	189	208	200.9	6.33

Note: n – count, Min – minimum, Max – maximum, $\overline{X}$ – Mean, SD – standard deviation

RESULTS & DISCUSSION

In order to test the accuracy of the results, the width and height data of different 30 men and 30 women users were used to test the accuracy. Shoulder width (S), bust width (B), arm open width (AO), height (H), and the hand up height (HU) of sixty users were computed via sensor data. The shoulder width measurements range from 35.5 to 44.5 cm and the average is 40 cm. The bust width measures range from 24.5 to 33 cm and the average is 28.65 cm. The arm open width measurements range from 160 to 180 cm and the average is 171.2 cm. The height measures range from 161 to 180 cm and the average is 172.6 cm. The hand up height measures range from 189 to 208 cm and the average is 200.9 cm.

Table 4

FRESULTS OF INTRA CLASS CORRELATION ANALYZE FOR THE REPEATED MEASUREMENTS		
Measures	**Single measurement reliability**	**Average measurement reliability**
Shoulder width (S)	0.944	0.971
Bust width (B)	0.983	0.992
Arm open width (AO)	0.983	0.992
Height (H)	0.981	0.991
Hand up height (HU)	0.972	0.986

Reliability of sensor system

ICC analyses in table 4 shows that all values are close to 1.0. This shows that there is no variance between the two measurements. There is seen a high level of inter-rater consistency both on the single measurements and on the average of the two measurements.

Comparing the sensor data with manual data

The measurements computed by the sensor system are different and are –1.15 to –0.35 cm different than the manual measurements (table 5). There are not many differences between the depth data of the sensor system and the manual measurements. Although the sensor's calibrations were provided, there are minimal differences because of the deformation in the depth images and the user position.

Table 5

COMPARISON OF TWO MEASURING METHODS					
Measures	**Sensor system**		**Manuel**		**Difference**
	$\overline{X}$	**SD**	**$\overline{X}$**	**SD**	
Shoulder Width (S)	40	2.75	40.55	2.61	–0.55
Bust width (B)	28.65	2.86	290	2.87	–0.35
Hand Open width (HO)	171.2	6.26	172.1	6.17	–0.90
Height (H)	172.6	6.39	173.3	7.08	–0.70
Hand up height (HU)	200.9	6.33	202.05	6.96	–1.15

There are some limitations that must be taken into account when the accuracy of the running depth data is measured. Firstly, the accuracy of the Kinect depth sensor is actually a function of the distance of the sensor. The resolution of the sensor distance residuals, depth measurements decreases and the error rate increases [17] measure the distance between the actual images of depth data measured by the human body by about 4 cm. When they confined this measurement to a certain joint by putting the sensor at a distance of 1–3 m, they obtained a result of about 2.5 cm [17]. Another limitation, the user's inhalation and exhalation process also has a negative effect on the reliability of the measurement [2, 36, 37].

Error rate of two measuring method

When the data in table 4 is examined, it is seen that there is not much differences between the sensor system and real data. Although the depth images' calibration is provided, there can be minimal differences because of the deformation in the depth images and not providing the user's standing posture. These differences not being so high and near to minimum percentage level show that the results are so near to real values.

The system calculates the error rate of measure with the equation in 4.

$$\text{Error rate (\%)} = \frac{|M_r - M_d|}{M_r} \qquad (4)$$

M_r gives the real measure knowledge and M_d gives the sensor system' measure knowledge in in the depth image. The rate of the absolute value of these differences to real measure rate provides the error rate in table 6.

The results show that error rates are 0.40% to 1.36%. The error rates fall in the same range when the averages of the measured values increase. Therefore, when the accuracy of the sensors against the real measurements is subtracted, 98.46% for shoulder width, 98.89% for bust width, 99.48% for hand open width, 99.6% for height and 99.43% for hand up height.

Table 6

ERROR RATE OF TWO MEASURING METHODS	
Measures	**Error rate (%)**
Shoulder Width (S)	1.36
Bust width (B)	1.21
Hand Open width (HO)	0.52
Height (H)	0.40
Hand up height (HU)	0.57

CONCLUSION

Sensors are frequently used to capture and scan many objects in the real time. This includes applications in body biometrics, human-activity recognition, 3D surface reconstruction, hand-gesture recognition and healthcare.

In this study, we used a calibrated sensor to measure, some parts of the body (shoulder width (S), bust width (B), arm open width (AO), height (H) and hand up height (HU)) as well as the accuracy of these measurements. The main objective of this study is to prove how close the depth image data are to the real measurements. The difference between the depth image data of different users, different positions and different body measures and real data is 0.35 to 1.15 cm. This shows that the sensor's results are close to real data. When the accuracy of the sensor against real measurements is examined, it is seen that these values are between 98.46% and 99.6%. The main reason of the differences between the sensor system and manual taken system is the time required for the three dimensional system to acquire the data. The involuntary body sway of human users is more difficult to control when the time span is too long. Thus, this depth image sensor is reliable and can be used as an alternative and cheaper way for body measurements.

Taking into account the sensitivity of the gesture based sensor data used, it is possible to classify the body shapes of the people in particular and to realize the virtual apparel applications as a result of the obtained measurements and even to calculate the gait activities and to realize the three dimensional clothing animation.

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Performance of recycled PET and conventional PES fibers in case of water transport properties

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ABSTRACT – REZUMAT

Performance of recycled PET and conventional PES fibers in case of water transport properties

In recent years the researches on liquid moisture transport properties of fabrics have great importance. Especially for the sport garments, fabric structure should led liquid moisture to transfer from skin surface to the outer layers. Special fibers and fabric structures were designed including channelled fibers and micro fiber productions to contribute higher capillary transport capability to the textile surface. Polyester fibers are used for this purpose frequently. Due to the increase in the demand of sustainable textiles, production and consumption of recycled polyester fibers are increasing recently. They are expected to have adequate mechanical properties to fulfil requirements. In this study, liquid moisture transfer properties of the polyester and r-PET fabrics were investigated. For this purpose, knitted fabrics produced from 100% polyester and 100% r-PET yarns were used. Dynamic liquid transport properties, capillary transfer property, drying rate and water absorption capacity of these surfaces were measured. According to the results, it was concluded that both fabrics were identified as "good" by using "Moisture Management Tester", in case of liquid moisture transfer properties. No significant difference was determined between water vapour permeability values. Static immersion test is helpful in order to determine wettability for the identification of sensitive differences and as a conventional method, vertical wicking test is a good indicator while distinguishing capillarity differences. It was found that r-PET fabric has better results than PES fabric, in case of absorption rate, wettability, drying rate and capillarity.

Keywords: *r-PET, recycled fiber, moisture management, water vapour permeability, liquid moisture transfer, capillarity, drying rate, evaporation speed*

Performanța fibrelor de PET reciclat și a fibrelor de PES convențional din punctul de vedere al proprietăților de transport al apei

În ultimii ani, cercetările cu privire la proprietățile de transport al umidității materialelor textile au o mare importanță. În special pentru articolele de îmbrăcăminte sportive, structura materialului textil ar trebui să ajute la transferul umidității de pe suprafața pielii către straturile exterioare. Au fost proiectate structuri speciale de fibre și de materiale textile, inclusiv fibre multicomponente și microfibre pentru a spori capacitatea de transport capilar prin suprafața textilă. Fibrele de poliester sunt utilizate frecvent în acest scop. Datorită creșterii cererii de materiale textile durabile, producția și consumul de fibre de poliester reciclat sunt în continuă creștere. Se așteaptă ca acestea să aibă proprietăți mecanice adecvate pentru a îndeplini cerințele. În acest studiu, au fost investigate proprietățile de transfer al umidității în cazul materialelor textile din poliester și din r-PET. În acest scop, au fost utilizate tricoturi realizate din fire de 100% poliester și de 100% r-PET. Au fost determinate proprietățile dinamice de transport al lichidului, transferul capilar, viteza de uscare și capacitatea de absorbție a apei pe aceste suprafețe. Conform rezultatelor, s-a ajuns la concluzia că ambele materiale textile sunt „adecvate", prin utilizarea „Testerului de control al umidității", în cazul proprietăților de transfer a umidității. Nu s-a determinat nicio diferență semnificativă între valorile permeabilității la vaporii de apă. Testul de imersie statică este util pentru a determina umectabilitatea pentru identificarea diferențelor sensibile și, ca metodă convențională, testul de absorbție verticală este un bun indicator, distingând în același timp diferențele de capilaritate. S-a constatat că materialele textile din r-PET înregistreează rezultate mai bune decât materialul textil din PES, în cazul ratei de absorbție, umectabilității, ratei de uscare și capilarității.

Cuvinte-cheie: *r-PET, fibră reciclată, controlul umidității, permeabilitatea la vapori de apă, transferul de umiditate, capilaritate, viteza de uscare, viteza de evaporare*

INTRODUCTION

Clothing is one of the most important and fundamental need of the humans. The initial aim of the clothing is to protect the body from uncomfortable environment such as warm, cold, wind, injures, chemicals etc. However, the recent researches revealed that consumers meet their clothing requirements according to their life conditions that is more dynamic and comfortable [1]. As a result, changing expectations of the consumers brought the concept of "comfort".

Continuous dynamic interaction of the garments along with the body movement is one of the important factors for perception of the comfort. Therefore skin temperature, sweating rate and moisture content on skin continuously change during the wearing duration. These effects cause mechanical and thermal warnings. These warnings define the users` comfort perception [2].

Body generates sweat in order to adjust the body temperature. As the action is low and the environmental heat is in a normal level, there is a constant moisture transfer between the environment and the pores of the skin and the sweat is released in vapour form. While the sweating is slow, it cannot be felt. However, if the heat, which is generated due to the increased action, is not given to the environment, the skin produces sweat to keep the body temperature in 37°C constant level. In order to evaporate the liquid sweat from the skin surface, it is necessary to take the heat energy from the body. By the way, the body temperature decreases.

Liquid moisture transport properties of the fabric in multi-dimensions, referred to as moisture management properties and that influence the human perception of moisture sensations and comfort significantly [3, 4].

The term ‘moisture management fabrics’ can be defined as textile fabrics which provide the control of the movement of body water (e.g. sweat) and moisture in such a way that they are transported away from the skin to the outer surface of the fabric where they can evaporate quickly [5, 6].

Niwa stated that liquid water (sweat) absorptivity of fabrics is more important than water vapour permeability in determining the comfort factor of fabrics [7]. Avcı investigated socks, which were knitted with using various fiber types. It was determined that the wet behaviour properties of socks are affected directly by fiber type [8]. Marmaralı and Oglakcıoglu found that production parameters like raw material (fiber and yarn specialties), fabric structure (construction, density, thickness, weight, etc.) and finishing applications have important effects on the thermal comfort specialties [9]. According to Matsudaira and Kondo, by means of grooved or non-grooved hollow in the fibre, space ratio and surface area of the fibres increase and by this way more water could be absorbed by polyester fibres [10]. Ozdil et al. analysed the moisture management properties of different materials such as cotton, polyester and wool. They investigated also same yarn count polyester with different filament fineness and found that the moisture transfer properties of polyester yarns from finer filaments are higher [11].

In a study carried out by Süpüren et al. the moisture management properties and the changes of the thermal absorptivity values of a special double-face structure were investigated and it was revealed that different moisture transport properties can be achieved by using different yarn settlements in double-face fabric construction [12]. Wardman and Abdrabbo developed an instrument that uses the image processing technique to exhibit the effect of oxygen plasma treatment on two polyester fiber types (polylactic acid and standard polyester) and its influence on their wetting characteristics [13]. In a study carried out by Ozdil N. et al., moisture transport properties of knitted fabrics, which were knitted from cotton yarns produced with using various yarn twists and yarn counts were investigated. It was pointed out that yarn count and yarn twist has important effect on the fabric moisture transport [14, 15].

Since moisture transmitting property of fabric is a key factor that affects textile and clothing comfort, many researchers have studied on this subject comprehensively. Although there are various studies in the literature on moisture management properties of natural and synthetic textile materials, recycled textile materials have not been investigated yet.

Consumption of textile fibers has increased with the overpopulation; it is clear that environmental problems of textile industry increased highly in recent years. For that reasons, finding new solutions is expected from the textile industry to reduce these environmental problems they have caused. In this situation, recycling is the most important topic to be focused on to extend the lifecycle of the materials used.

In reference to environmental approach, waste of a product should be used for producing the same product. Because this way, it will gain primary raw material characteristics again and therefore its life cycle will be longer. However, higher contamination in the recycled polymers and lower viscosity are the restrictions prevent using PET flakes as raw material of PET bottle production. PET flakes are produced for secondary textile products like as carpet bottoms, sleeping bags, pillows and insulation materials in the past but these recycled fibers are being used in garment industry recently. Therefore, using recycled PET fibers in apparel industry can extend their life cycle and make them primary raw material for this industry. When it is considered that the highest consumption of PET polymer in the world is for filament and staple fiber production, it is clear that, it will present environmental advantages [16–19].

r-PET fibers are obtained by recycling of PET bottle wastes. Firstly, PET bottle wastes are separated from the other wastes; then they are broken into flakes, washed and dried respectively before spinning process. PET flakes are converted into fibers using chemical and mechanical methods. PET is degraded into oligomer or monomer form and again a polymerization occurs in chemical method. In mechanical method, PET flakes are melted and r-PET fibers are obtained by melt-spinning process [19–21].

These fibers have economic advantages because of the lower raw material cost. They also have lower energy consumption and low carbon emission in production stage. Therefore, it can be concluded that, r-PET fibers are environmentally friendly fibers [17, 19, 20, 22].

Nowadays, recycled products are being used in many areas and designers in world are accountable for waste production for downstream products such as clothes and interior finishing [23].

As it can be seen, due to the increasing conscious on sustainable materials and products, recycling of textiles is becoming more common. However, moisture and liquid transmission properties that is essential for thermal comfort characteristics of the fabrics. These characteristics of recycled materials have not been investigated in detail. The aim of this study is to examine moisture management and absorptivity properties of these fabrics produced from conventional polyester and r-PET fibers.

MATERIALS AND METHODS

Polyester and r-PET yarns were used in this experiment. r-PET fibers produced by mechanical methods from PET flakes were supplied. Yarns were produced in Ne 20 yarn count and twist coefficients of the yarns were kept constant (α = 3.6) for the spun yarns. The fabrics were knitted in single jersey structure by using Mesdan Lab. knitting machine [24]. The fabrics were conditioned in standard atmosphere conditions 20±2°C and 65±4% relative humidity before the tests and the moisture management properties of fabrics were measured by Moisture Management Tester (MMT-SDL Atlas) (figure 1) according to AATCC 195 [25].

Fig. 1. MMT – Moisture Management Tester Instrument [27]

Some conventional methods can be employed to evaluate the fabric's simple absorbency; wicking and moisture transfer properties, whereas 6 different characteristics such as wetting time, absorption rate, maximum wetted radius, spreading speed, accumulative one way transport capacity and moisture management capacity can be tested by moisture management tester [26].

The specimen is held flat by top and lower sensors at a certain pressure. The computer dynamically records the resistance change between each couple of proximate metal rings individually at the top and lower sensors. A certain weight (0.15 g) of a predefined test solution (synthetic sweating, AATCC 15) is then put into the sweat gland and imparted onto the top surface of the fabric. The solution will transfer in three directions after arriving on the fabric's top surface: spreading outward on the fabric top surface, transferring through the fabric from the top surface to the bottom surface, and spreading outward on the fabric bottom surface and then evaporating [6]. The parameters measured by the instrument are wetting time (WT_t (top surface) and WT_b (bottom surface) – (seconds)), Absorption Rate (TAR (top surface) and BAR (bottom surface) – (%/sec)), Maximum Wetted Radius (MWRtop and MWRbottom – (mm)), Spreading Speed (SS_{top} and SS_{bottom} – (mm/sec)) and Overall Moisture Management Capacity (OMMC).

Overall Moisture Management Capacity (OMMC) is an index to indicate the overall capability of the fabric to manage the transport of liquid moisture and calculated as:

$$OMMC = 0.25\ BAR + 0.5\ OWTC + 0.25\ SS_{bottom} \quad (1)$$

where BAR is the absorption rate, OWTC is the one-way transport capacity, and SS_b is the spreading/drying rate [27]. The larger the OMMC is the higher the overall moisture management ability of the fabric [6, 11, 14, 15, 27–29].

In order to analyse the change in surface properties of the fibers, SEM images of the fibers were also taken by using a scanning electron microscope (Hitachi TM-1000).

Water vapour permeability of the fabrics was tested by Permetest instrument. The instrument provides measurements according to ISO Standard 11092. The Permetest instrument can be considered as a small-scale "skin model", which simulates dry and wet human skin in terms of its thermal feeling and serves for determination of water vapour and thermal resistance of fabrics [29].

In order to determine wicking properties of the fabrics, vertical wicking test was conducted. Capillary forces in the pore structures of the medium govern the liquid transport through the pores. Wettability and wickability are two important phenomena related to liquid transport in fabrics. Wetting is known as the displacement of fiber-air interface with fiber-liquid interface and wicking is the transport of fluid which flows in a porous structure, by means of capillary forces. BS 3424-18, the standard test method was used for vertical wicking. A strip of fabric to be tested was suspended vertically into an infinite liquid reservoir. The rise of the liquid on the specimen versus time was recorded and liquid movement speed is calculated. A little dye was added to make the tracking of the movement of water easy.

There is a growing market demand for sportswear with moisture management properties. The drying rate of fabric demonstrates the overall effectiveness of sweat removal by evaporation. Quick dry and fast wicking functions are key features of moisture management fabric. A slow drying fabric could adversely affect the thermal comfort of a highly active wearer who sweats excessively. Measurement of drying rate has become one of the important tests for studying the performance of moisture management fabrics. In order to measure the drying capability of the fabrics testing conditions were chosen as 33±2°C temperature. The 200 mm×200 mm square fabric specimen was put on the plate of the balance, and the drying weight was recorded as W_f(g). The weight of water added to the fabric is equal to 30% of the dry sample weight before testing, designated W_o(g). The change in the amount of water W_i(g) was recorded every 2 minutes continuously for 12 minutes. "Water Evaporating Rate" (WER) was calculated by equation (2) to express the change of water weight remained in the specimen over time, to draw the evaporating curve from 100% to 0%.

$$WER(\%) = \frac{(W_o - W_i)}{(W_o - W_f)} \times 100\% \quad (2)$$

In this study water absorbency time was also determined according to TS EN 14697 [30]. Water absorbency time is the time required to completely immersed of the fabric into the water. Experimental samples were cut in (100 ± 1) mm × (100 ± 1) mm sizes, and each of sample was put into the water and the time elapsed to thoroughly immerse the sample was noted which is defined as absorbency time. The test was repeated for 5 times.
In this study, static immersion method was used to evaluate water absorption capacity [31]. In the test weighed samples were immersed in water and calculated the water absorption in terms of following equation:

$$\text{Water Absorption Capacity} = \frac{(M_W - M_D)}{M_D} \times 100 \quad (3)$$

where M_D is mass of fabric before immersion (g) and M_W – mass of fabric after immersion (g).
In this test, mean absorbency time identifies wettability of the fabrics and water absorption capacity indicates hydrophility. Higher the water absorption capacity means higher the hydrophility.

RESULTS AND DISCUSSION

Moisture management capacity of the fabrics

Moisture management properties of the fabrics are given in table 1.
After the measurements, results of fabrics produced from conventional and recycled fibers were evaluated statistically by independent samples t-test with the significance level of α = 0.05. Results of Independent Sample T-Test are given in table 2.

According to the results of two variable comparisons, difference between top absorption rate values was found statistically significant. That means, there is an absorption rate difference between the fabrics produced from r-PET and conventional PES fibers. However, the differences between the other liquid moisture transfer properties such as wetting time, max wetted radius and spreading speed measured by MMT tester were not found statistically significant.
As the SEM images given in figure 2 analysed, damages in the surface morphology can clearly be seen. r-PET fibers are produced by mechanical recycled method using bottles. Due to the contamination of PET flakes and re-heating process, molecular weight and tensile properties of the macromolecules change. For this reason, surface of the fibers become rougher. As the surface roughness increases, surface area of the fibres also increases. As a result, wicking and wetting property of the material changes. Therefore, water transfer properties of the fabrics are expected to be changed. In MMT test parameters, it can be seen in top absorption rate value. However, in case of other test parameters, the distinguishing transfer properties of these two fibers could not be clearly detected.
According to the water location vs time graphs given in figure 3, it can be determined that maximum wetted radius value of PES and r-PET are close to each other. Although, the wetted radius of outer surface is a bit higher for r-PET fabric, the difference between the values (table 2) was found insignificant.
According to the Overall Moisture Management Capacity (OMMC) test results, polyester and r-PET fabrics are both categorized in “fast absorbing and quick drying fabrics” by the software of the instrument, since, the pumped test liquid could be transferred from the inner surface to the outer surface.

Table 1

MOISTURE MANAGEMENT PROPERTIES OF THE FABRICS

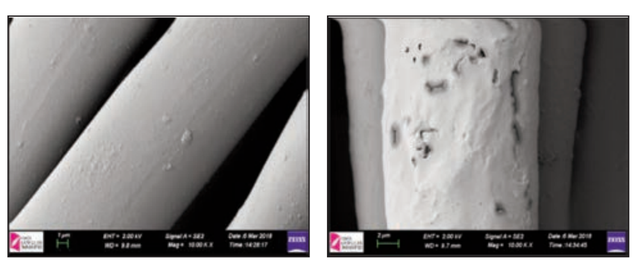
Materials	Wetting time top (sec)	Wetting time bottom (sec)	Top absorption rate (%/sec)	Bottom absorption rate (%/sec)	Top max wetted radius (mm)	Bottom max wetted radius (mm)	Top spreading speed (mm/sec)	Bottom spreading speed (mm/sec)	OMMC
PES	7.96	8.02	15.37	36.62	15	13.33	1.19	1.22	0.52
r-PET	7.34	7.88	58.9	38.42	15	16.25	0.88	0.91	0.53

Table 2

SIGNIFICANCE VALUES OF INDEPENDENT SAMPLE T-TEST

Measured parameters	Significance (p)
Wetting Time top(sec)	0.629
Wetting Time Bottom (sec)	0.918
Top Absorption Rate (%/sec)	0.017*
Bottom Absorption Rate (%/sec)	0.886
Top Max Wetted Radius (MM)	1.000
Bottom Max Wetted Radius (MM)	0.066
Top Spreading Speed (mm/sec)	0.460
Bottom Spreading Speed (mm/sec)	0.464
OMMC	0.851

* Significant according to α = 0.05 significance level.



a *b*

Fig. 2. SEM image of: *a* – polyester; *b* – r-PET fabric coated with 10nm of gold using a 15 kV beam

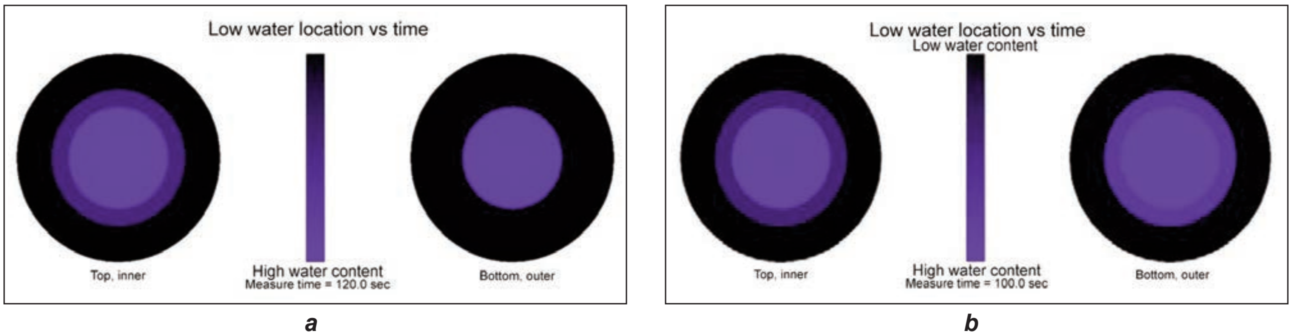


Fig. 3. The wetting radius changes in the inner/outer surfaces of fabrics: *a* – polyester; *b* – r-PET

Table 3

OVERALL MOISTURE MANAGEMENT CAPACITY OF THE FABRICS		
Parametres	**PES**	**r-PET**
OMMC Value	0.52	0.53
Evaluation	Good	Good

OMMC values, changing between 0 and 1, which indicates multidirectional liquid transfer ability of the fabrics, are given in table 3.

According to OMMC evaluation scale, the values are categorized as: 0–0.2 Very poor, 0.2–0.4 Poor, 0.4–0.6 Good, 0.6–0.8 Very good, >0.8 Excellent. In scope of OMMC values of the fabrics, r-PET and polyester fabrics are both identified as "good" in terms of their overall moisture management properties. It indicates that, r-PET fabric has good moisture management characteristics to be used even in garments.

Water absorption capacity of the fabrics

Water absorption capacity and water absorption time values of the fabrics are given in table 4.

Table 4

WATER ABSORPTION PROPERTIES OF THE FABRICS (STATIC IMMERSION TEST RESULTS)			
Parametres	**PES**	**r-PET**	**Significance* (p)**
Water absorption capacity (%)	4.78	4.67	0.492
Water absorption time (Sec)	5.12	3.36	0.007

* Significant according to α = 0.05 significance level.

According to the results, water absorption capacity values of the fabrics were found close to each other. However, water absorption time value of r-PET fabric was found statistically lower than the conventional PES fabric. It is due to the increased surface area of r-PET fibers that increases the wettability of these fibers.

Water-vapour permeability of the fabrics

Water vapour permeability results of the fabrics are given in table 5. According to the results, water

Table 5

SIGNIFICANCE VALUES OF INDEPENDENT SAMPLE T-TEST			
Characteristic	**PES**	**r-PET**	**Significance* (p)**
Water-vapour permeability	2.86	2.78	0.587

* Significant according to α = 0.05 significance level.

vapour permeability of the fabrics produced from PES and r-PET fibers were found close and the difference between them was found insignificant.

Vertical wicking results of the fabrics

The water vertical wicking speed of PES and r-PET fabrics is given in figure 4.

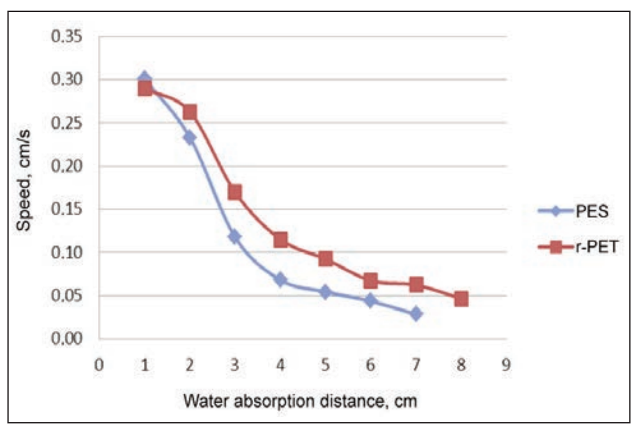


Fig. 4. Water vertical wicking speed of PES and r-PET fabrics

In this measurement, bottom end of fabric sample is immersed into the distilled water and the height of water transmission is measured. Therefore, water can be transferred through the all capillary tubes in the test area. Quantity of the test liquid is high enough for the sensitive determination of the differences in capillary forces.

As figure 4 was analysed, it can be pointed out that due to the deterioration in surface structure, r-PET fibers are more fractured and the number of capillary tubes between fibers increases. For this reason, performance of r-PET fabric was found better than PES fabric in this test.

Drying rate of the fabrics

Results of drying test were given in figure 5. In this measurement, although the weight of water added to the fabric is equal to 30% of the dry sample weight, water evaporating rate of the r-PET fabric was found higher than conventional PES fabric. It is related with the higher surface area of the r-PET fibers that increases the evaporation.

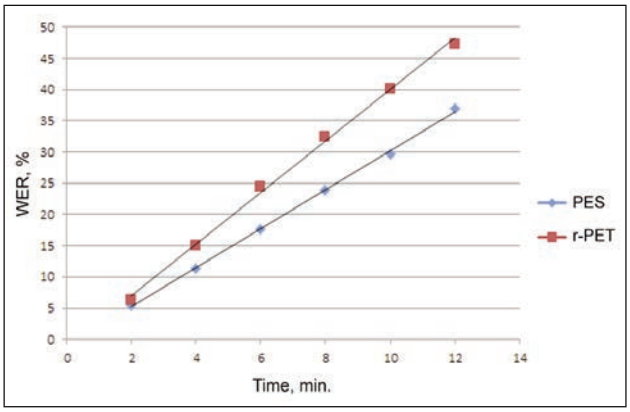


Fig. 5. Water evaporating rate change versus time

CONCLUSION

Liquid moisture management property is especially important in sportswear, where exposure to perspiration is intense. Research in this subject is more focused on high technological fibrous products such as channelled fibers and micro fibers. Recycling based researches and looking for new applications of such products is increasing worldwide.

Previous studies shows that there are numerous studies on Moisture Management Properties of products produced from polyester fiber but there is a huge need for more studies on recycled products. This study aims to compare moisture management, liquid moisture transfer and water vapour permeability properties of r-PET and conventional polyester fabrics. For this purpose, different measurement systems including conventional and new generation methods were used.

Polyester fibers are hydrophobic; therefore, water is transferred to the outer layers from the surface of the fibers by capillary forces. Due to the mechanical and thermal effects, fiber surface is rougher in r-PET fibers. That increases its wettability, capillary transfer performance and its drying rate. However, each of these differences in water transfer properties can be detected by different test procedures.

According to the MMT Instrument results, both fabrics were classified as fast absorbing and quick drying fabrics category and identified as "good" in terms of overall moisture management properties. Absorption rate differences were found between the PES and r-PET fabrics. Static Immersion test was used to measure wettability differences between the fabrics. However water absorption capacity differences could not be distinguished.

Water vapour permeability in synthetics is mostly related with the porosity of the fabrics. Fiber deteriorations in r-PET fibers changes surface characteristics of the fabrics; however it does not change porosity of the fabric in macro scale. For this reason, water vapour permeability of the both fabrics was found close to each other.

Liquid transport of conventional and r-PET fabrics were detect by wicking test which is a sensitive measurement method and found significant differences between them. Drying rate test which demonstrates the overall effectiveness of sweat removal by evaporation was used to determine the water evaporation rate of the fabrics. According to results the r-PET fabric was found higher than conventional PES fabric because of the higher evaporation speeds of the r-PET fabric obtained by higher surface area.

As recycling, sustainability and environmental pollution was considered, it should be underlined that, the fabrics produced from r-PET fibers have competitively good moisture management properties which can be used in textile goods more commonly.

ACKNOWLEDGEMENT

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Investigation of droplet impact on inclined fabric based on CMOS imaging technology and FSI numerical method

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ABSTRACT – REZUMAT

Investigation of droplet impact on inclined fabric based on CMOS imaging technology and FSI numerical method

In order to study the impact characteristics of droplet on inclined fabric, the relevant experiment was setup in this paper. The process of a single droplet (2.12 mm) impacting inclined fabric (45°) was captured by CMOS (Complementary Metal-Oxide Semiconductor) imaging technology. It could be found that there was a second impact phenomenon during spreading stage, which was very different from impacting horizontal fabric. Then a two-way coupling method was used to simulate that impacting process. The numerical results were basically consistent with the experimental results. In addition, the reaction force and vibration characteristics of fabric which couldn't be collected by experiments were also obtained. Finally, the effect of inclination angle on impact characteristics was analyzed by numerical method. The bigger the inclination angle was, the longer the stability time of droplet was, and the smaller the reaction force on fabric was. The change law conformed to the momentum theorem. The method and conclusions could provide some references for the design of parachute system.

Keywords: *CMOS, aeronautical fabric, fabric response, two-way coupling, polyamide*

Analiza impactului picăturilor pe suprafața țesăturii înclinate pe baza tehnologiei de imagistică CMOS și a metodei numerice FSI

În cadrul acestei lucrări a fost realizat un experiment relevant, pentru a studia caracteristicile de impact ale picăturii pe țesătura înclinată. Impactul unei singure picături (2,12 mm) care intră în contact cu suprafața țesăturii înclinate (45°) a fost surprins de tehnologia de imagistică CMOS (Semiconductor complementar metal-oxid). S-a putut constata că a existat un al doilea fenomen de impact în etapa de răspândire, care a fost foarte diferit de impactul asupra țesăturii orizontale. Apoi, a fost utilizată o metodă de cuplare bidirecțională pentru a simula acel proces de impact. Rezultatele numerice au fost practic conforme cu rezultatele experimentale. În plus, au fost obținute și forța de reacție și caracteristicile de vibrație ale țesăturii, care nu au putut fi colectate prin experimente. În cele din urmă, influența unghiului de înclinare asupra caracteristicilor de impact a fost analizată prin metodă numerică. Cu cât unghiul de înclinare a fost mai mare, cu atât a fost mai mare și timpul de stabilitate al picăturii, iar forța de reacție pe țesătură este mai redusă. Legea schimbării s-a conformat teoremei impulsului. Metoda și concluziile ar putea oferi câteva referințe pentru proiectarea sistemului unei parașute.

Cuvinte-cheie*: CMOS, țesătură pentru domeniul aeronautic, răspunsul materialului textil, cuplare bidirecțională, poliamidă*

INTRODUCTION

Parachute is a kind of important aerodynamic deceleration equipment in aerospace field. However, in some bad weather, droplets impingent will seriously affect the deceleration effect of parachute system and reduce the probability of success in life saving.

At present, many scholars have carried out a large number of researches on droplet impacting on rigid objects. Sikalo et al. investigated the effects of velocity, viscosity, surface wettability and roughness on impacting processes [1–3]. Chen et al replaced the impacted object with a cylinder or sphere, and the effect of different geometric characteristics on impacting processes was investigated [4]. Moita et al. investigated the heat transfer on impacting behavior [5–6]. However, the processes of droplets impact on porous media were more complex than on non-porous media. In addition to the known spreading stage and recoiling stage, there was also process of liquid absorption by porous media. Reis et al. used MAC (Marker and Cell) method to track the position and shape of liquid region [7]. Anderson used one-dimensional immersion/deformation model to investigate the deformation of porous media [8]. Other scholars applied VOF (Volume of Fluid) method to simulate the spreading and absorbing behaviors of droplets on porous substrates [9–10].

Although the fabric is a typical porous material, the droplet impingement could cause material deformation, and the fabric deformation will interact with droplet deformation. However, the nature of fluid structure interaction mechanics has not been taken into account in the above studies. In addition, the effect of inclination angle on impacting processes has not been reported publicly. Therefore, the experiment used to capture the process of droplet impacting on inclined fabric was built based on CMOS imaging technology in this paper. Then a two-way coupling numerical method was used to obtain the data of vibration characteristics and reaction force.

EXPERIMENT SETUP

Figure 1 is the schematic diagram of the experiment. The height of syringe needle could be adjusted to obtain the initial impact velocity. The magnetic bases are used to suspend and fix the fabric, and adjust the inclination angle of the fabric. The cold light source is used for imaging illumination. The high speed camera (512*512 dpi, 3000 fps) based on CMOS imaging technology is used to record the impacting process. The computer is used to control the syringe pump to produce the droplet and record the experimental data.

According to the Pu's analysis of rain spectrum [11], it could be found that the droplets with diameter from 1 mm to 3 mm contribute most to rainfall intensity and water content. In addition, the steady dropping speed of parachute is 6 m/s. When the droplet's diameter is less than 1.9 mm, the steady dropping speed is less than 6 m/s, and the probability of droplet impact on the canopy is smaller. Therefore, the impacting process of droplet with a diameter of 2.12 mm (the corresponding steady dropping velocity is 6.77 m/s [11]) is investigated, and the initial relative impact velocity is 0.77 m/s in this paper.

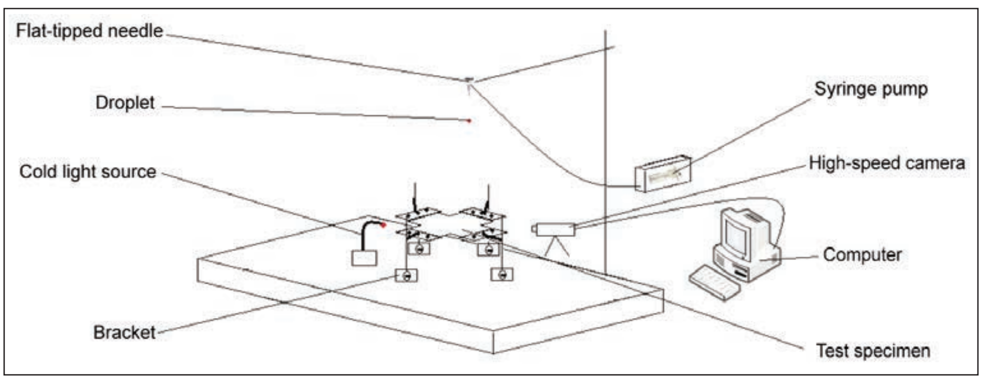
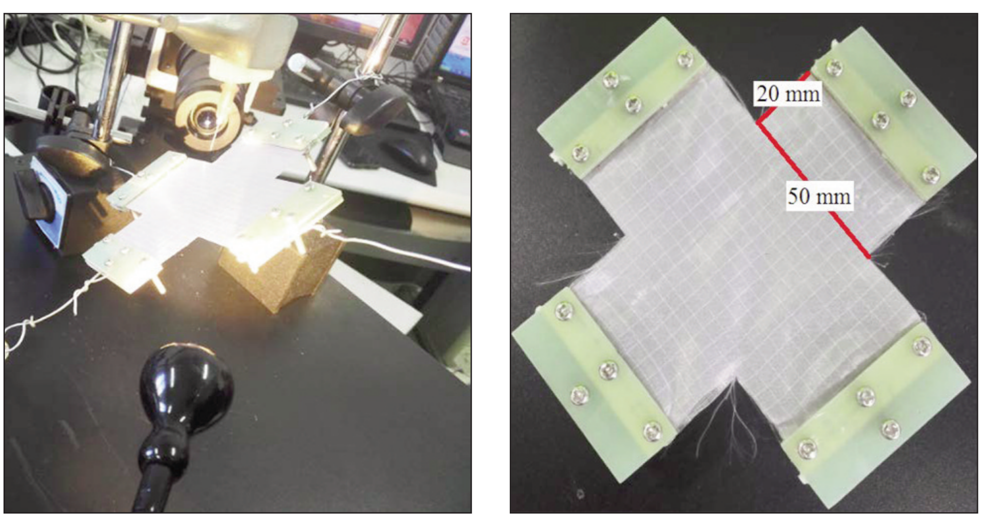


Fig. 1. The schematic diagram of experiment



a *b*

Fig. 2. The experiment setup: *a* – test bench; *b* – fabric specimen

In this paper, the 66 type polyamide grid silk is taken as the research object. The bottom side of the fabric specimen is coated by silica gel. The permeability coefficient α and pressure drop coefficient C_2 are 1.5E-12 m^2 and 2.5E8 m^{-1} respectively. The thickness of fabric specimen is 0.08 mm. The test bench and specimen are shown in figure 2.

MODEL DEVELOPMENT

In this paper, the VOF model is used to calculate the fluid field. Here the air is taken as main phase and water is the secondary phase. The control equations are as follows:

$$\frac{\partial(\alpha_w \rho_w)}{\partial t} + \nabla \cdot (\alpha_w \rho_w \boldsymbol{v}_w) = 0 \quad (1)$$

$$\frac{\partial(\rho \boldsymbol{v})}{\partial t} + \nabla \cdot (\rho \boldsymbol{v}\boldsymbol{v}) = = -\nabla \rho + \nabla \cdot \left[\mu(\nabla \boldsymbol{v} + \nabla \boldsymbol{v}^T)\right] + \rho \boldsymbol{g} + \boldsymbol{F} + \boldsymbol{S} \quad (2)$$

where α_w is the volume fraction of water, ρ – density, $\boldsymbol{v}$ – velocity vector, t – time, μ – dynamic viscosity, $\boldsymbol{g}$ – gravity vector, $\boldsymbol{F}$ – additional momentum source term caused by surface tension [12], $\boldsymbol{S}$ – the term caused by porous media. Geometry reconstruction method is applied to deal with the interface between different phases.

Here, the turbulence model is not considered because the Reynolds number is small. Meanwhile, the energy equation is not needed to be solved because the thermodynamic problem is not involved. In this paper the PISO (Pressure Implicit Split Operator) algorithm is used to solve the above equations.

The structural domain is calculated by Finite Element Method. The control equation is as follows:

$$[\boldsymbol{M}]\{\ddot{x}\} + [\boldsymbol{C}]\{\dot{x}\} + + [\boldsymbol{K}]\{x\} = \{\boldsymbol{F}(t)\} \quad (3)$$

where $[\boldsymbol{M}]$ is mass matrix, $[\boldsymbol{C}]$ – damping matrix, $[\boldsymbol{K}]$ – stiffness matrix, x – node displacement vector, $\{\boldsymbol{F}(t)\}$ – load vector. Here, the

Newark algorithm is used to solve the structural domain.

In this paper, the two-way coupling is realized by the separation method [13]. In each time step, the flow field is calculated first, and the coupling force is taken as boundary condition to calculate the structural domain. Then the displacement is used to adjust the flow field grids. The coupling calculation will continue

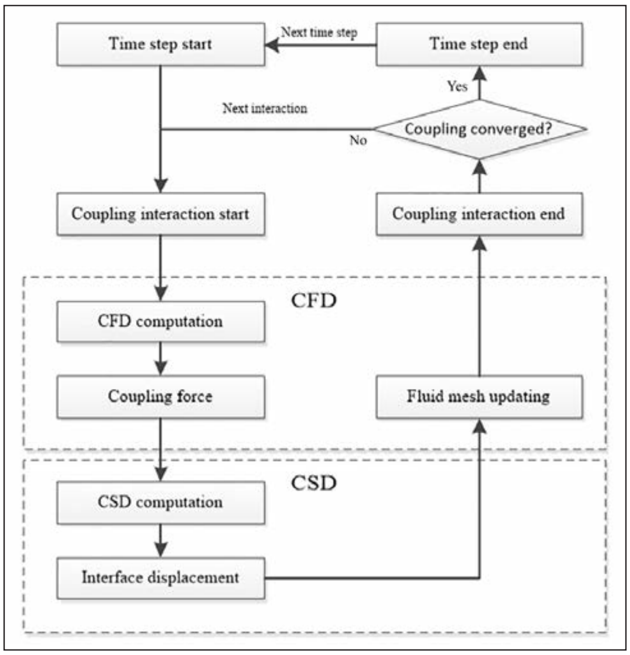


Fig. 3. The diagrammatic sketch of two-way coupling

until the results converge, and then the coupling calculation of the next time step will begin (figure 3).

In order to save computational resources, a symmetrical model is established (figure 4). Then 1,500,287 grids are used to discretize the flow field, and 24,241 grids are used to discretize the structure. While the calculation parameters are shown in table 1.

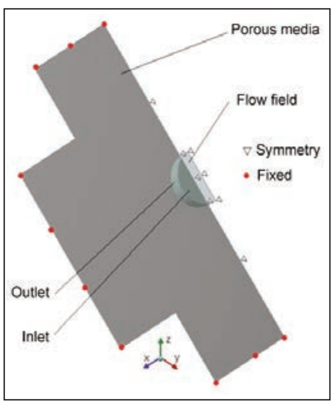


Fig. 4. The flow field model and structure model

Table 1

PARAMETERS OF FLOW FIELD		
Boundary conditions	Velocity inlet (m/s)	0
	Pressure outlet (Pa)	0
Properties of air	Density (kg/m^3)	1.204
	Viscosity (Pa·s)	1.82E-5
Properties of droplet	Diameter (m)	2.12E-3
	Density (kg/m^3)	998
	Surface tension (N/m)	7.4E-2
	Viscosity (Pa·s)	1.01E-3

RESULTS AND DISCUSSION

Figure 5 is the droplet shape comparison between experimental and numerical results. It could be found that the whole impact process also can be divided into colliding stage (0–0.333 ms), spreading stage (0.333–15 ms), recoiling stage (15–36 ms) and oscillating stage (after 36 ms).

Colliding stage (0–0.333 ms): The duration of this stage is very short. The droplet begins to contact the fabric, and keep spherical shape basically.

Spreading stage (0.333–15 ms): This stage is the most complex stage of the whole impacting process. At the beginning of this stage, droplet could maintain symmetrical shape (figure 6, *a*). But the droplet begins to slide to lower position under the action of gravity (figure 6, *b*). Meanwhile, the liquid velocity decreased gradually from the top to the bottom due to the viscous force, the upper liquid part of droplet keeps gathering to the lower position by gravity force. The droplet shows serious asymmetry (figure 6, *c*). Then the height begins to increase (figure 6, *d*). At about 15 ms, the upper part of droplet collapse, and the droplet partially impact on the fabric again (figure 6, *e*).

Recoiling stage (15–36 ms): After the second impact on the fabric, the bottom of the droplet begins to stabilize. While the upper liquid of the droplet begins to rebound in reverse (figure 6, *f*).

Oscillating stage (after 36 ms): At 36 ms, the upper liquid of the droplet begins to move downward again. Droplet begins to stabilize gradually due to the constant dissipation of kinetic energy (figure 6, *g*).

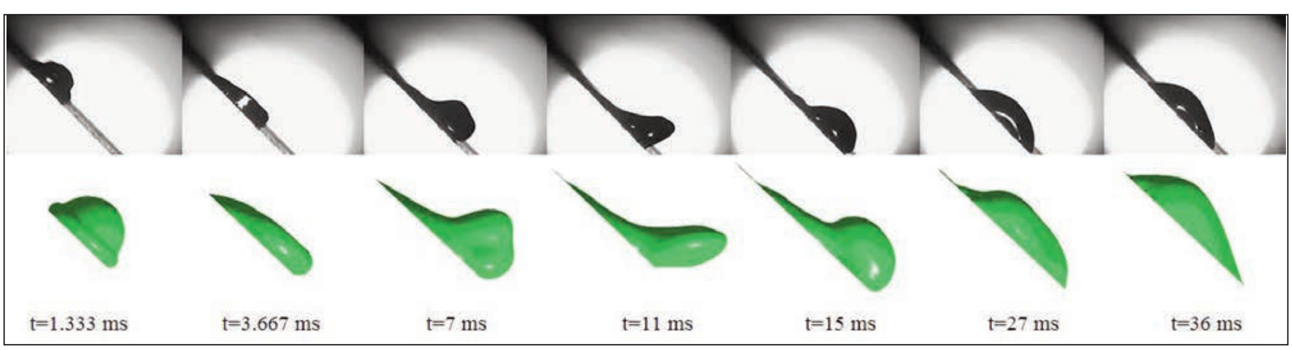


Fig. 5. The comparison between experimental and numerical results

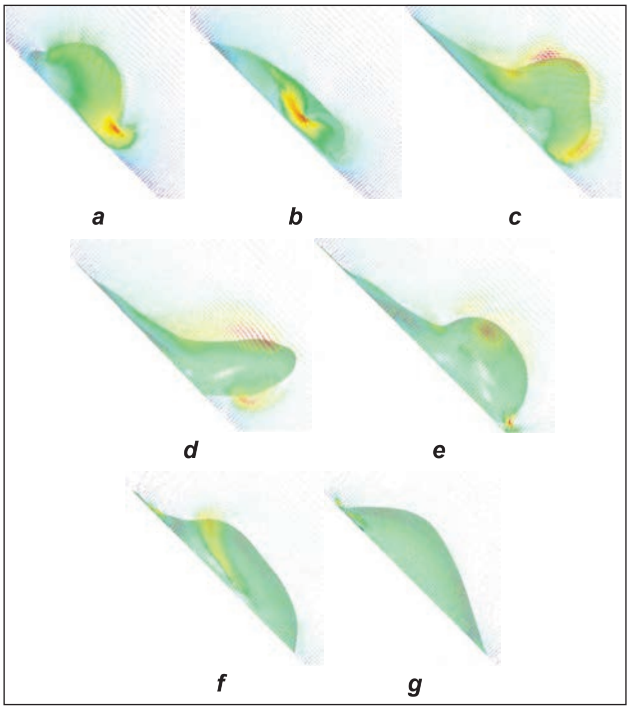


Fig. 6. The velocity vector of flow field: *a* – 1.333 ms; *b* – 3.667 ms; *c* – 7 ms; *d* – 11 ms; *e* – 15 ms; *f* – 27 ms; *g* – 36 ms

Figure 7 shows the change of spreading factor. It could be found that the numerical results are basically consistent with the experimental results. After the droplet contact the fabric, it spread rapidly. At 8 ms, the spreading factor is gradually stable and tends to shrink due to the viscous resistance acts on the bottom of the droplet. Meanwhile, the liquid on the upper part of the droplet continuously gathers to one side and causes the collapse at about 15 ms (figure 5). The secondary impact causes instantaneous increase of spreading factor. In the recoiling stage, the spreading factor changes steadily.

In addition, the processes of droplets impact on fabric with different inclination angles are also simulated. It could be found that the smaller the inclination angle is, the earlier the droplet reaches its maximum spreading factor, and the smaller the maximum spreading factor is. Under the same conditions, the bigger the inclination angle is, the more severe the droplet deformation is and the longer the continuous deformation time is (figure 8, *a*).

Figure 8, *b* shows the comparison of the reaction force. The smaller the inclination angle is, the smaller the horizontal force (*Y* direction) is, and the larger the vertical force (*Z* direction) is. When the inclination

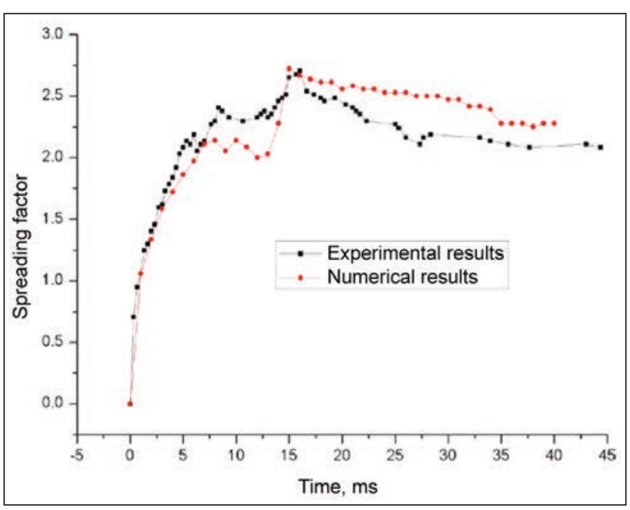
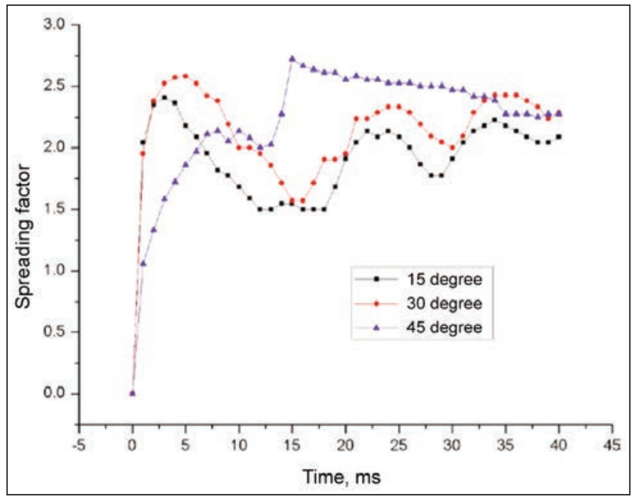
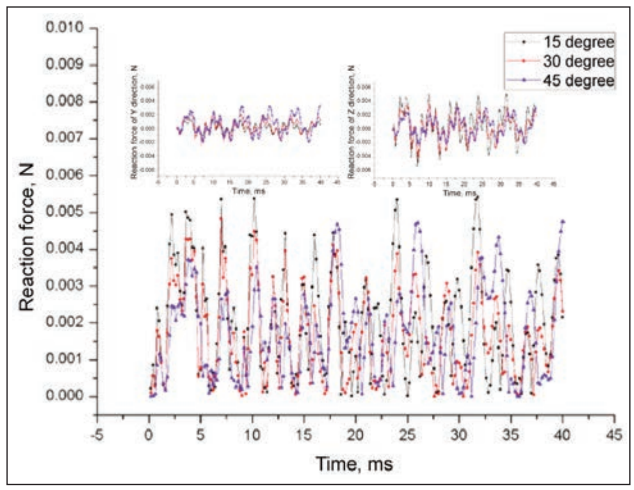


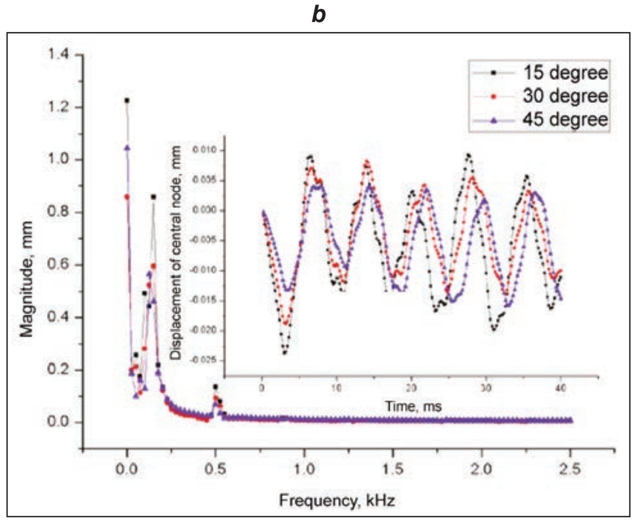
Fig. 7. The comparison of spreading factor



a



b



c

Fig. 8. The effect of inclination angle on impacting process: *a* – spreading factor; *b* – reaction force; *c* – amplitude-frequency characteristic

angle is 45 degree, the reaction forces of fabric in horizontal and vertical directions are almost the same. Generally speaking, the smaller the inclination angle is, the shorter the change time of droplet velocity is, and the larger the reaction force is. The above change law basically satisfies the momentum theorem ($F \cdot t = m \cdot \Delta v$).

Figure 8, *c* shows the comparison of amplitude-frequency characteristic of specimen's center node. It could be found the inclination angle has little effect on fabric vibration. But the smaller the inclination angle is, the larger the amplitude is.

CONCLUSIONS

In this paper, the experiment of droplet impact on inclined fabric was setup. The impacting process was captured based on CMOS imaging technology. It could be found that the process could also be divided into colliding stage, spreading stage, recoiling stage and oscillating stage. However, the spreading stage is complex and there was a secondary impact phenomenon. In addition, a two-way coupling numerical method was used to obtain the data that can't be collected by the experiment. At last, the effect of inclination angle on impacting processes was analyzed. The experimental and numerical methods described in this paper could provide some reference for the design of parachute system.

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Effect of fabric parameters on fragrance retention

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ABSTRACT – REZUMAT

Effect of fabric parameters on fragrance retention

This study is to explore the effect of fabric parameters on fragrance retention, which was based on the olfactory measurement technology with the quantitative headspace method. The fragrance retention of different fabrics was quantitatively evaluated by Electronic Nose (e-nose) at different time after volatilization. Quick-drying Tester was used to test the fabric drying rate, which was related to fragrance retention. Besides, wicking property and porosity of fabrics, two factors of moisture transmission, were tested and calculated for analysis too. It was found that fabrics with the higher cotton content had the better fragrance retention due to their hydrophilicity and water retention property of fibers. Plain fabric had the shorter fragrance retention than twill fabric since its lower porosity and the higher capillary pressure led to the faster fragrance dissipation. As the fabric density increased or the yarn count decreased, the fragrance retention increased. Since their wicking properties decreased, the process of perfume diffusion would slow down. The data and methods presented in this paper provide a basis for optimizing the parameters of fragrant fabric.

Keywords: *fabric parameters, fragrance retention, electronic nose, moisture transmission, wicking property, quick-drying tester*

Influența caracteristicilor materialului textil asupra retenției parfumului

Acest studiu analizează influența caracteristicilor materialului textil asupra retenției parfumurilor, care s-a bazat pe tehnologia de măsurare olfactivă cu metoda cantitativă a spațiului liber. Retenția parfumului diferitelor materiale textile a fost evaluată cantitativ prin Electronic Nose (e-nose), la diferite momente după volatilizare. Testerul cu uscare rapidă a fost folosit pentru a testa rata de uscare a materialului textil, care a fost corelată cu retenția parfumului. În plus, proprietatea de absorbție și porozitatea materialelor textile, doi factori de transmitere a umidității, au fost testate și calculate pentru analiză. S-a constatat că materialele textile cu un conținut mai ridicat de bumbac înregistrează o mai bună retenție a parfumului, datorită proprietății de hidrofilitate și de retenție a apei din fibre. Țesătura cu legătură pânză a avut o retenție de parfum mai redusă, decât țesătura cu legătură diagonal, deoarece porozitatea sa este mai mică și presiunea capilară este mai mare, ce a condus la disiparea mai rapidă a parfumului. Pe măsură ce desimea țesăturii a crescut sau finețea firului a scăzut, retenția parfumului a crescut. Deoarece proprietățile lor de absorbție au scăzut, procesul de difuzare a parfumului a fost încetinit. Datele și metodele prezentate în această lucrare oferă o bază pentru optimizarea caracteristicilor materialelor textile parfumate.

***Cuvinte-cheie**: caracteristicile țesăturii, retenția parfumului, “electronic nose”, transmiterea umidității, proprietate de absorbție, tester cu uscare rapidă*

INTRODUCTION

Nowadays, perfume is widely used in people’s daily life. It can satisfy wearers and leave a deep impression on others [1, 2]. Also, such undesirable smells as sweat and hircismus can be covered up [3]. Besides, it was reported that fragrances have the functions of sedation, sterilization, hypnosis, health care, and so forth [4]. However, according to researches, there were negative effects spraying directly on the skin, such as allergenic potential or other skin diseases [5, 6]. Therefore, it seems that perfume is more suitable to be used on clothes. At present, the methods of adding fragrance to textiles include coating, microcapsule finishing and aromatic fibers preparing [7], which can only produce a single fragrance. But consumers have different fragrance pursuits for different occasions and moods. Therefore, spraying perfume on clothing directly has a more practical significance. However, it needs further exploration of how to prolong the fragrance retention, which is an effective and natural way to delight customers.

As a new testing item, the detection of aromatic textiles is in the stage of continuous exploration and gradual development. Previously, the odour detection and evaluation of textiles used to be carried out by experts after olfactory training [8]. But these experts were easy to be affected by subjective factors. Now, Electronic nose (e-nose), known as odour fingerprint detector, is often applied to detect, identify, and analyse volatile components [9]. E-nose works with a series of sensors. The composition of the volatile analytes can be judged based on the corresponding resistor value (G/G_0) of sensors [10]. E-nose has been widely used in the food industry, tobacco identification, medical diagnosis, environmental protection, textile industry, and other fields [11–15]. In addition, headspace method was often used for volatile extraction [16]. Thus, it is advisable to utilize the olfactory measurement technology (i.e. e-nose) with quantitative headspace method in this study.

The fragrance retention may be associated with moisture transmission, while which is further related to the type of fabric. In this study, the fragrance retention would be explored by using e-nose with the quantitative headspace method. Furthermore, to reveal the relationship between fragrance retention and moisture transmission, the drying rate, the wicking property, and the porosity of fabrics were tested and calculated. The fabric parameters involved in material composition, fabric weave, fabric density, and yarn count, they were analysed separately under the same conditions.

EXPERIMENTAL

Materials

Fabrics, each differing in material composition, fabric weave, fabric density, and yarn count were used. All of them were bought from Linya Textile Co. Ltd, China. Their specific parameters are listed in table 1. All these undyed fabrics were rinsed and dried before experiment. Generally, perfume consisted of top, middle and base notes [17]. Fruity top note had a relatively short volatilization time (*i.e.* about 3 hours) and single fragrant base would not change in tonality, both of which were advantageous to the detection of experiments [18]. Additionally, odour-free alcohol was often applied to configure perfume. Thus, the fruity base of grapefruit (Eprhan Spices Co., Ltd., China) and the odour-free alcohol (concentration 95%, Gold Alcohol Chemical Co. Ltd, China) were selected as raw materials.

Table 1

DIFFERENT FABRIC PARAMETERS

Fabric number	Material composition	Fabric weave	Fabric density (count/ 10 cm)	Yarn count (Ne)
Sample # 1	100% Cotton	Plain	524×283	40
Sample # 2	35% Cotton/ 65% Polyester	Plain	524×283	45
Sample # 3	10% Cotton/ 90% Polyester	Plain	524×283	45
Sample # 4	100% Cotton	Twill	524×283	40
Sample # 5	100% Cotton	Plain	524×394	40
Sample # 6	100% Cotton	Plain	433×283	40
Sample # 7	100% Cotton	Plain	276×197	40
Sample # 8	100% Cotton	Plain	524×283	32
Sample # 9	100% Cotton	Plain	524×283	21

Perfume preparation

The experiments were carried out under the condition of constant temperature and humidity (i.e. 25 ± 2 °C with humidity of 30 ± 3 %). The fruity base was serially diluted with odor-free alcohol until the resistor values (G/G_0) of e-nose (PEN3, Airsense Analytics GmbH, Germany) displayed stably. The main applications of sensors in PEN3 are listed in table 2 [19]. The resistor value (G/G_0) of sensor No. 9 was selected, since its response to the fragrance was the strongest in the experiment. In the remainder of this article, the resistor value (G/G_0) of sensor No. 9 will be referred to as "R9". When R9 was within 10 and the resistor values stayed stable, the ratio of fruity base and odour-free alcohol was 1:79.

Table 2

SENSORS USED AND THEIR MAIN APPLICATIONS IN PEN3

Number in array	Sensor-name	Object substances for sensing
MOS 1	W1C	Aromatic compounds
MOS 2	W5S	Nitrogen oxides
MOS 3	W3C	Ammonia, aromatic compounds
MOS 4	W6S	Hydrogen
MOS 5	W5C	Alkanes, less polar compounds
MOS 6	W1S	Sensitive to methane (environment), broad range
MOS 7	W1W	Sulfur compounds, terpenes, sulfur organic compounds
MOS 8	W2S	Detects alcohol's, broad range, Ssimilar to MOS 6
MOS 9	W2W	Aromatic compounds, sulfur organic compounds
MOS 10	W3S	Reacts on high concentrations >100 ppm, Sometimes very selective (methane)

Exploration of experiment parameters

Four sizes of swatches (i.e. 6 cm, 7 cm, 8 cm, 9 cm) were placed at the bottom of the corresponding four specifications of beakers (i.e. 250 ml, 500 ml, 800 ml, 1000 ml). Then, perfume with three dosages (i.e. 50 μl, 100 μl, 200 μl), taken by the pipette (F3, 20–200 μl, Thermo Fisher Scientific, America), was evenly dropped onto four swatches respectively. Finally, e-nose was used to select the suitable samples. The size of beaker and swatch depends on each other, and the area of swatch further determines the amount of perfume. Moreover, the perfume droplets applied to the fabric ought to spread evenly and do not overlap. Results manifested that the 6 cm, 7 cm and 8 cm diameter circular swatches applied with 50 μl perfume respectively, and the 9 cm diameter circular swatches applied with 50 μl or 100 μl perfume were able to obtain stable and reliable results.

Furthermore, from the R9, it was found that 50 μl perfume had a steady trend prematurely (i.e. 30 min), while the usage of 100 μl stepped down within 60 min, which was more conducive to detect. Thus, 100 μl perfume was chosen as the experimental parameter. Meanwhile, the swatch with the diameter of 9 cm and the beaker size (i.e. 1000 ml) were selected. Besides, the large beaker is also more beneficial to the extraction of headspace air.

The same amount of perfume was dropped onto four fabrics having the same parameters. After volatilization for 10 min, these fabrics were sealed in beakers respectively for different time (i.e. 5 min, 10 min, 15 min and 18 min). By observing R9, the sealing time would be determined when fragrance was full of beaker. The curve of R9 was fitted at stability (i.e. at 60–80 s). As shown in table 3, the fragrance filled the beaker completely at 15 min, since its R9 was the highest and its curve fitting slope of R9 tended to 0. Thus, 15 min was selected as the sealing time.

The samples were detected by e-nose per hours to find out the range of detection time. The sampling time was preliminarily set as 60 min, 120 min and 180 min respectively. According to the detection, R9 dropped sharply within 60 min, but its rate declined from 60 to 180 min. Moreover, R9 tended to be constant at 180 min. Therefore, the detection time was separately set as 10 min, 20 min, 30 min, 40 min, 50 min, 60 min, 90 min, 120 min and 180 min, a total of 9 detection time points.

Testing on fragrance retention of fabrics by e-nose

Based on the above experimental parameters, 100 μl perfume was evenly dropped onto the 9 cm diameter swatch which was placed at the bottom of the 100 ml beaker. After the same 9 swatches separately volatilizing for different detection time, the beaker was sealed with plastic wrap for 15 min. The headspace air of the beaker was detected by e-nose to obtain R9. A total of five experiments were performed on each sample. Detailed information of the experiment groups is provided in table 4.

Table 3

RESPONSE OF SENSOR 9 AT DIFFERENT SEALING TIME

Sealing time (min)	5	10	15	18
Resistor values (G/G_0)	3.605	4.693	5.063	2.414
Curve fitting slope (60–80 s)	0.03882	0.02085	–0.00036	–0.00305

Table 4

EXPERIMENT GROUPS WITH DIFFERENT FABRIC PARAMETERS

No.	Experimental variable	Fabric number		
Group 1	Material composition	Sample # 1	Sample # 2	Sample # 3
Group 2	Fabric weave	Sample # 1	-	Sample # 4
Group 3	Fabric density (count/10 cm)	Sample # 5	Sample # 6	Sample # 7
Group 4	Yarn count (Ne)	Sample # 1	Sample # 8	Sample # 9

Testing of fabric drying rate

The water evaporation rate and time were achieved through Quick-drying Tester (DST-5200B, Daiei Kagaku Seiki Mfg. Co., Ltd., Japan). The time interval was present to 1 min since fragrance has a strong ability of volatility. 200 μl perfume was evenly dropped onto swatch. Then, the test was conducted in accordance with the GB/T 21655.1. All fabrics were tested five times in sequence. And their water evaporation rates were recorded based on the peak of the "time-evaporation" graph.

Testing on wicking properties of fabrics

The absorbability of fabric, which reflects the wicking property, was measured by Automatic Water Absorption Speed Tester (PW-5P-AT2, Daiei Kagaku Seiki Mfg. Co., Ltd., Japan). According to JIS L 1907, the water absorption speed was evaluated by automatically-measured water rising height in 10 min, which was denoted as sample # X H_{wrap}, H_{weft}. Each fabric was tested five times.

RESULTS AND DISCUSSION

The effect of material composition on fragrance retention

As shown in figure 1, the fragrance retention of fabrics was proportional to the cotton content. At the same time, with the proportion of cotton decreasing, the drying rate of fabric increased (figure 2). While, another evaluation of the drying time, *peak* decreased (figure 2). It was reported that the drying rate of fabrics depended on the moisture content of fibers, which relied on their hydrophilicity and water retention property [20]. Cotton fibers had the better hydrophilicities since their surface had more bonding sites for water molecules than polyester [21]. Besides, the irregular shape of cotton fibers contributed to the better water retention property [22]. What's more, according to the optical microscope images of yarns (figure 3), the yarn hairiness became much messy as the cotton content increased leading to less moisture transmission. Additionally, when the fragrance was absorbed by fibers, the fibers swelled up and the size of air spaces narrowed down, thereby slowing down the diffusion process [23]. On the other hand, the wicking property was inversely proportional to the cotton content in accordance with the test results (*i.e.* sample # 1 H_{wrap} = 70.1 ± 1.3 mm, H_{weft} = 57.4 ± 1.1 mm; sample # 2 H_{wrap} = 89 ± 1.5 mm, H_{weft} = 72.27 ± 1.1 mm; sample # 3 H_{wrap} = 94.47 ± 1.7 mm, H_{weft} = 75.87 ± 1.3 mm). It meant that polyester fiber was favourable to the moisture transmission, resulting in the shorter fragrance retention. Therefore, in summary, samples with the higher cotton content would have a slower drying rate, allowing the fragrance to remain longer.

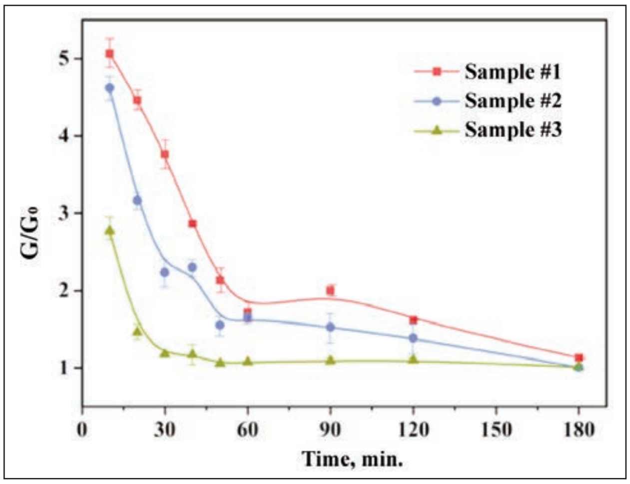

Fig. 1. The resistor value of different material compositions

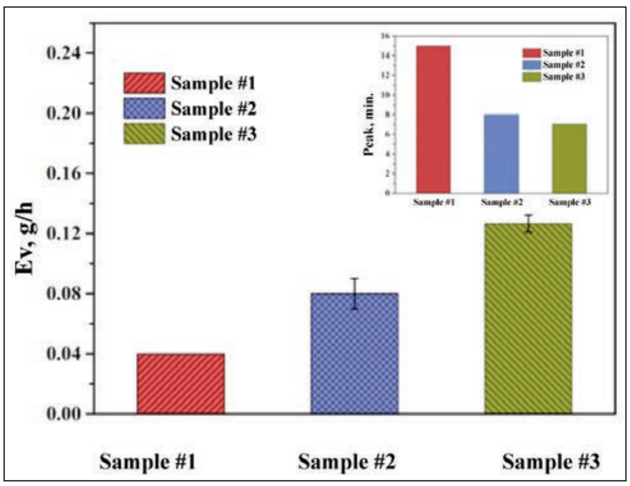

Fig. 2. The drying rate Ev (g/h) of different material compositions and the inset is the corresponding peak (min)

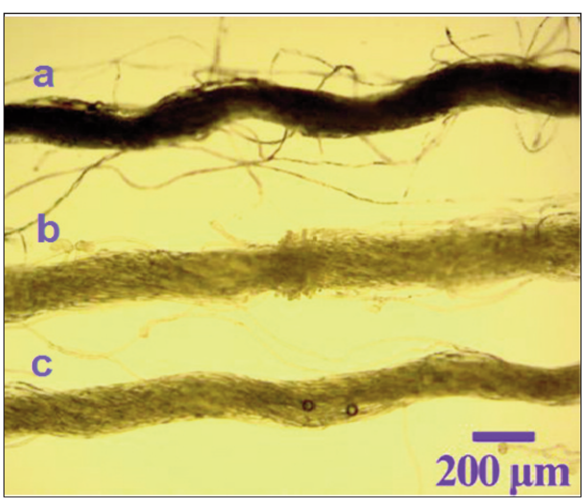

Fig. 3. The optical microscope image of yarns with different material compositions: *a* – sample # 1; *b* – sample # 2; *c* – sample # 3

The effect of fabric weave on fragrance retention

The R9 for plain and twill fabric is shown in figure 4. It reflects that the value of twill fabric was higher than the plain fabric, and both of their fragrance reduced over time. As drying rates diversity is not obvious, the peak of two fabrics is shown in the inset of figure 5. It is noticeable that twill fabric required a longer time for drying, indicating a better fragrance retention. It is widely accepted that the liquid transfer mechanism included capillary wicking which was associated with the fabric porosity [20]. The porosity of plain fabric was lower than twill fabric based on the equation 1 (i.e. ε_{plain} = 0.679%, ε_{twill} = 0.698%) [24], which is in agreement with the findings presented by Atasağun's report [25]:

$$\varepsilon = \frac{V_{pores}}{V_{fabric}} \cdot 100 = \left(1 - \frac{\rho_{fabric}}{\rho_{fiber}}\right) \cdot 100 = = \left(1 - \frac{M_{fabric}}{T_{fabric} \cdot 1000 \cdot \rho_{fiber}}\right) \cdot 100 \quad (1)$$

where ε is the total porosity (%), V_{pores} – the volume of pores in woven fabrics (cm^3), V_{fabric} – the volume of woven fabric (cm^3). ρ_{fabric} and ρ_{fiber} represent physical

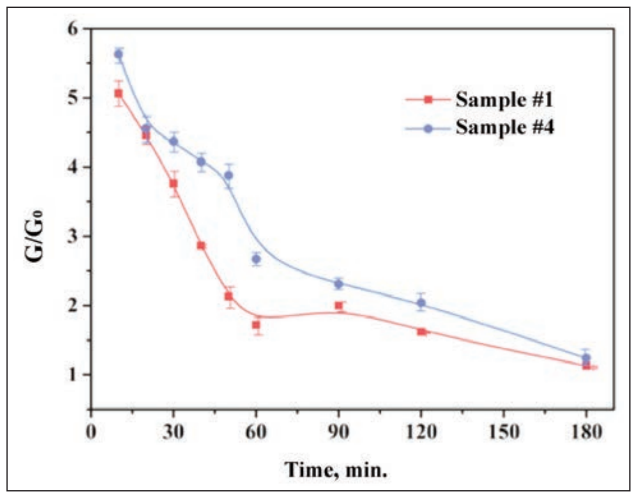

Fig. 4. The resistor value of different fabric weave

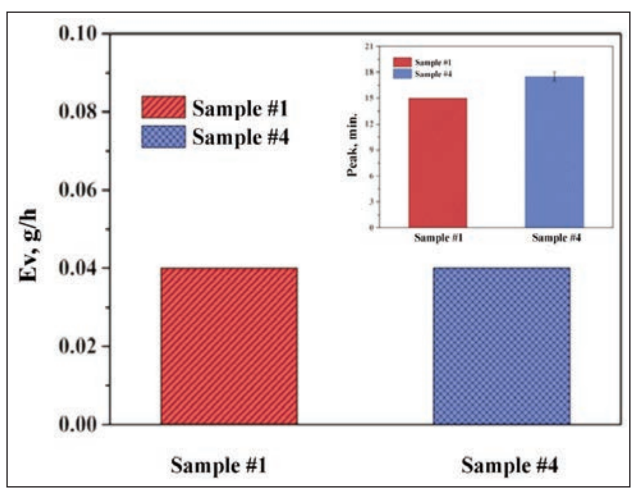

Fig. 5. The drying rate Ev (g/h) of different fabric wave and the inset is the corresponding peak (min)

densities of woven fabrics (g/cm^3) and of fibers (g/cm^3), respectively. M_{fabric} is the mass of the fabric per square meter (g/m^2) and T_{fabric} – the thickness of the fabric (mm).

The reason is that the smaller pores led to the higher capillary pressure and the greater liquid advancement [26, 27], causing the less fragrance residue. In addition to pore structure, the wettability of a fabric by liquid is of great importance in terms of its liquid absorption capacity [22]. Between the two fabrics, the wettability of plain fabric was higher than twill fabric based on the test results (i.e. sample # 1 H_{wrap} = 70.1 ± 1.3 mm, H_{weft} = 57.4 ± 1.1 mm; sample # 4 H_{wrap} = 67.93 ± 1.4 mm, H_{weft} = 55.57 ± 1.06 mm). Thus, it turned out that plain fabrics had the shorter fragrance retention than twill fabrics.

The effect of fabric density on fragrance retention

From the result of figure 6, it is found that R9 increased with the increasing of fabric density. Similarly, as revealed in figure 7, the higher the fabric density was, the smaller the drying rate would be, the longer the drying time required. All above indicated that fabric with the higher fabric density had the better fragrance retention. According to the test, the wicking properties of fabrics increased as the fabric densities decreased (i.e. sample # 5 H_{wrap} = 64.6 ± 1.5 mm, H_{weft} = 53.4 ± 1.5 mm; sample # 6 H_{wrap} = 71.5 ± 1.2 mm, H_{weft} = 61.3 ± 1 mm; sample # 7 H_{wrap} = 78.2 ± 1.3 mm, H_{weft} = 65.6 ± 1.3 mm). It proved that the lower fabric density led to the better liquid transport with a certain range. Similar trends can be found in previous studies [29]. The truth is that in the case of a certain amount of perfume, the inter-yarn spaces of fabrics which have the lower fabric densities would be filled with more liquid, and it was available for perfume diffusion [30]. In the experiment, the inter-yarn spaces became smaller when the fabric densities became higher. The diffusion and drying process slowed down, making the fragrance remain for a longer time.

The effect of yarn count on fragrance retention

The results of fragrance retention detection and drying rate test for different yarn counts are shown in figures 8 and 9, respectively. As the yarn count of fabric decreased, the R9 and peak increased while the drying rate decreased, which mirrored the longer

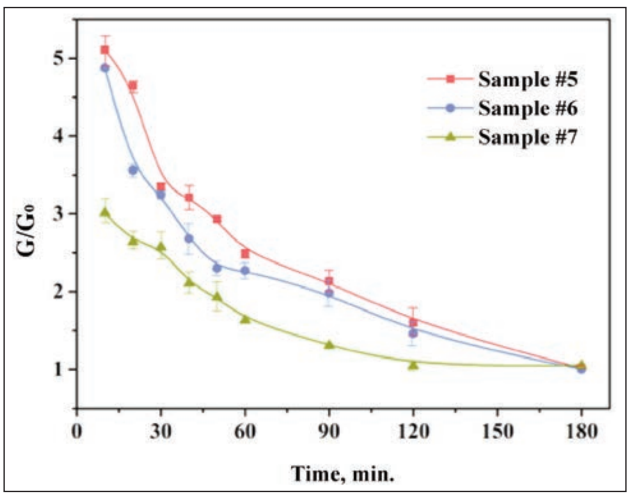

Fig. 6. The resistor value of different fabric densities

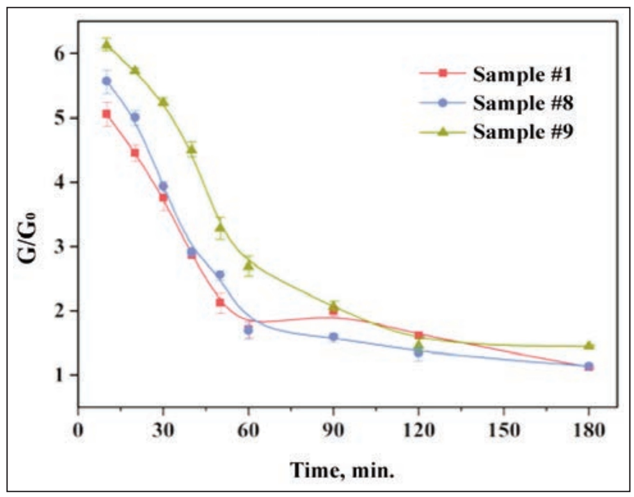

Fig. 8. The resistor value of different yarn counts

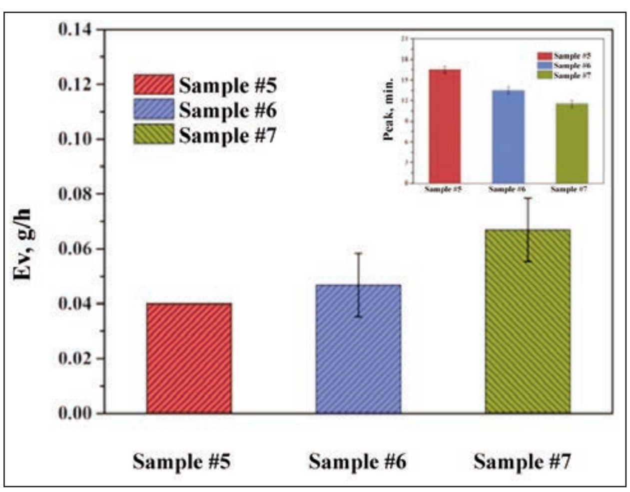

Fig. 7. The drying rate Ev (g/h) of different fabric densities and the inset is the corresponding peak (min)

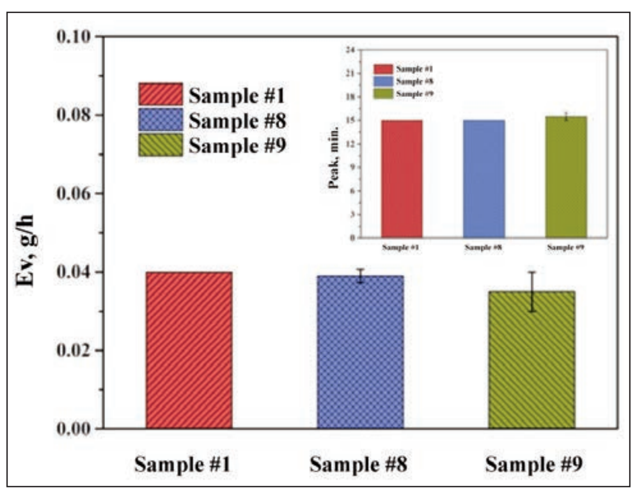

Fig. 9. The drying rate Ev (g/h) of different yarn counts and the inset is the corresponding peak (min)

fragrance retention. And the data of wicking property test indicates that the smaller yarn count resulted in a worse wicking property (i.e. sample # 1 H_{wrap} = 70.1 ± 1.3 mm, H_{weft} = 57.4 ± 1.1 mm; sample # 8 H_{wrap} = 69.43 ± 1.4 mm, H_{weft} = 54.63 ± 1.2 mm; sample # 9 H_{wrap} = 57.7 ± 0.7 mm, H_{weft} = 46.4 ± 1.5 mm). That is the moisture transmitted faster in the fabric with the higher yarn count. In the case of diffusion along the fiber, the absorbed liquid diffused from the interior of the fiber to its surface [23, 30]. Therefore, the finer fiber would absorb less perfume, and the diffusion process from the interior to its surface would become faster. Moreover, under the condition of a constant perfume, with the increasing of the yarn count, there would be more liquid in the inter-yarn space which contributed to moisture transmission, likewise [29].

CONCLUSIONS

It concluded that the effect of fabric parameters on fragrance retention was attributed to the water absorption, retention properties of fibers, and the diffusion of the perfume among yarns. The fragrance retention was related to the drying rate and the wicking property. Fabrics with the higher cotton content had the better fragrance retention, for cotton fibers had better water retention properties and polyester fibers had better moisture transmission properties. Twill fabrics remained fragrance longer than plain fabrics. Since the lower porosity of plain fabrics caused the higher capillary pressure, it could contribute to a greater liquid advancement. As the fabric density increased, the fragrance retention increased. The reason is that the less thread spacing (i.e. the higher fabric density) resulted in the worse wicking in fabrics, leading to less perfume volatile. Except that, when the yarn count increased, there would be less perfume absorbed in and faster liquid diffusion from the inside to the fiber surface, which finally caused less residue of fragrance. This study provides a useful reference for prolonging the fragrance retention in actual wear, which may be applied in fields such as sport and business.

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Design of a new braiding device with 3D integral active yarn carrier

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ABSTRACT – REZUMAT

Design of a new braiding device with 3D integral active yarn carrier

The braided motion of a Cartesian braiding machine is realized by pushing the yarn carriers against each other, which results in the low braiding efficiency, single product and poor expansion at present. A new braiding device three-dimensional (3D) integral active yarn carrier is designed. Firstly, the Integral braiding technology and traditional braiding equipment are analysed. Then an automated guided vehicle (AGV) based active carrier and its braided chassis are designed. A new steering device and power supply system are developed. The braiding process is wirelessly controlled. Finally, it is concluded that the flexible braiding of prefabricated parts of various complex shapes can be realized by the integrated braiding technology of the active yarn carrier through the analysis of the structure and working mode of the active yarn carrier.

Keywords: *Cartesian braiding, active yarn carrier, AGV, 3D integrated braiding, flexible braiding*

Proiectarea unui nou dispozitiv de împletire cu purtător de fir activ integral 3D

Mișcarea de împletire a unei mașini de împletit Cartezian se realizează prin împingerea purtătorilor de fir unul spre celălalt, ceea ce are ca rezultat o eficiență scăzută a împletirii, un singur produs și o extindere slabă, în prezent. Este conceput un nou dispozitiv de împletire cu purtător de fir activ integral 3D. În primul rând, sunt analizate tehnologia de împletire integrală și echipamentul tradițional de împletire. Apoi, sunt proiectate un purtător activ bazat pe un vehicul ghidat automat (AGV) și șasiul său împletit. Sunt dezvoltate un nou dispozitiv de direcție și un sistem de alimentare cu energie electrică. Procesul de împletire este controlat wireless. În cele din urmă, se concluzionează că împletirea flexibilă a părților prefabricate de diferite forme complexe poate fi realizată prin tehnologia integrată de împletire a purtătorului de fir activ prin analiza structurii și a modului de lucru al purtătorului de fir activ.

Cuvinte-cheie: *împletire Carteziană, purtător de fir activ, AGV, împletire integrată 3D, împletire flexibilă*

INTRODUCTION

The technology of 3D integral braiding is characterized by the capability of braiding the preforms with cross-sectional variations for 3D braided composites, with its technology and equipment, a variety of preforms can be formed at a single net size [1–2]. At present, the chassis track of "four-step" Cartesian braiding machine is mainly divided into sliding type and fixed type. The yarn carriers of braiding machine can be moved by pushing against each other, which are placed into the corresponding position of the chassis manually according to the shape of the preforms before braiding. There is no gap between the driving carriers. Therefore, it takes a lot of work to determine the position of the carriers when braiding multiple varieties of composites preforms [3–6]. The low braiding efficiency of cross-sectional variations preforms is due to manual intervention. The "four-step" braiding technology is limited by traditional braiding equipment, resulting in low efficiency, single product and high cost. Therefore, the research of braiding technology and the development of new equipment are critical.

3D INTEGRAL BRAIDING TECHNOLOGY AND PRE-EQUIPMENT

3D integral braiding technology can be divided into cross-sectional variations and profiled technology [7]. The characteristics of cross-sectional variations braiding technology is to change the number or fineness of yarns involved in the braiding process which do not affect the subsequent braiding process, and then the integral braiding of cross-sectional variations performs is realized [8]. The complex shaped preforms can be braided mainly by profiled braiding technology, such as T-shaped and I-shaped section preforms, which are not braided properly by the traditional "four-step" braiding method as the array of the carrier is different from that of the braided rectangular section. Therefore, the mixed braiding technology is usually adopted for the complex shaped preforms [9].

Automation was difficultly achieved by traditional braiding equipment due to the structural limitation of chassis transmission device. The flexible integral braided chassis device was developed by our research group in early-stage, as shown in figure 1. The motion control card and micro-controller were used to control the stepping motor and positioning mechanism and make the yarn carrier move in any row or column. It was suitable for the integral braiding of profiled braiding preforms by a mixed braiding technology. The track structure of the chassis was fixed, which makes it difficult to expand the overall scale. Li utilized an active yarn carrier model with linear stepping motor as self-driving device. The high requirements for track laying, power supply and anti-electromagnetic interference were necessary [10].

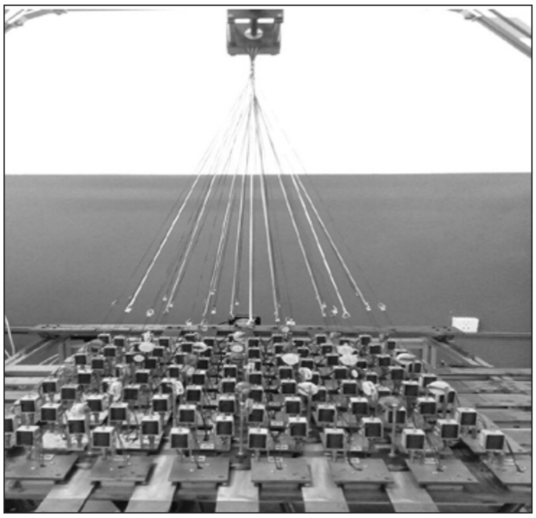

Fig. 1. Flexible integral braiding chassis device

In order to solve the problems of traditional equipment, the active yarn carrier based on AGV technology is proposed, which has the characteristics of simple structure, easy control, good adaptability and modular assembly. The automatic braiding of cross-sectional variations and profiled preforms can be realized.

NEW ACTIVE YARN CARRIER AND MATCHED CHASSIS DEVICE

Structural design of active yarn carrier and its matching chassis

Active yarn carrier and its matched chassis device is shown in figure 2. The yarn storage device is omitted. It mainly includes active yarn carrier 1 and braiding chassis 2. The double power structure in vertical and horizontal direction with four wheels steering was adopted. Zero radius steering can be realized in row or column braiding motion. The braiding chassis adopts modular design and each module was wired, then assembled according to the size of cross-section of preforms, and providing power and guidance for the yarn carrier. A positioning device is placed at the junction at the bottom of the groove to provide positioning for the carrier. The axis can be arranged at the junction of the gaps between the carriers. The motion of the carrier is controlled by a host computer. The motion state and position of the carrier can be feed backed in real time by the feedback module. The entire braiding process is controlled by automation to reduce manual intervention.

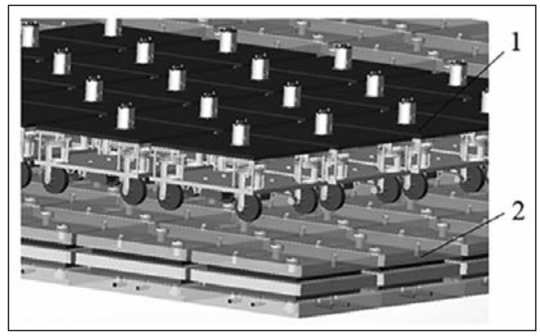

Fig. 2. Active yarn carrier and its matching chassis structure diagram: *1* – active yarn carrier; *2* – braiding chassis

Design of core mechanisms

The steering device is shown in figure 3. The original steering and rotation angle of the four bogies are limited by the torsion spring and location pin. For example, the sample is rotated through 90° by the location pins 8 and 9, so that the direction of the wheel 10 controlled by the bogie is parallel to the X-axis or the Y-axis. The circular belt 3 is connected to the two bogies on the left and the two ends are respectively fixed by fasteners 1 and 7 in the corresponding positions of the bogies. Similarly, the circular belt 13 is connected to the corresponding positions of the two bogies on the right. In order to prevent the belt from slipping with the steering wheel 5, the corresponding position is fixed by fasteners 4 and 12. The steering wheel is rotated 90° clockwise by the steering motor. Under the action of the torsion spring and the belt, the four bogies are rotated 90° at the same time, the wheels 7 and 14 are rotated counter-clockwise 90°, and wheels 2 and 10 are rotated clockwise 90°. Then the four wheels are parallel to the Y axis. When the steering motor is rotated counter-clockwise 90°, the four wheels are parallel to the X axis. By fixing the belt on the same steering wheel, the torque of the

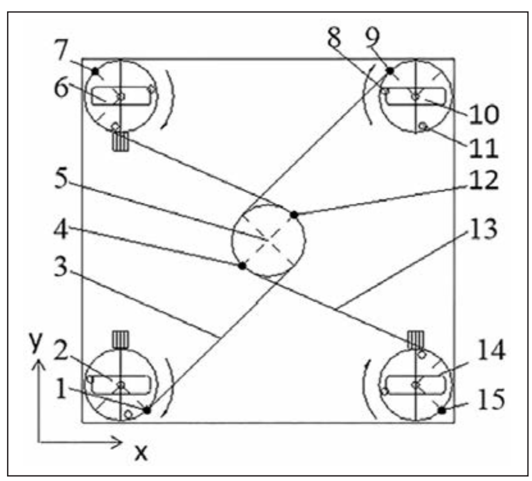

Fig. 3. Schematic views of steering gear: *1* – fastener; *2* – wheel; *3* – circular belt; *4* – fastener; *5* – steering wheel; *6* – wheel; *7* – fastener; *8* – location pin; *9* – fastener; *10* – wheel; 11 – location pin; *12* – fastener; *13* – circular belt; *14* – wheel; *15* – fastener

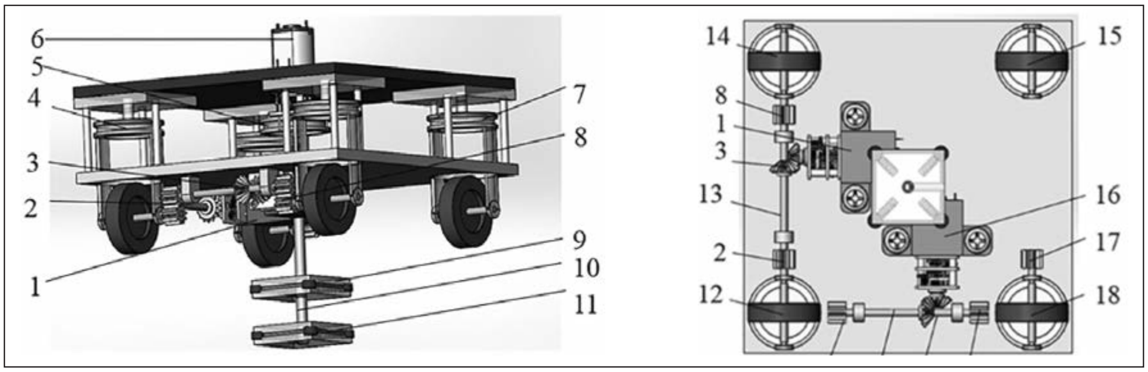

Fig. 4. Structural diagram of active yarn carrier: *1* – gear motor; *2* and *3* – spur gear pair; *4* – steering wheel; *5* – steering wheel; *6* – steering motor; *7* – steering wheel; *8* – spur gear pair; *9* – negative guide block; *10* – shaft; *11* – positive guide block; *12* – wheel; *13* – shaft; *14* – wheel; *15* – wheel; *16* – gear motor; *17* – gear; *18* – wheel; *19* – gear; *20* – bevel gear pair; *21* – transmission shaft; *22* – gear

four torsion springs offset will be created. The dependence on the torque of the steering motor is reduced. The structure of the active carrier is shown in figure 4. In order to improve the stability of the motion of the yarn carrier, the driving system is placed at the bottom. The driving system is composed of two gear motors and mechanical structure. The shaft 13 is driven by the gear motor 1, and then the wheels 12 and 14 are driven through spur gear pair 2 and 8. The positive and negative motion of the carrier in the X axis is realized by controlling the positive and negative rotation of the motor 1. When the steering wheel 5 is rotated 90° clockwise by the steering motor 6, the four wheel directions are parallel to the Y axis. The two pairs of gear pairs are constituted by the gears 19 and 22 at the two ends of the transmission shaft 21 respectively. Similarly, the power of wheels 12 and 18 can be provided by the gear motor 16 and the motion of the yarn carrier in the positive and negative directions of the Y axis will be realized.

The guiding and power supply modules are integrated as shown in figure 5. The row or column movement of the yarn carrier can be guided and the bias caused by the tension of the braided yarn will be avoided. In order to avoid short circuit or open circuit at the intersection of the track, the negative lead 3 on the upper side and the positive lead 4 on the bottom are adopted by the chassis module wiring. A unified power supply system for the entire braided chassis can be formed through the wire interface 6 of each module. The carbon brush 5 is embedded in the corners of the guiding and power supply block to ensure that the carrier is kept in contact with the chassis wiring during the movement, and the contact is stable at the row or column crossing positions.

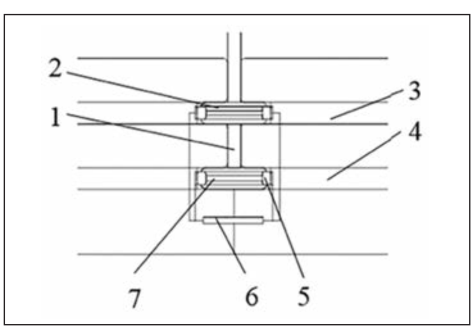

Fig. 5. Guiding and power supply schematic diagram: *1* – connecting rod; *2* – negative guide block; *3* – negative lead; *4* – positive lead; *5* – carbon brush; *6* – wire interface; *7* – positive guide block

RESULTS AND DISCUSSION

As the independent driving system of the active yarn carrier, it can move independently or in groups on the braiding chassis. It is suitable for cross-sectional variations and profiled braiding with "four-step" method. The motion of yarn carrier is introduced with the examples of variable cross-section preform braided by unit number reduction method and profiled preform braided by mixed method.

Figure 6 shows the array of the carrier on the chassis when the braiding of the preform is reduced from 6×6 to 4×4 mode, and physical picture of preform. Beginning of braiding, the 6*6 mode carriers move in groups according to the "four-step" method. When the cross-section of the preform is reduced, the additional carriers are moved from the braiding area to the standby area in the nearest path, and join the braiding area again to continue braiding when the

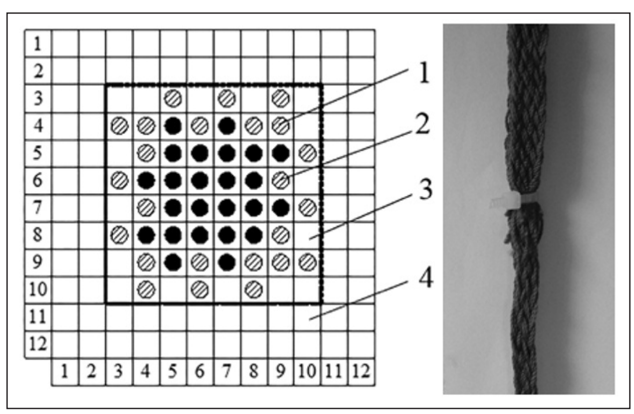

Fig. 6. Reduction of 6 × 6 patterns to 4 × 4 patterns braided chassis array and resulting braid: *1* – main carrier; *2* – additional carrier; *3* – braiding area; *4* – standby area

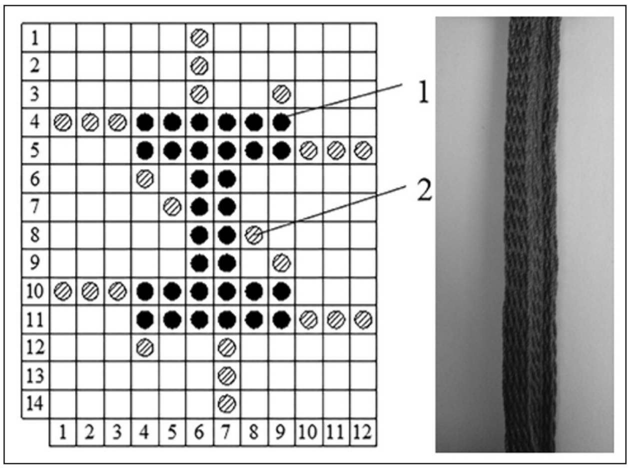

Fig. 7. Chassis initial array diagram of braiding I-shaped fabric 8×6 patterns and resulting braid: *1* – main carrier; *2* – additional carrier

cross-section is enlarged. At this time, the remaining carriers still are moved according to the "four-step" method. Based on the change of section, the carriers can be controlled to join or exit the braiding area. The braiding area and standby area are determined by the variation of section size.

Figure 7 shows the initial array of the carrier on the chassis when the braiding 8×6 mode I-shaped preform by using "four-step" method 1×3 and 3×1 hybrid pattern,and physical picture of preform. Since each carrier can move independently, without considering the vacancy position. In the first step, the 4th and 10th rows of the carriers move to the right by three positions, the 7th row of the carriers move to the right by one position, and the 5th and 11th rows of the carriers move to the left by three positions. The 8th row of carriers moves to the left by one position number. In the second step, the 4th and 7th column carriers move up one and three positions respectively, and the 6th and 9th column carriers respectively move downwards three and one position number. The third step is opposite to the first step and the fourth step is opposite to the second step. A cycle weaving can be completed by a four-step cycle. It is necessary to design the corresponding control scheme according to the required braiding technology when braiding different performs.

CONCLUSIONS

In this paper, a new type of active yarn carrier is designed for cross-sectional variations and profiled performs braiding. The integral braiding of performs with various complex shapes can be realized by the self-powered active yarn carrier and assembled braiding chassis through wireless control system, which avoids the problems of single braiding variety and poor expansion of traditional braiding equipment. It can be applied to the braiding of various performs in small batches. The carrier can work longer hours by the chassis wiring power supply mode. The host control signal can be accepted by the wireless control module to achieve independent or group motion on the chassis. It is suitable for 3D integral braiding technology to braid performs with various structures and shapes. The flexibility and versatility of braiding equipment will be improved.

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Texture features extraction of multi-coloured fancy yarn

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ABSTRACT – REZUMAT

Texture features extraction of multi-coloured fancy yarn

In the present work, a framework of extracting important texture features of multi-coloured fancy yarns is proposed. A self-developed image capturing apparatus is used to record the image of fancy yarn. Subsequently, the captured digital images are processed to produce spatially corresponding pixel points to reconstruct digital images of the object, including image greying, filtering and morphology processing. At last, different segmentation methods are used to extract the texture features of fancy yarns, and the optimal segmentation method to each kind of fancy yarn is analysed.

Keywords: *fancy yarn, digital image analysis, image segmentation, colour textures, image graying*

Determinarea caracteristicilor de textură ale firelor de efect multicolore

În lucrarea de față, este propusă o metodă de determinare a caracteristicilor importante de textură ale firelor de efect multicolore. Un echipament de captare a imaginii este utilizat pentru a înregistra imaginea firelor de efect. Ulterior, imaginile digitale captate sunt procesate pentru a produce puncte pixel corespunzătoare spațial, pentru a reconstrui imaginile digitale ale obiectului, incluzând scara de gri, filtrarea și procesarea morfologică a imaginii. În cele din urmă, sunt folosite diferite metode de segmentare pentru a determina caracteristicile de textură ale firelor de efect și se analizează metoda optimă de segmentare a fiecărui tip de fir de efect.

Cuvinte-cheie*: fir de efect, analiza imaginii digitale, segmentarea imaginii, texturi colorate, scara de gri a imaginii*

INTRODUCTION

Yarn is the basic unit of fabrics. The knowledge of texture feature of yarn is essential for reconstructing the simulated appearance of the fabric. In particular, the multi-coloured fancy yarns, which include a wealth of texture information, such as yarn twist, yarn fineness, surface brightness and colour alteration, are recently emerged as new building blocks for the multi-colour fabric [1, 2]. The exaction of the texture features of fancy yarn dramatically benefits the simulation of appearance streaks in fabrics [3, 4].

There are two ways to obtain yarn image, i.e., experimental measurement and computer simulation. There are advantages and disadvantages to each method. If the yarn characteristics, such as colour, illumination and evenness, can be accurately measured, the simulated appearance of the fabric is close to that of a real product. However, it requires arduous and delicate pre-treatment on yarn surface due to excessive hairiness and unevenness in practical textile production and thus may lower the work efficiency of the designer. In contrast, one can easily set up the basic parameters of the yarn using computer simulation, which does not require any pre-treatment of yarn. However, computer simulation generally yields unreliable results due to the lack of an adequate way to extract texture characteristics of the actual yarn, leading to the unrealistic appearance of the simulated fabric. Therefore, it is essential to establish a framework to extract the texture features in various kinds of multi-coloured fancy yarns.

In the present work, a framework of extracting important image features through a serial of image processing techniques is demonstrated. It eliminates or reduces the background noises of the image to the maximum [5, 6], whereas the colour texture features and detailed information about yarn structure such as yarn diameter and yarn evenness are retained. At last, the effects of different segmentation algorithms on fancy yarn images are compared and analysed, and optimal algorithm of segmenting different types of fancy yarn images is proposed.

THEORETICAL MODELS

For multi-colour fancy yarn images, segmentation algorithms are needed to extract the textural properties, that is, information on the evenness, colour and diameter of the coloured spun yarn. Several image segmentation methods are employed in an attempt to find the optimal one that is suitable for extracting textural features of fancy yarn.

OTSU threshold segmentation algorithm

The OTSU method, which is named after Nobuyuki Otsu and also known as the maximum inter-class variance method, is a self-adaptive thresholding method used to determine the threshold values for binary image segmentation. The OTSU method was based on grayscale properties of an image where inter-class variance increases while intra-class variance decreases between image background and object. In other words, the method can be used to maximize the separation between foreground and background for the purpose of highlighting the object region from the background [7–9], based on the assumption that the mixture density function of object foreground and background in an image is comprised of two sub-distributions that conform to normal distributions with equal variances.

The OTSU thresholding segmentation algorithm can automatically and rapidly calculate the threshold values based on the grey values of a grey scale image to maximize the grey value differences between foreground and background regions, thereby obtaining a binary image with clearly distinguishable foreground and background.

Assuming the size of an image is $M \times N$ pixels and the number of the image's different grey levels is L, that is $[0, 1, 2, \ldots, L-1]$. The number of pixels in i^{th} grey level is n_i; the threshold value for segmentation of foreground and background is denoted by $T(k) = k$; the pixels in the image whose grey values fall within $[0,k]$ are classified as C_1; and the pixels in the image whose grey values fall within $[k+1, L-1]$ are classified as C_2. Given the presence of components in a normalized histogram, the procedure of the algorithm is shown in the following equation (1) and equation (2):

$$q_i = \frac{n_i}{MN} \quad (1)$$

$$\sum_{i=0}^{L-1} q_i = 1 \quad (2)$$

where q_i is the percentage of pixels in i^{th} grey level. With the known threshold value k, then the probability that the pixels are classified to C_1 is $P_1(k)$, while the probability that they are classified to C_2 is $P_2(k)$.

$$P_1(k) = \sum_{i=0}^{k} q_i \quad (3)$$

$$P_2(k) = \sum_{i-k-1}^{L-1} q_i = 1 - P_1(k) \quad (4)$$

Therefore, the average gray value of pixels classified to C_1 is $m_1(k)$, as shown in equation (5). Similarly, the average gray value of pixels classified to C_2 is $m_2(k)$, as shown in equation (6) [7].

$$m_1(k) = \sum_{i=0}^{k} iP\left(\frac{i}{C_1}\right) = \frac{1}{P_1(k)} \sum_{i=0}^{k} iq_i \quad (5)$$

$$m_2(k) = \sum_{i-k-1}^{L-1} iP\left(\frac{i}{C_2}\right) = \frac{1}{1 - P_1(k)} \sum_{i-k-1}^{L-1} iq_i \quad (6)$$

The final inter-class variance is g, as shown in equation (7) [10]. The threshold value $T(k)$ that maximizes the interclass variance can thus be solved iteratively [11].

$$g = P_1 P_2 (m_1 - m_2)^2 \quad (7)$$

Kmeans segmentation algorithm

As a typical clustering algorithm based on distance partition, the Kmeans algorithm uses distance evaluation indicators as measures of similarities between pixel samples [12, 13]. Essentially, Kmeans algorithm is an iterative algorithm that tries to partition data and seeks an optimal solution to the clustering criterion function of each partitioned cluster, thereby maximizing intra-cluster similarity and the inter-cluster difference between the partitioned data clusters. The letter K represents the centre value of an arbitrarily selected initial cluster, that is, the cluster value; while Means denotes the mean value, that is, the mean value of all sample values in each partitioned cluster, which represents the centre of the boundary of each cluster.

An image is partitioned into several clusters, and the initial centroid of each cluster should be present when using the Kmeans clustering segmentation algorithm. Therefore, selecting the number of clusters and initial cluster centres is crucial for the goodness of clustering. The selected number of clusters should be in line with the best partitioning of samples. Otherwise, a different number of clusters may result in totally different clustering results and increase the processing time. Therefore, data partitioning is required for each iteration of the algorithm to ensure the data are as close to each cluster as possible. When all data are included in its cluster, one round of iterative process is completed, and new centroids will replace the old ones. If clustering results do not change at the next iteration, the convergence is achieved for the clustering. The specific procedure of the algorithm is shown as follows:

I. Given the known training-data object $\{x^1, x^2, \ldots, x^p\}$ is an element of R_n, where p vectors are partitioned into i groups, the clustering centre of each group of vectors is obtained to ensure that the distance criterion function which serves as the evaluation indicator is minimized. Select k data objects as initial cluster centres, that is, $\mu_1, \mu_2, \ldots, \mu_k$;

II. Calculate the Euclidean distance of each data object from each cluster centre, denoted by $D^{(i)}$, as shown in equation (8):

$$D^{(i)} = \text{argmin} \left\| x_i - \mu_j \right\|^2 \quad (8)$$

where μ_j is the centroid of x^i's cluster.

III. After completing the first round of data object clustering, perform recalculations to update the centre of each cluster to ensure data objects can be continuously clustered based on new cluster centres, as shown in equation (9) [13].

$$\mu_j = \frac{\sum_i^p x^{(i)} \big|_{D^{(i)}=j}}{\sum_i^p 1 \big|_{D^{(i)}=j}} \quad (9)$$

IV. Repeat the above procedure until there are no changes in cluster centres, that is, the distortion function $J(D,\mu)$ in equation (10) converges, and the sum of squares of all data objects' Euclidean distances from their cluster centres is obtained.

$$J(D,\mu) = \sum_{i=1}^{p} \left\| x^{(i)} - \mu_{D^{(i)}} \right\|^2 \quad (10)$$

Mean-shift segmentation algorithm

The Mean-shift algorithm is widely used for clustering, image smoothing, segmentation and video tracking. In image segmentation, Mean-shift is a statistical iterative algorithm that estimates the kernel density [14, 15]. The specific procedure of the algorithm is as follows: Assume there are n data points in a d-dimensional space, the set of data points is $\{x_1, \ldots, x_i\}$, where

i denotes $1, 2, \dots, n$. Select a random point x in the space; the mean-shift vector $M_h(x)$ is basically defined by equation (11), where $S_h(x)$ is the high latitude region with a radius h, as shown in equation (12) [16], where k denotes the number of observations falling within the range of $S_h(x)$.

$$M_h(x) = \frac{1}{k} \sum_{x_i \in S_h(x)} (x_i - x) \tag{11}$$

$$S_h(x) = \{y : (y - x_i)^T (y - x_i) < h^2\} \tag{12}$$

After incorporating the Gaussian kernel function, the Mean-shift algorithm, i.e., equation (11), is converted into density estimator, as shown in equation (13), where $k(x)$ denotes the Gaussian kernel function, $c_{k,d}/n^{hd}$ is unit density. To find the points of the maximum probability density, the equation (14) can be derived from equation (13).

$$f_{h,k(x)} = \frac{c_{k,d}}{nh^d} \sum_{i=1}^{n} k\left(\left\|\frac{x-x_i}{h}\right\|^2\right) \tag{13}$$

$$\hat{\nabla} f_{h,k(x)} = \frac{2c_{k,d}}{nh^{d+2}} \sum_{i=1}^{n} (x - x_i)\, k'\left(\left\|\frac{x-x_i}{h}\right\|^2\right) \tag{14}$$

Let $g(x) = -k'(x)$, then equation (15) can be obtained.

$$\hat{\nabla} f_{h,k(x)} = \frac{2c_{k,d}}{nh^{d+}} \sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right) \cdot \left[\frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)} - x\right] \tag{15}$$

Finally, a mean-shift vector $m_{h,g(x)}$ can be obtained, as expressed by equation (16). If $\hat{\nabla} f_{h,k(x)} = 0$, the maximum value, that is, regions of maximum densities can be obtained if and only if $m_{h,g(x)} = 0$. Thus, the equation of new origin coordinates, as shown in equation (17), is obtained.

$$m_{h,g(x)} = \frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)} - x \tag{16}$$

$$x = \frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{x-x_i}{h}\right\|^2\right)} \tag{17}$$

METHODOLOGY

Image capture

The recordation of high-quality yarn images is the basis for the simulation of weft knitted fabrics. In the present work, an image capturing apparatus developed by the research institute of textile technology in Jiangnan University [17], as shown in figure 1, is used to record the yarn image. The colour images are recorded onto a single high-resolution colour charge-coupled device (CCD) sensor and saved as the BMP or TIF or JPG image formats. The output

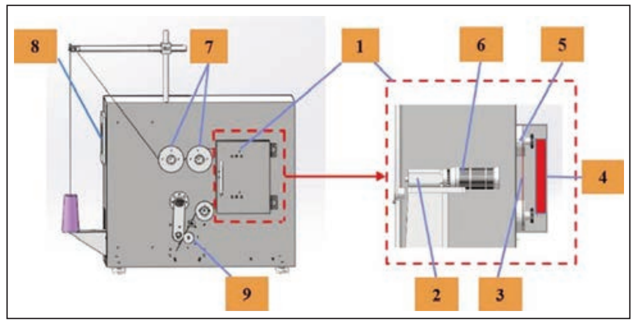

Fig. 1. Yarn image acquisition device: *1* – imaging box; *2* – CCD area image sensor; *3* – yarn; *4* – a light source; *5* – yarn guide device; *6* – camera lens; *7* – tension control panel; *8* – touch screen; *9* – Servo motor for output roll

image size is 56×473 pixels, and the physical size of the image is calibrated to 1 cm. When recording images, the yarn is fully straightened out under the camera. The camera is set up in such a way that the main feature of fancy yarn is fully exposed under the camera. This setup ensures the accuracy of image processing later on. The device can measure yarn diameter and colour distribution along the longitudinal direction of moving fancy yarn to extract texture features of yarn.

Image graying

The grey scale processing is to convert a colour image into a grayscale image. The colour of each pixel is composed of Red (R), Green (G) and Blue (B) components, and the value ranges of the three components are between 0 and 255, which means each pixel has more than 10 million kinds of colours. The grey scale image is a special colour image with equal proportions between R, G and B, i.e., the variation range of each pixel is only between 0 and 255. There are no colour changes in the grey scale image except the brightness value, which significantly reduces the amount of computation in post-processing and improves the processing efficiency. In this paper, the weighted average method, as shown in equation (18), is used to deal with yarn image:

$$H = R \times W_r + G \times W_g + B \times W_b \tag{18}$$

where W_r, W_g, W_b are weight ratios of R, G and B components; H is the tristimulus value.

Image filtering

Image filtering is used to enhance some spatial frequencies of an image to improve the grey difference between target and background. In this work, two smoothing filters were employed, i.e., linear filtering and median filtering to process the images of fancy yarns. The linear filter replaces each pixel value of image with the average value of a surrounding pixel field, which is also called the average field method. The median filter is a nonlinear method, similar to convolution. Instead of a weighted sum, the grey value of the middle pixel point of the pixel field is used. Thus, the median filter can eliminate isolated noise pixels. Meanwhile, the details, such as edge characteristics, are well reserved.

Binarization of image and morphology processing

Even after the filter processing, the noises and concave/convex edges of the image cannot be entirely removed, which is problematic for the subsequent fabric simulation. Therefore, the image is turned into the binary representation to prepare for morphology processing. In general, the binarization of the image divides the grey values of all pixel points in the image into two categories: black and white, i.e., the background and the target, respectively. The goal is to classify the 256 brightness levels in the grayscale image by comparing with thresholds, so that the pixels can be divided two fields, which are the background field and the foreground field (I.e., the target), respectively. In general, grey value greater than or equal to the threshold value belongs to the foreground field, and their grey values are set as 255; however, If the grey value is less than the threshold, these pixels are excluded from the object area (i.e., background field), and their grey values are set as 0. Mathematical morphology is an accurate tool for image analysis of geometrical structures, such as size, shape and convexity [18], based on the binary image. There are four basic operations, i.e., dilation, erosion, opening and closing [18], among which the opening operation can remove the sharp objects in images. We use the opening operation of mathematical morphology to process the binary representation of yarn, as shown in figure 2. The sharp edges (marked by a rectangular circle) in figure 2, *a* is removed in figure 2, *b* after opening operation. The image processing, including greying, filtering, morphology processing and segmentation, were carried out using the self-developed code written in MATLAB software package.

a *b*

Fig. 2. Binary image of yarn: *a* – image before opening operation; *b* – image after opening operation

RESULTS AND DISCUSSION

Figure 3 shows the recorded images of different types of fancy yarns, which are later used for investigating the effects of different segmentation methods on multi-coloured fancy yarn. Figure 4 shows the images processed by using two different filtering methods. The images processed with linear filter include more fuzziness, hairness and noises than the images processed with the median filter. Therefore, we chose the median filter to process the recorded images of fancy yarns.

In order to find out the optimal segmentation methods to these images, the fancy yarn images are processed by using three segmentation methods and then compared with recorded images. To characterize the differences between the segmented and recorded

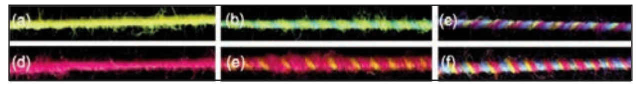

Fig. 3. Recorded images of fancy yarns: *a* – single-coloured yarn; *b* – two-coloured yarn with the 3:7 weight ratio between blue and yellow fiber components; *c* – three-coloured yarn with the 2:4:4 weight ratio between red, yellow and blue fiber components; *d* – single-coloured slub yarn; *e* – two-coloured slub yarn with the 1:1 weight ratio between yellow and red fiber components; *f* – three-color slub yarn with the 1:1:1 weight ratio between red, yellow and blue fiber components

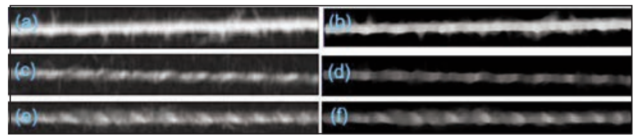

Fig. 4. Comparison of filtering methods of grayscale images of yarns: *a, c, e* – images processed with the linear filter method; *b, d, f* – images processed with the median filter method

images, each image is decomposed into R, G and B colour channels respectively. Then, the mean value and standard deviation (SD) of each channel are calculated, respectively, as shown in table 1.

Figure 5, *a, b, g, h, m, n* show the segmented images of the single-coloured fancy yarn by using different segmentation methods. It can be seen that there are no differences in three segmentation methods concerning the extraction of texture features, such as yarn evenness and colour; however, they are slightly different regarding the edges. Figure 5, *g* retains edge characteristics of the yarn compared to Figure 5, *a*. Our observation is further verified by comparing the mean values and SDs between segmented and recorded images in table 1, in which the mean values and SDs based on Kmeans method are closer to those of recorded images than the other two methods. In Figure 5, *m*, the appearance of yarn is more evident than others, and there is no hairiness. In terms of segmentation time, Kmeans clustering segmentation is quicker than OTSU threshold segmentation and mean-shift segmentation; OTSU threshold segmentation is quicker than mean-shift segmentation.

Figure 5, *c, d, i, j, o, p* shows the segmented images of two-coloured fancy yarn with different segmentation methods. Through comparing with recorded images, i.e., figure 4, *a, f*, the segmented images of figure 5, *o, p* are closest ones, which indicates mean-shift algorithm is better at processing two-coloured fancy yarn images than the other two methods, and is consistent with the mean values and SDs in table 1. However, in terms of segmentation time, OTSU segmentation is quicker than Kmeans clustering segmentation and mean drift segmentation, which means the Kmeans method becomes slower than the OTSU method when processing two-coloured fancy yarn images. The decrease of efficiency of Kmeans method is attributed to the increased number of images, the differences in colour appearances between the target and the background, and the

Table 1

MEAN VALUES AND STANDARD DEVIATIONS OF RGB VALUES FOR SEGMENTED AND RECORDED IMAGES																		
Samples	**Mean (OTSU)**			**SD (OTSU)**			**Mean (Kmeans)**			**SD (Kmeans)**			**Mean (Mean-shift)**			**SD (Mean-shift)**		
	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
1#	48.9	52.2	12.5	86.2	91.3	42.8	51.1	54.7	11.8	82.1	87.7	22.1	57.8	60.8	23.9	91.1	95.6	55.3
2#	64.2	12.6	30.7	95.6	13.1	41.6	63.4	19.49	25.9	91.5	40.0	54.4	58.1	6.84	24.6	90.8	15.1	42.3
3#	63.4	15.2	16.1	88.9	29.5	16.3	63.0	27.4	29.5	92	57.1	55.1	83.4	15.3	25.9	88.7	30.0	26.3
4#	37.9	52.4	25.2	60.5	70.6	49.3	39.8	55.9	25.9	66.6	85.1	51.3	37	50.8	24.9	60.8	80.7	42.8
5#	26.0	23.5	29.6	54.4	52.8	59.4	25.3	23.0	28.9	54.2	52.6	59.1	21.8	18.3	27.0	41.4	38.3	48.4
6#	43.6	29.9	33.0	76.8	61.6	61.5	56.2	38.4	44.5	87.5	73.6	76.1	54.5	41.2	44.4	81.0	64.6	67.5
Recorded images	1#	2#	3#	4#	5#	6#	1#	2#	3#	4#	5#	6#	1#	2#	3#	4#	5#	6#
	R/mean						G/mean						B/mean					
	55.4	75.0	82.0	34.2	22.7	59.8	60.4	22.3	22.3	51.3	19.3	41.3	13.4	24.6	24.6	20.7	28.4	47.6
	R/SD						G/SD						B/SD					
	1#	2#	3#	4#	5#	6#	1#	2#	3#	4#	5#	6#	1#	2#	3#	4#	5#	6#
	80.3	90.0	87.9	57.1	42.0	80.0	85.5	39.9	46.2	78.5	38.7	64.5	22.8	52.2	43.6	36.4	48.6	66.7

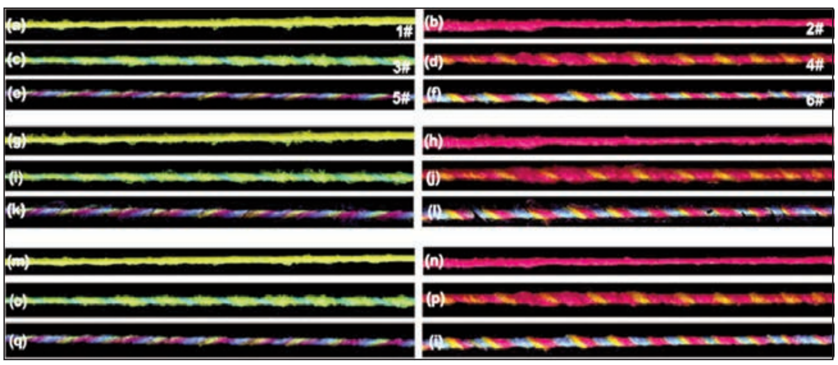

Fig. 5. Segmented images of single-coloured, two-coloured and three-coloured fancy yarns by using three different image segmentation methods: *a–f* – segmented images generated by using the OTSU segmentation method; *g–l* – segmented images generated by using the Kmeans segmentation method; *m–r* – segmented images generated by using the mean-shift segmentation method

number of iterations, which jointly increase the processing times of Kmeans method [19–21].

Figure 5, *e, f, k, l, q, r* shows the segmented images of three-coloured fancy yarn with different segmentation methods. The effect of Kmeans clustering segmentation is not ideal, because, for three-coloured fancy yarn, some colours are close to the background colour, leading to the discontinuity in the segmented image, as shown in figure 5, *k, l*. However, for the OTSU and mean-shift segmentation methods, there are no discontinuities in the segmented images owning to different processing techniques. It appears that the images processed by OTSU and mean-shift methods are similar to one another, and the only difference occurs to the edges. For the OTSU method, spikes appear at the edges, which may change the yarn diameter. However, in the case of the mean-shift method, the pixel points of the edges of the images are appropriately processed, and thus, it is better than the OTSU method in terms of segmenting three-coloured fancy yarn. This is also consistent with the mean values and SDs in table 1.

CONCLUSIONS

In this study, we successfully developed a framework of extracting the texture features of multi-coloured fancy yarn. The high-resolution images of fancy yarns are recorded by using a self-developed image capturing device. The captured digital images are first converted by image greying, and subsequently, processed with filtering. We found the images processed with a median filter include less fuzziness, hairness and noises than the images processed with a linear filter. Furthermore, using the opening operation of mathematical morphology, we remove the sharp objects in the images. At last, we compare and analyse different segmentation methods to extract the texture features of digital images of fancy yarn. It is found that the Kmeans method is more effective in segmenting single-coloured and two-coloured fancy yarns, while the mean-shift method is more effective in segmenting three-coloured fancy yarn.

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Investigation of the damp-heating processing of multilayer fabric

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ABSTRACT – REZUMAT

Investigation of the damp-heating processing of multilayer fabric

With the global industrial technology development, technological processes in the textile and clothing industry are constantly evolving. These rapid rates of development necessitate the need for continuous research and analysis to establish optimal operating modes for various technological processes. The damp-heating processing/DHP is one of the main technological processes in the sewing industry. The quality of the sewing article depends to a large extent on the quality of the performance of operations in the damp-heating processing. The wide variety of textile materials, each with different composition, structure and properties, is a prerequisite for conducting extensive research to refine manageable factors of the DHP process. In recent years, textile materials with an increasingly complex structure and multi-component composition have become increasingly important. Of particular interest are the so-called double woven fabrics. Therefore, the subject of this study is the damp-heating processing of an innovative textile fabric tissue – a multilayer weave type "double cloth". One of the main controllable factors of the damp-heating processing is the amount of moisture introduced into the processed textile materials. The aim of this paper is to determine the limit values for the amount of steam used in the damp-heating processing of a tissue – a multilayer weave type "double cloth".

Keywords: *sewing companies, amount of steam, limit values*

Investigarea prelucrării prin încălzire umedă a țesăturilor multistrat

Odată cu dezvoltarea tehnologiei industriale globale, procesele tehnologice din industria textilă și de îmbrăcăminte sunt în continuă evoluție. Această dezvoltare rapidă necesită cercetare și analiză continuă pentru a stabili modurile de operare optime pentru diferite procese tehnologice. Prelucrarea prin încălzire umedă/DHP reprezintă unul dintre principalele procese tehnologice din industria de îmbrăcăminte. Calitatea articolului asamblat depinde într-o mare măsură de calitatea performanței operațiilor din prelucrarea prin încălzire umedă. Varietatea largă de materiale textile, fiecare cu compoziție, structură și proprietăți diferite, este o condiție prealabilă pentru desfășurarea unor cercetări ample pentru a optimiza parametrii controlabili ai procesului DHP. În ultimii ani, materialele textile cu o structură din ce în ce mai complexă și o compoziție multi-componentă au devenit din ce în ce mai importante. Un interes deosebit îl reprezintă așa-numitele țesături duble. Prin urmare, subiectul acestui studiu este prelucrarea prin încălzire umedă a țesăturilor textile inovatoare – o țesătură multistrat tip „țesătură dublă". Unul dintre principalii parametri controlabili ai prelucrării prin încălzire umedă este cantitatea de umiditate introdusă în materialele textile prelucrate. Scopul acestei lucrări este de a determina valorile limită pentru cantitatea de abur utilizată în prelucrarea prin încălzire umedă a unei țesături multistrat tip „țesătură dublă".

Cuvinte-cheie*: companii din industria de îmbrăcăminte, cantitate de abur, valori limită*

INTRODUCTION

Damp-heating processing is one of the main technological processes in the sewing industry. The quality of the sewing article depends to a large extent on the quality of the performance of operations in the damp-heating processing.

From the literature review, it can be summarized that some relationships between individual parameters of this process have been investigated [1–5]. These studies have been the subject of work by a number of scientific experts and elite world-renowned sewing companies. However, many of the results from these studies are confidential or commercial information.

The influence of some factors on the efficiency of the damp-heating processing has been investigated. For example, a mathematical model of heat and mass exchange in a textile bundle where moisture permeability is present has been developed [1]. In it the problem of heat transport in a bundle of textile material is considered, but the effect of pressure is not taken into account.

Furthermore, for various types of textile materials, the complex influence of manageable factors that optimally satisfy the quality and productivity criteria is not sufficiently clarified. The subject of scientific research was the damp-heating processing of textile materials of different composition – cotton and cotton type [2], chemical textile materials [3] and others. However, the processes of damp-heating processing with a steam press for textile materials of different structure have not been clearly explained and defined.

The wide variety of textile materials and the emergence of more and more new ones requires continuous experimentation to determine parameters of the damp-heating processing for textile materials of different structure. For example, a tissue – a multilayer weave type "double cloth" have become more and more used in the sewing industry in recent years and this has motivated the present study.

One of the main controllable factors of the damp-heating processing is the amount of moisture introduced into the processed textile materials.

Traditionally, many preliminary experiments are generally performed in scientific works in order to define the limits of the individual controllable factors of the respective technological process, and then they proceed to mathematical modelling and optimization [6–9] of the process.

EXPERIMENTAL WORK

In light of the foregoing, the aim of this paper is to determine the limit values for the amount of steam used in the damp-heating processing of a tissue – a multilayer weave type "double cloth". This study is essential because it creates the conditions for mathematical modeling of the process for the type of textile material involved.

In addition, the present study proposes that the method for the determination of the parameter limit values "the amount of steam used" be used as a method of operation for the production of large lots as well. This will create conditions for the precise adjustment of the ironing machines in advance, in accordance with the composition and structure of the processed textile materials in large series of clothing.

In connection with these goals, the main task is to study the relationship between:

– the temperature difference measured at different points of processed textile materials;

– the amount of steam introduced in the damp-heating processing.

Conditions to execute the experiment

The most commonly used wet-heat treatment machines are steam ironing presses. The present studies are carried out with a steam ironing press HR-2A-04 HOFFMAN.

The moisture quantification means is a bolt, spring and piston, by means of which the opening – inlet steam and the outlet – steam of the press are regulated.

Highly effective levels of the steam temperature and the pressure between pressing cushions were determined in preliminary studies. In this study, they are constant values.

The steam temperature is 150°C.

The pressure between the pressing cushions is 130 kPa.

Materials

The textile material studied is a double woven fabric (for winter sports, hunting and tourism) "Hunter'12", produced by "E. Miroglio SA" – Sliven, Bulgaria.

Flexible textile product is a fabric of multilayer weave type "double fabric". The considered pattern consists of 2 classical twills – 3/1 twill for the face fabric and 2/1 twill for the reverse fabric. Between the face fabric and the reverse fabric there is an intermediate bonding layer of chemical threads [10, 11].

Pure 100% cotton fibers make the face layer of the fabric and 100% wool fibers make the reverse layer of the fabric. The intermediate layer is made of chemical fibers – polyamide and viscose [10, 11].

This textile material has an extremely complex structure and multicomponent composition. It is relatively new and especially up-to-date as it is multifunctional. It was created and protected by an invention patent at the end of 2016 [11]. In this sense, the results of this research are of particular interest. It is for this reason that the current research is conducted with it.

Methods

In formulating the conditions and methods for conducting the experiment, the principles of the morphological method for analysis and synthesis of methods are applied [12].

In the technological production of sewing products in actual production, the most commonly used types of seams are analogs of seams given in figure 1.

In the context of the above, two experiments were conducted:

– the first experiment („Experiment I") – with two number of layers of processed textile materials with analogues of stitches given in figure 1, *a, b*;

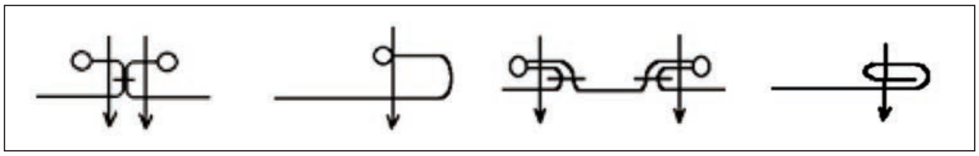
– the second experiment („Experiment II") – with three number of layers of processed textile materials with analogues of seams given in figure 1, *c, d.*

„Experiment I" is conducted for two layers of tissue.

„Experiment II" is conducted for three layers of tissue.

The method of measuring the temperature of textile materials when steam cushions are closed is an interesting engineering task. In this work, the method of establishing direct contact with the tissue packet studied is used. For this purpose a computer integrated measuring system is used [13]. In this way constant feedback is maintained with processed textile materials.

It is important to keep in mind that each layer of processed textile materials changes its temperature to a different degree. For this reason, it is necessary to monitor the temperature below the top and bottom layers of textile materials. Therefore, the temperature reading method should allow the temperature to be monitored at two points in the tissue packet being processed. The computer-integrated measurement



a ***b*** ***c*** ***d***

Fig. 1. Laying of textile materials in the course of „Experiment I" and „Experiment II": *a* – superimposed connecting seam, with two-way ends; *b* – end-folded seam with a once-folded end; *c* – superimposed connecting seam with one-sided ends; *d* – double-folded end seam

system [13] provides this capability and is therefore used to carry out experiments in the present work.
The method of accounting for temperature data is given as follows:
– for „Experiment I“, in figure 2, *a*;
– for „Experiment II“, in figure 2, *b*.
Temperature data are reported in points 1 and 2 (illustrated in figure 2) of processed textile materials.

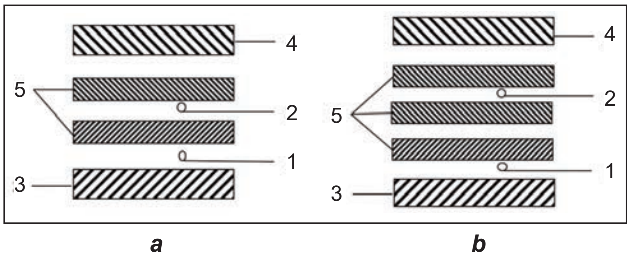


Fig. 2. Method of placement of thermocouples at temperature reading for: *a* – „Experiment I“; *b* – „Experiment II“; *1, 2* – report points; *3* – bottom cushion of the press; *4* – top cushion of the press; *5* – number of layers of the treated textile material

RESULTS AND DISCUSSIONS

Experimental results

In this paper, the dependence of ΔT [°C]/H [mm] is investigated for the specific steam press and textile materials tested, where:
T_1 – the temperature recorded by the sensor from position 1 (figure 2, *a* – for „Experiment I“; figure 2, *b* – for „Experiment II“);
T_2 – the temperature recorded by the thermocouple from position 2 (figure 2, *a* – for „Experiment I“; figure 2, *b* – for „Experiment II“).
H, mm – steam quantity according to the position of the adjustment bolt of the ironing machine and

$$\Delta T = T_2 - T_1 \tag{1}$$

The results of "Experiment I" and "Experiment II" are presented in table 1.

Table 1

RESULTS OF CONDUCTED STUDIES FOR "EXPERIMENT I" AND "EXPERIMENT II"

Study №, j	Temperature difference ΔT_I (°C)		Temperature difference ΔT_{II} (°C)	
Variant №, i, H (mm)	$\Delta T_{I,1}$	$\Delta T_{I,2}$	$\Delta T_{II,1}$	$\Delta T_{II,2}$
B_1 – 0	10.5	11.5	14.0	13.0
B_2 – 1	8.0	7.5	11.0	10.0
B_3 – 2	5.5	5.0	7.5	7.0
B_4 – 3	3.0	2.5	4.5	4.0
B_5 – 4	1.5	2.0	3.0	3.5
B_6 – 5	1.0	1.5	2.5	2.0
B_7 – 6	0.5	1.0	1.5	1.0
B_8 – 7	1.0	0.5	0.5	1.0
B_9 – 8	0.5	0.5	1.0	0.5
B_{10} – 9	1.0	0.5	1.0	0.5

The number of repeated observations at each point in the experiment was 2.

Discussion of experimental results

It is necessary to carry out a process reproducibility check, which is reduced [14, 15] to a dispersion perseverance check (by Cochran's C test):

$$G_C = \frac{S^2_{i\max}}{\sum_{i=1}^{B} S_i^2} \tag{2}$$

$$G_T \left\{ \begin{array}{l} f_1 = m - 1 \\ f_2 = B \\ r = 0.05 \end{array} \right\} \tag{3}$$

where m is the number of repeated observations for each variant, B – number of variant, f_1 and f_2 – degrees of freedom, r – significance level.
For "Experiment I", the results for the calculated and tabulated value of the Cochran's C test are:

$$G_{C,I} = 0.3333; \quad G_{T,I} \left\{ \begin{array}{l} f_1 = 1 \\ f_2 = 10 \\ r = 0.05 \end{array} \right\} = 0.6020 \tag{4}$$

For "Experiment II", the results for the calculated and tabulated value of the Cochran's C test are:

$$G_{C,II} = 0.25; \quad G_{T,II} \left\{ \begin{array}{l} f_1 = 1 \\ f_2 = 10 \\ r = 0.05 \end{array} \right\} = 0.6020 \tag{5}$$

Therefore, the intra-group dispersion (for "Experiment I" and "Experiment II") does not differ statistically and the process is reproducible.
As a result of the experiments conducted, limit values for the factor "amount of steam introduced" (according to the position of the special steam control bolt for this press) can be determined. The minimum value of the amount of steam introduced into processed textile materials is determined by the condition [9] for proper operation of the damp-heating processing. According to this condition, the temperature difference in the thickness of processed textile materials (between point 1 and point 2 of figure 2) should not be greater than 2–4°C. Therefore, the minimum value of the setting bolt position is H = 3 mm (for "Experiment I" and "Experiment II").
On the other hand, in table 1, it can be clearly seen that an increase in H, mm above a certain value does not lead to a decrease in the temperature difference ΔT°C. Therefore, increasing the amount of steam introduced (according to the position of the adjustment bolt – H, mm) above this limit value will not lead to a positive technological effect. Such an increase in H, mm will only leads to energy and time over consuming. Therefore, the appropriate maximum value of the position of the adjustment bolt H, mm the amount of steam introduced is:
– for "Experiment I" – H = 6 mm;
– for "Experiment II" – H = 7 mm.

CONCLUSIONS

In the light of the results obtained, it can be summarized that the present research has an applied scientific character.

From one side, this research creates the conditions to put on a scientific basis a multifactorial engineering problem through the application of a mathematical method.

The amount of steam introduced into textile materials during damp-heating processing (according to the position of the special press adjustment bolt) is one of the main controllable factors of the process. The determination of its limit values for the particular type of textile material (a tissue a multilayer weave type "double cloth" – "Hunter'12", produced by "E. Miroglio SA" – Sliven, Bulgaria) creates the conditions for planning and conducting a multifactorial experiment. This will allow mathematical modelling and optimization of the damp-heating processing for this type of textile materials.

The applicability of this study is expressed in the presentation of the method that can be used in the production of large batches.

The methodology is expressed in the presentation of the successive stages for the determination of limit values of the parameter "amount of moisture introduced".

This gives the possibility of precise adjusting of ironing machines in the production of large batches.

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Smart textiles perspective for the Romanian fashion industry

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ABSTRACT – REZUMAT

Smart textiles perspective for the Romanian fashion industry

Fashion companies started to use advanced technologies for their new collections to grow their business. Smart textiles add value and differentiate products on the market. The application possibilities of smart textiles are often limited only by our creativity and imagination. But for the most part, modern wearables represent a narrow niche market. We interviewed twelve managers from different Romanian fashion brands. This research paper aims to show which is the opinion of Romanian fashion managers about smart textiles and if they have experience within this field. This study sets the ground for future marketing research regarding the potential demand for smart clothing in Romania.

***Keywords**: advanced garments, fashion industry, smart clothing, smart textile, wearable*

Perspectiva textilelor inteligente pentru industria modei din România

Companiile din domeniul modei au început să utilizeze tehnologii avansate pentru noile lor colecții, pentru a-și extinde afacerea. Textilele inteligente adaugă valoare și diferențiază produsele pe piață. Posibilitățile aplicării textilelor inteligente sunt limitate doar de creativitatea și imaginația noastră. Dar în cea mai mare parte, tehnologiile "purtabile" moderne reprezintă o nișă de piață redusă. Au fost intervievați doisprezece manageri de la diferite branduri de modă românești. Această cercetare dorește să prezinte opinia managerilor din domeniul modei privind textilele inteligente și experiența în acest domeniu. Studiul nostru pune bazele pentru cercetări viitoare privind cererea potențială pentru produsele de îmbrăcăminte inteligente în România.

***Cuvinte cheie:** produse avansate, industria modei, îmbrăcăminte inteligentă, textile inteligente, tehnologii "purtabile"*

INTRODUCTION

Smart textiles could sense different stimuli from the environment, reacting and adapting to them by integration of functionalities in the textile structure [1]. Smart garments are able to sense different stimuli such as mechanical, thermal, optical, chemical, electrical or magnetic stimuli, to respond and adapt to them [2]. Smart textiles could be also known as intelligent textiles, stimuli-sensitive or environmentally – responsive [1] or e-textiles. Advanced garments such as fire-resistant, waterproof or breathing garments are not considered smart textiles.

Since the beginning of the 19th century fashion designers started to introduce electricity in their new clothing collection, developing a series of illuminated items, such as hats or costumes [3]. Since then, the fashion designers developed new smart concepts using different technologies, generating an enormous potential to this field. The development of smart textiles has the potential to revolutionize the aesthetics and functionality of our clothing. Nanotechnologies application results in new functionalities such as sensing, self-cleaning, communicating, lighting or shape memory.

The intelligent textiles can be classified into three subgroups:

- Passive smart textiles are the first generation of smart textiles and they can only sense the environmental conditions. Examples are textile changing colour, shape, thermal or with electrical resistivity.
- Active smart textiles are the second generation of smart textiles; they can sense and react to the environmental stimuli. They also have an actuator function. Examples of active smart textiles could be shape-memory, chameleonic, water-resistant, heat-storage or thermo-regulated fabrics [4].
- Ultra-smart textiles represent the fabrics having triple functions – they can sense, react and adapt. They have sensors, which can receive external stimuli, and they can react and adapt/reshape to the environmental conditions. Examples of ultra/very smart textiles are the space suits, thermo regulating clothing or health monitoring apparel.

The result of smart textiles interest generated the expansion of commercial products and the development of new techniques for incorporating electrical functionality into garments [5]. The terms used to designate this concept of smart textiles have multiples names: "smart textile", "intelligent textiles", "e-textiles", "fibertronics" or "electronic textiles" [6].

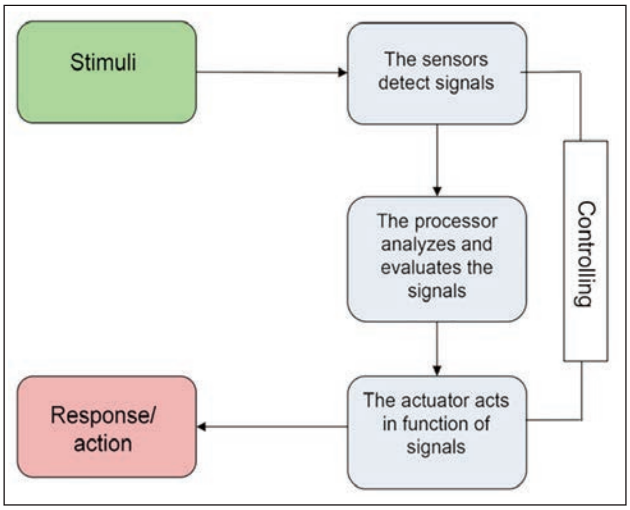

Fig. 1. Smart textile operations

SMART TEXTILES APPLICATIONS

As smart garments could detect temperature, level of moisture and stress, deformation, light intensity and other signals from our body and the environment, their use has a wide range of applications.

Sports and human performance – many sports sectors seek to improve personal comfort, athletic performance and protection in specific environmental conditions. A number of important functions can be implemented using sports clothing like monitoring heart rate, breathing, body temperature and level of moisture and other physiological parameters. Smart sport shoes could record pressure or specific joint movements, a GPS could be also incorporated or LED emitting light that a runner can be seen in the dark.

Healthcare – wearable monitoring systems allow doctors to receive vital signals from their patients. Smart textiles could monitor, through sensors, the heart rate, breathing or the moisture level. Personalized healthcare empowers individuals to get better treatment, for their own specific needs [7]. Smart clothing serves as a mobile monitoring system, promoting also the concept of health prevention.

The life jacket is medical clothing monitoring the blood pressure and the heart rate. The information is sent to a medical center, enabling them to evaluate and react immediately at any time.

Military and security fields – smart clothing could increase the safety and the capabilities of military forces. In extreme environmental conditions it is essential to increase the protection of people working in these conditions and to monitor their vital signs. A real-time communication with an emergency service center helps military forces to be more efficient.

Fashion and lifestyle – advanced technology may transform textiles into amazing portable devices. The fabrics appearance may be dramatically changed, giving new and more functional properties. Having entertainment or medical-care properties, smart textiles can be served as ideal materials for fashion designers [8].

Here are some of smart textile functions in fashion industry:

- Health monitoring system;
- Warning signaling function;
- GPS system;
- Environmental protection;
- Massage or acupuncture function;
- Intelligence temperature control;
- Body posture control;
- Music playing function;
- Light/color change in function of external stimuli;
- Shape changing function;
- Emitting scent function;
- UV protection;
- Compatibility with Phone, iPad control,
- Wireless communication;
- Protection against chemical and biological warfare;
- Waterproof functions.

Every year numerous inventors apply for patents applications in the smart textiles field such as acupuncture therapy using smart thermal textile [9], piece of fabric that has computer-based technology woven into it or adaptive smart textiles that facilitate reduced energy consumption [10].

SMART TEXTILE USE IN ROMANIA

During the last years we observed an increased interest for smart textiles in Romania. The Faculty of Industrial Design and Business Management from Iasi developed a modern research laboratory for smart textiles and fashion design. The National Institute for Research and Development of Textiles and Leather products from Romania is a central promoter of smart textile applications. Siderma Company is a Romanian producer of smart fabrics for different industries, such as fashion, footwear, military, environmental protection, automotive or furniture [11].

Still there are only a few Romanian companies interested in this field. To develop new smart textiles needs a lot of scientific and technical human capital and financial resources.

METHODOLOGY

In order to understand which is the smart textile perspective for the Romanian fashion industry, we designed a qualitative research with twelve managers who developed national fashion brands in Romania [12]. They include 10 CEOs, one marketing manager and one production manager from 5 large and 7 SME organizations, 6 of them using the lohn system, one working for a luxury brand and 5 for Romanian designer brands. We used semi-structured interview we could get important data about their experiences and opinion. Each interview was forty minutes long, blending closed-ended and open-ended questions.

International brands use smart textiles to grow their business, revolutionizing the aesthetics and functionality of the clothing. Do the Romanian fashion companies use smart textiles for their new collections?

How do they implement it in their production lines? How do they promote it?

FINDINGS AND CONCLUSIONS

The semi-structured interview guide covered four topics:
- What do they know about smart textiles?
- Experiences with smart textiles.
- Difficulties in using smart textiles for their new collections.
- Futures plans to use smart textiles.

What do Romanian fashion managers know about smart textiles?

All the interviewees heard about smart textiles, but less than 50% could give us more examples and information about this topic. Light emitting smart textiles and health monitoring textiles for sport clothing are the most popular concepts among them. They don't know any local or international smart textile producer or developer. The Romanian designers heard, for the first time, about smart textiles in faculty and from TV shows.

Usually the Romanian clothing manufacturers heard about smart textiles at international trade fairs and exhibitions (France, Germany). There is a medium degree of interest for smart textiles use. The biggest threats are: there is a low interest from potential clients, and even if they offer a new concept to the market, how do they find smart textiles developers and manufacturers?

Experiences with smart textiles

Only one interviewee has experiences with smart textiles. This factory from Sighisoara is managed by a young manager very open to challenges and smart textile applications. Her studies in Germany and Australia helped her to approach clients from Western Europe easier, such as Germany, Netherlands or Denmark clients. They developed prototypes and small productions with smart textiles, which needed special production models and patterns. This could be a good beginning for a long-term collaboration between the manufacturer and the client.

Regarding the other managers they didn't receive any requests to use smart textiles from their clients and they don't have experiences within this field. Smart textiles involve additional costs, research and people training – usually the managers from Romanian fashion industry are not willing to assume it.

Difficulties in using smart textiles for their new collections

The use of smart textiles could be considered a long-term strategy for attracting new clients and retention of the existing clients. We observed that especially managers that are early adopters, with design or economics superior studies, want to use smart textiles for growing their business. They don't expect immediate profit, and they know that innovative projects like that are risky. The use of smart textiles involves extra investments for people's training, production and research.

This qualitative research identifies fourteen challenges that Romanian fashion companies have in using smart textiles. These challenges are structured in four implementation business phases.

There are many uncertainties regarding smart textiles: Where do they find smart textile manufacturers? How do they wash smart textiles? Do the manufacturers have after-sales services? Do the manufacturers sell small quantities of smart textiles? How durable smart textiles are? Is my target market interested in smart textiles?

Futures plans to use smart textiles

More than half of interviewees said that they would use smart textiles for promotion and entertainment, and not for profitability. The main interest was for changing color smart textiles and light emitting smart textiles. We observed that designers and small producers are more willing to use smart textiles in the future than bigger companies. Managers from bigger fashion companies said that they would use smart textiles only if they see in another place a nice use of smart textiles and if that solution was already tested. They said that Romanian clients are more interested in natural fabrics than in synthetic fabrics requested by smart technical solutions.

There are many uncertainties regarding the smart-textiles developers, the demand, the production costs and functionality. After our interviews, two managers

Table 2

CHALLENGES IN USING SMART TEXTILES	
I. Business Vision Statement – Immediate profit thinking – Easy production implementation – Decision making process	**II. Concept Development** – People's training – Research & development – Innovative technical solutions – Creating added-value
III. Implementation, trails and errors – Increase in budget production solutions – Increase in budget prototypes stage – Long time to market	**IV. Sell & marketing** – Build trust – Generate competitive advantage – Differentiate from other competitors – Customer analytics

contacted us to ask for more information or some smart materials to test.

The biggest question now: Is there demand for smart clothing and accessories? This could be the starting point for a new quantitative research regarding smart clothing and accessories demand in Romania.

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Chitosan – a non-invasive approach for the preservation of historical textiles

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ABSTRACT – REZUMAT

Chitosan – a non-invasive approach for the preservation of historical textiles

Old textiles represent important samples of the mobile cultural heritage, having implications on the social and spiritual life of each population. In order to keep them in the best condition, it is necessary to implement methods to prevent damages, but also to rehabilitate and clean the already affected fabrics. In the case of textiles that need to be treated, a fundamental thing is the unaltered preservation of the initial characteristics of the materials, even after the interventions. The aim of our study is to test the feasibility of a non-invasive alternative to usual chemicals for cleaning textiles; Chitosan's antimicrobial and cleaning effects on a pair of Romanian traditional cotton trousers, from Maramures area was analyzed. A few images were taken from SEM of untreated and treated fabric with Chitosan solution using different magnifications, in order to check the changes on the fabric surface. The purpose was to observe if there are some color changes after Chitosan treatment, so the CIELAB color values (L, a, b) of untreated and treated samples were analyzed. The analysis of the treated samples revealed strong antimicrobial effects of Chitosan.

Keywords: *Chitosan, old* traditional *clothing, SEM images, colour measurement*

Chitosanul – o abordare neinvazivă pentru prezervarea textilelor istorice

Materialele textile vechi reprezintă eșantioane importante ale patrimoniului cultural mobil, având implicații în ceea ce privește viața socială și spirituală a fiecărei populații. Pentru conservarea acestora în stare cât mai bună, este necesar a se implementa metode de prevenție, dar și de reabilitare și curățare a țesăturilor deja afectate. În cazul materialelor textile care necesită a fi tratate, un lucru fundamental îl reprezintă păstrarea nealterată a caracteristicilor inițiale ale materialelor, chiar și după efectuarea intervențiilor. Prezentul studiu își propune a proba viabilitatea unei alternative neinvazive la substanțele chimice obișnuite pentru curățarea materialelor textile. Au fost analizate efectele antimicrobiene și de curățare ale chitosanului asupra unei perechi de pantaloni tradiționali românești, din bumbac, din zona Maramureșului. Câteva imagini SEM au fost preluate de pe țesătura netratată și apoi tratată cu soluție de chitosan, la diferite grade de mărire, pentru a verifica modificarea suprafetei materialului textil. Scopul a fost să observăm dacă după tratamentul cu chitosan există unele schimbări de culoare, deci, eșantioanele netratate și tratate au fost analizate in spatiul color CIELAB (L, a, b). Analiza probelor tratate a evidențiat efecte antimicrobiene puternice ale chitosanului.

Cuvinte-cheie: *Chitosan, îmbrăcăminte tradițională veche, imagini SEM, măsurători de culoare*

INTRODUCTION

Old textiles, and especially those that make up the traditional costume [1], are an important part of the cultural heritage [2–4]. They must be kept in good condition because they represent elements of individual, local and national identity [5]. Some of the fabrics can provide valuable information on the everyday context, the status of the society and its history [6]. The state of preservation of textiles depends largely on the type and composition of the fibers, the dyes used their history of usage and storage conditions [5]. Over time, textiles are subject to negative effects due to their aging, such as their yellowing [7, 8] and low tear resistance [9, 10], but also the development of bacteriological microflora [5, 11–14] and impurities [15]. In order to preserve them as long as possible, the process of textile degradation must be understood and both preventive and reactive solutions must be sought [16]. Textiles already in the process of degradation must be subjected to chemical treatments in order to be properly cleansed and preserved. Looking back at the studies undertaken in the field, it can be seen that for the treatment of textiles, both non-invasive chemicals [17–19] and some harmful ones for fabrics are used [20].

Chitosan is one of the most powerful natural polysaccharides of biotic origin, derived from chitin, with great applicability in different fields [21, 22]. Among the fundamental properties of Chitosan are the strong disinfectant and antimicrobial effects [23, 24] while being less harmful to the human body [25, 26] and to the support materials [27, 28].

These being known, the present study aims to analyze through SEM images [29–31] and spectrophotometric [32] images the effects that occur after the application of Chitosan on an old piece of traditional [33] cotton clothing.

MATERIALS AND METHODS

In order to carry out the study, it was considered the analysis of samples of materials taken from a traditional Romanian trousers called “gatii” (leggings) from the Maramures area (figure 1), made from cotton, which is one of the main materials the Romanian traditional folk costumes are mainly made of. The value of the piece is given by the conventional way it was produced (in the loom) and by its age, dating from the first half of the last century.

Fig. 1. The traditional Romanian trousers from which the samples were taken

Chitosan powder (medium molecular weight, viscosity 200.000 cps, CAS 9012-76-4) was purchased from the Aldrich Chemical and acetic acid (80%) was sumministrated by Panreac. Samples were treated by padding what allows impregnating fabric; we used a 2608 TEPA foulard. The bath treatment for padding comprised 10 g/l of Chitosan and 6 ml/l of acetic acid. The pick-up obtained was around 90–95%, this means that 90 g of bath treatment were absorbed in 100 g of fabric. Samples were dried at 85°C and cured for 30 seconds at 130°C.

In order to compare fabric surface before and after the treatment, untreated and treated samples were characterized by Zeiss model ULTRA 55 field emission Scanning Electron Microscope (FESEM) (Oxford instruments). Each sample was fixed on a standard sample holder and sputter coated with plati. Samples were then examined with suitable acceleration voltage and magnification and prepared for colour measurement, which was carried out by following a standard procedure. Colour values were evaluated in terms of CIELAB values (L*, a*, b*) using illuminant D65/10° observer on Minolta CM-3600d UV-visible spectrophotometer.

Total colour difference of dyed cotton samples was obtained using the following equation:

$$(\Delta Eab) = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2} \quad (1)$$

To determine the degree of bacteriological contamination of the folk piece of clothing, the Koch sedimentation method was used. Petri dishes were positioned on the textile materials for sampling, both before and after applying Chitosan powder.

RESULTS AND DISCUSSIONS

To check the changes on the fabric surface, some images from SEM were taken from the untreated and treated fabric with Chitosan solution using different magnifications. In figure 2, we can observe that untreated fabric (A1, B1, C1) shows some impurities or dirt on the surface which can’t be noticed on the surface of the treated fabric (A2, B2, C2).

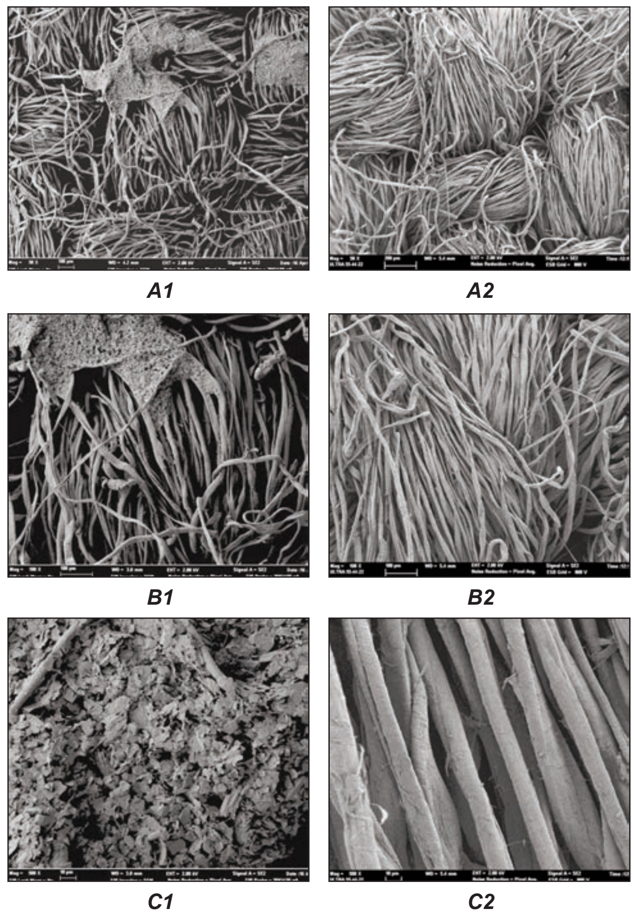

Fig. 2. SEM images of: A1, B1, C1 – untreated fabric and A2, B2, C2 – treated fabric using different magnifications (A1, A2 with 50×, B1, B2 with 100× and C1, C2 with 500×)

In order to check if there are some colour changes after Chitosan treatment CIELAB colour values (L, a, b) of untreated and treated samples were analyzed, these results are given in table 1.

L* values refer to light-dark values from 100 to 0 representing white to black, a* values range from negative (green) to positive (red) and b* values range from negative (blue) to positive (yellow) and the total colour is given by ΔEab. Results show the effect of Chitosan treatment, as L value shows the lightness is higher when the fabric is treated and it is significant b value, as this parameter shows the yellowness and after the treatment sample gets decrease this value.

Table 1

COLORIMETRIC DATA OF UNTREATED AND TREATED FABRIC				
Fabric type	**L**	**a**	**b**	**ΔEab**
Untreated	86.081±0.16	1.452±0.19	–1.791±0.19	-
Treated	87.221±0.13	1.388±0.11	–2.119±0.11	1.22±0.11

Early bacteriological testing revealed the presence of *Klebsiella* bacteria with the *Klebsiella pneumonia* subtype. This is a gram-negative bacillus, ubiquitous in nature, which normally colonizes the intestinal tract, pharynx and skin in humans. It is responsible for severe infectious epidemics (respiratory tract infections, urinary tract, digestive, systemic and nosocomial), constantly increasing globally [34]. The mode of transmission is mainly represented by the direct contact between the skin (containing wounds or burns) and the contaminated surfaces, much less through the air path by breathing from the oropharynx [35, 36]. The strong antimicrobial effects of Chitosan were confirmed by analysing the examination of the treated samples.

CONCLUSIONS

The current study indicates that the application of Chitosan on the historical textiles in a degradation state is a non-invasive alternative for cleaning and improving their conservation status. After application, the SEM images showed an improvement in the degree of cleaning of the materials, the fabrics remaining intact. The material became more intense white, due to the fact that the dirt was largely removed. At the same time, favourable conditions have been created for it to be worn, without endangering human health.

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Is Taiwan a black swan phenomenon for local textile and clothing industry? A robust nonlinear regression-based model for stock exchange prediction

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ABSTRACT – REZUMAT

Is Taiwan a black swan phenomenon for local textile and clothing industry? A robust nonlinear regression-based model for stock exchange prediction

Local apparel and textile manufacturing industry in Taiwan is a sector of great importance for sustainable economic growth. A stock market is an effective barometer indicating the economic health of a country and Taiwan is a case even more special. However, is Taiwan a black swan phenomenon for local apparel and textile manufacturing industry considering its economic growth and financial perspectives? In addition to existing literature, this research article provides a new robust nonlinear regression-based model for stock exchange prediction for Taiwan stock market. The financial data series used for the econometric analysis include the period from January 2000 to July 2018 for 13 main stock markets from countries all around the globe, such as: Taiwan, Spain, Poland, Hungary, Romania, Canada, USA, Japan, Germany, France, UK, India, and China. The final multiple regression equation provides a new prediction model for Taiwan's main stock market index. A sustainable economic growth in Taiwan is necessary to achieve major objectives such as social justice, poverty alleviation and natural environment protection. The stock market in Taiwan plays an essential role in order to stimulate economic growth and technological progress by attracting foreign investment and foreign capital. In a globalized economy, the inter-linkages between stock markets are complex and can significantly influence Taiwan's sustainable development.

Keywords: *textiles, apparel industry, manufacturing sector, emerging stock market, economic growth, sustainable development, economic sustainability, nonlinear regression-based model*

Este Taiwanul un fenomen de tipul "lebădă neagă" pentru industria textilă și de îmbrăcăminte? Un model robust, bazat de regresie non-lineară, pentru predicția comportamentului pieței bursiere

Industria locală de textile și de îmbracăminte din Taiwan reprezintă un sector de mare importanță pentru o creștere economică durabilă. Piața bursieră reprezintă un barometru efficient, care indică sănătatea economică a unei țări, iar Taiwanul este un caz cu atât mai special. Totuși, reprezintă oare Taiwanul un fenomen de tipul "lebădă neagră" pentru industria locală de textile și de îmbrăcăminte, având în vedere creșterea economică și perspectivele sale financiare? În plus față de literatura existentă, acest articol de cercetare furnizează un model nou și robust, bazat pe regresie neliniară privind predicția bursieră pentru piața bursieră din Taiwan. Seria de date financiare utilizate pentru analiza econometrică include perioada ianuarie 2000 – iulie 2018 aferentă celor 13 piețe bursiere reprezentative, cum ar fi: Taiwan, Spania, Polonia, Ungaria, România, Canada, SUA, Japonia, Germania, Franța, Marea Britanie, India și China. Ecuația finală de regresie multiplă oferă un nou model de predicție pentru principalul indice bursier din Taiwan. O creștere economică durabilă în Taiwan este necesară pentru a atinge obiective majore precum justiția socială, reducerea sărăciei și protecția mediului natural. Piața bursieră din Taiwan joacă un rol esențial pentru a stimula creșterea economică și progresul tehnologic, prin atragerea investițiilor și a capitalului străin. Într-o economie globalizată, legăturile dintre piețele bursiere sunt complexe și pot influența semnificativ dezvoltarea durabilă a Taiwanului.

Cuvinte-cheie*: textile, industria de îmbrăcăminte, sectorul manufacturier, piața bursieră emergentă, creștere economică, dezvoltare durabilă, sustenabilitate economică, model neliniar bazat pe regresie*

INTRODUCTION

Is Taiwan at least a country? Taiwan is officially recognized as the Republic of China or ROC, paradoxically, because there are many sceptics who do not consider Taiwan as an independent and sovereign country. People's Republic of China (PRC) commonly called China is one of the great powers in the world politics. The geopolitical consequences on the territorial sovereignty of the island of Taiwan are very complex at international level. China does not recognize Taiwan as an independent and separate country, but as an inalienable part of China. However, governmental authorities mention that the Republic of China (ROC) is a sovereign and independent state that maintains its own national defence and conducts its own foreign affairs. In other words, Taiwan is Taiwan. China is China. There are two different countries because Taiwan is not an integrated and inalienable part of China. Furthermore, Taiwan is considered one of the four Asian Tigers due to its high-growth economy and rapid industrialization. The Asian Tigers is a metaphorical syntagm on the fast-growing economies of Singapore, Hong Kong, Taiwan and South Korea. Global systemic challenges related to unsustainable economic growth, demographic dynamics, urbanization, disease and pandemics, accelerating climate change and environmental degradation, technological innovation progress, sharp decline of biodiversity, all make it even more difficult to achieve long-term sustainable development. A very important strategy should focus on the absolute decoupling of economic growth from environmental degradation. Nevertheless, ensuring the long-term prosperity of the Taiwan (ROC) requires further integrated government actions and strategies in order to overcome these challenges and achieve an optimal level of sustainable development. Some researchers consider that Taiwan has exhibited a very successful pattern of rapid economic growth and declining income inequality over the past three decades based on four major structural transformations: agricultural reform, import-substitution industrialization, export-led growth, and change from labour-intensive to technology-intensive production [1]. Most often it is assumed that export-oriented industrialization (EOI) strategy was the basic cause of the rapid economic growth in Taiwan but this was also the result of several unique historical and geo-political factors, as well as necessary infrastructure, international linkages, and political support from foreign governments including a high amount of foreign aid from the U.S. [2]. China, unlike Taiwan is recognized for limited foreign investor access.

In terms of sustainable development, Taiwan can be considered a Black Swan phenomenon. A Black Swan is a metaphor which highlights a multidimensional approach. More technically, a Black Swan is a highly improbable event with three principal characteristics: it is unpredictable; it carries a massive impact; and, after the fact, we concoct an explanation that makes it appear less random, and more predictable, than it was [3]. But where does the Black Swan symbolism come from? For centuries, Europeans who were accustomed only to white swans, considered that a Black Swan is a myth or a fairy-tale impossible to become reality. However, the reality is quite different. In Australia, Black Swans were widely known so certain indestructible landmarks, suddenly became immaterial and irrelevant. Extrapolating the concept, the impact of highly improbable events is very high and can have significant consequences. A Black Swan event is extremely rare, unpredictable, unexpected, highly improbable but generates catastrophic effects. Practically, a Black Swan phenomenon has multiple widespread ramifications, such as the global financial crisis of 2008, Brexit, the 9/11 terrorist attacks, the rise of the Internet, Muslim mass immigration in European Union, transnational terrorism, the rise of FinTech industry, the rise of intelligent technologies used for smartphones, tablet computers and other digital devices.

TAIWAN – A BRIEF MULTIDIMENSIONAL FRAMEWORK

Local apparel and textile manufacturing industry in Taiwan has a significant impact on sustainable economic growth. Chen Chiu [4] investigated the progress of textile and garment industry in Taiwan from the period after 1945, when the industry was small and inconsequential, to the contemporary period, where the industry is a world leader at the frontier of fibre and new material development. Moreover, Spulbar et al. [5] suggested that a sustainable stock market provides a transparent and effective solution to inherent challenges related to environmental, social, economic and corporate governance issues. Taiwan has a dynamic capitalist economy based mainly on industrial manufacturing, and in particular on exports of electronics, machinery, and petrochemicals but its robust dependence on exports exposes the economy to severe fluctuations in global demand due to Taiwan's diplomatic isolation, low birth rate, rapidly aging population, and increasing competition from China and other Asia Pacific markets according to the Central Intelligence Agency (CIA) [6]. The economy of Taiwan (ROC) is a complex system but closely related to social and environmental level factors. Taiwan is a largely mountainous island nation in East Asia, formerly known as Formosa. Taiwan has a population of 23.5 million (in 2015), so it is one of the most populated countries in the world considering the fact that it has a geographical area of 36,197 km² and shares maritime borders with China, Japan, and the Philippines taking into account official statistics provided by Nations online – Taiwan. The Ministry of Foreign Affairs of Republic of China (Taiwan) suggested that around 20 percent of the country's land area is protected considering that Taiwan is the second most densely populated area in the world. However, in literature is hardly any information available on the economic sustainability of the economy and thus not on the overall sustainability of the economy, which comprises all four components, i.e. economic, social, environmental and institutional aspects [7].

The concept of economic sustainability is very important in understanding Taiwan island's capitalist behaviour patterns of a growing economy. Theoretically, economic sustainability includes the ability of an economy to support a certain level of economic output for an indefinite period of time. Moreover, a sustainable economic growth is necessary to achieve major objectives such as social justice, poverty alleviation and natural environment protection. According to United Nations, The Division for Sustainable Development Goals (DSDG), sustainable economic growth will require societies to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment considering that currently almost half the world's population still lives on the equivalent of about US$2 a day with global unemployment rates of

5.7% [8]. On the other hand, the relevant question is not whether economic growth has environmental consequences but whether those consequences threaten the resilience of the ecological systems on which economic activities depend [9]. Moreover, the maintenance of the stock of natural resources should be part and parcel of economic policymaking, particularly in less developed countries because the reverse of this situation implies facing scarcity of wealth induced by decline of their environment [10]. Taiwan's current economic success is partly the result of nearly half a century of careful government planning but coincides with an almost proportional decline in Taiwan's natural-environment endowment [11]. According to the World Bank's Asia economic report 1961 on the economy of Taiwan, in spite of the continuing heavy defence burden and a high population growth rate, a substantial amount of economic development has taken place and national product has increased considerably and this progress is attributable to several factors such as: an already high degree of development, literacy, agricultural skills, institutions, transportation, and power facilities prior to 1949, the transfer of skilled administrators from the mainland in 1949, and a large U.S. aid program. Taiwan was once known as the "Garbage Island" which was a very pressing and humiliating stigma, especially in the context of a globalized economy. Currently, Taiwan is a genuine global waste recycling leader due to an effective waste management policy and it has achieved for several years one of the highest recycling rates in the world. Chen, Wu and Chen [12] suggested that regardless of the progressive success for the current system in Taiwan, a flat rate recycling fee scheme possesses limited inspiration to promote the concept of design for environment (DfE).

The Ministry of Science and Technology (MOST) of Republic of China (Taiwan) highlighted that Taiwan (ROC) is actively involved in many international organizations with economic activity such as: World Trade Organization, Asia-Pacific Economic Cooperation, Asian Development Bank, Central American Bank for Economic Integration, the Inter-American Development Bank, European Bank for Reconstruction and Development and committees of the Organization for Economic Cooperation and Development. However, Taiwan (China) has very special features so is not listed as a separate country for World Development Indicators as are Macao (China) and Hong Kong (China) [13–15]. The economic relationship between Taiwan (ROC) and China (PRC) are very tight, despite political and military tensions. However, the economic performance of Taiwan from the mid-1950s to the mid-1980s is regarded as that of an archetypal Asian Newly Industrializing Economy (ANIE) so it achieved rapid growth, marked structural change and significant export effectiveness [16]. The rapid industrialization process in Taiwan is often associated with the significant support of the United States. On the other hand, the progress of industrialization was also influenced by the high level of accumulation in the agricultural sector, aspect which provided the following development directions: to sustain the rapidly expanding surplus population, to provide an abundant labour force, and to form the base for capital formation for labour-intensive industry [17]. Despite the fact that Taiwan has long time been considered an industrial economy, some authors concluded that data based on the GDP and employment implicate that Taiwan by 1970 had evolved into a service economy considering that services in general have grown faster than manufacturing, been less prone to adverse effects of recession and quicker to recover from economic downturns [18].

The GDP (purchasing power parity) in Taiwan was $1.189 trillion in 2017, $1.156 trillion in 2016 and $1.14 trillion in 2015, while the GDP – real growth rate was estimated to 2.9% in 2017, 1.4% in 2016 and 0.8% in 2015. A nation's gross domestic product (GDP) at purchasing power parity (PPP) exchange rates is the sum value of all goods and services produced in the country valued at prices prevailing in the United States in the year noted. The gross domestic product (GDP) composition, by sector of origin in 2017 was agriculture 1.8%, industry 36% and services 62.1%, while the labour force by occupation in 2016 was: agriculture 4.9%, industry 35.9% and services 59.2%. The inflation rate (consumer prices) was: 1.1% in 2017 and 1% in 2016, while the unemployment rate was: 3.8% in 2017 and 3.9% in 2016. Taiwan's government authorities have highlighted that the situation has improved since 2016, and statistics indicate that in 2017 Taiwan's overall exports and imports increased by 13.2 percent and 12.5 percent respectively, while its economy expanded 2.86 percent, higher than in 2016. The World Bank argued that for the current 2019 fiscal year, low-income economies are defined by the World Bank as those with a GNI per capita, calculated using the World Bank Atlas method, of $995 or less in 2017; lower middle-income economies are those with a GNI per capita between $996 and $3,895; upper middle-income economies are those with a GNI per capita between $3,896 and $12,055; high-income economies are those with a GNI per capita of $12,056 or more. As can be observed in the figure below, Taiwan has a GNI per capita which exceeds $12,056 for the past several years so it is included in the selective category of high-income economies [19, 20].

RESEARCH METHODOLOGY, DATA ANALYSIS AND EMPIRICAL RESULTS

The financial data series used for the econometric analysis include the period from January 2000 to July 2018 for 13 main stock markets from countries all around the globe, such as: Spain, Poland, Hungary, Romania, Taiwan, Canada, USA, Japan, Germany, France, UK, India, and China. The empirical econometric analysis is based on the following stock market indices: IBEX 35 index (Spain), WIG 20 index (Poland), BUX index (Hungary), DAX Index (Germany), BET index (Romania), CAC 40 index (France), FTSE 100 index (UK), TSX Composite index (Canada), DJIA index (USA), NIKKEI 225 index (Japan), SSE Composite index (China), BSE SENSEX index (India) and FTSE TSEC index (Taiwan). The selection of the authors included countries from several continents, such as Europe (Spain, Poland, Hungary, Romania, Germany, France, UK), Asia (Japan, Taiwan, India, and China) and North America (USA). Daily stock market index data are collected from official websites of selected stock markets.

The following model is a quadratic primary model for fitting problem data:

$$yhat = \beta_1 x_1 + \beta_2 x_1^2 + \beta_3 x_2 + \beta_4 x_2^2 + \beta_5 x_3 + \beta_6 x_3^2 + \beta_7 x_4 + \beta_8 x_4^2 + \beta_9 x_5 + \beta_{10} x_5^2 + \beta_{11} x_6 + \beta_{12} x_6^2 + \beta_{13} x_7 + \beta_{14} x_7^2 + \beta_{15} x_8 + \beta_{16} x_8^2 + \beta_{17} \quad (1)$$

In this section, our problem is finding optimal coefficients for the above model.

We can define an optimization model as follows for it:

$$MinMAPD = \frac{\sum_{i=1}^{100} |error_i|}{\sum_{i=1}^{100} |y_i|} \quad (2)$$

So that the programming model is defined as follows:

$$yhat_j = \beta_1 x_{j,1} + \beta_2 x_{j,1}^2 + \beta_3 x_{j,2} + \beta_4 x_{j,2}^2 + \beta_5 x_{j,3} + \beta_6 x_{j,3}^2 + \beta_7 x_{j,4} + \beta_8 x_{j,4}^2 + \beta_9 x_{j,5} + \beta_{10} x_{j,5}^2 + \beta_{11} x_{j,6} + \beta_{12} x_{j,6}^2 + \beta_{13} x_{j,7} + \beta_{14} x_{j,7}^2 + \beta_{15} x_{j,8} + \beta_{16} x_{j,8}^2 + \beta_{17}; \quad (3)$$

$$j = 1, 2, 3, \ldots, 100$$

where $error_j = y_j - yhat_j$; $j = 1, 2, 3, \ldots, 100$; $\beta_k IsFree$; $k = 1, 2, 3, \ldots, 17$

This mathematical model should be solved with MATLAB Software and after solving, optimal answer is as follows:

$MAPD^* \cong 0.02$

$\beta_1^* = 2.0541$

$\beta_2^* = -0.00013252$

$\beta_3^* = -23.7037$

$\beta_4^* = +0.0018983$

$\beta_5^* = +6.2478$

$\beta_6^* = -0.00065553$

$\beta_7^* = +34.312$

$\beta_8^* = -0.0075388$

$\beta_9^* = -12.7307$

$\beta_{10}^* = +0.0041743$

$\beta_{11}^* = -23.2139$

$\beta_{12}^* = +0.0010944$

$\beta_{13}^* = -8.5695$

$\beta_{14}^* = +0.00057286$

$\beta_{15}^* = -1.8156$

$\beta_{16}^* = +0.00010694$

$\beta_{17}^* = +194161.4895$

Thus, the best nonlinear regression model for fitting the problem data (table 1) is as follows:

$$yhat = 2.0541\, x_1 - 0.00013252\, x_1^2 - 23.7037\, x_2 + 0.0018983\, x_2^2 + 6.2478\, x_3 - 0.00065553\, x_3^2 + 34.312\, x_4 - 0.0075388\, x_4^2 - 12.7307\, x_5 + 0.0041743\, x_5^2 - 23.2139\, x_6 + 0.0010944\, x_6^2 - 8.5695\, x_7 + 0.00057286\, x_7^2 - 1.8156\, x_8 + 0.00010694\, x_8^2 + 194161.4895 \quad (4)$$

Table 2 shows the Values R, R Square, Adjusted R square, Std. error of the estimate. The corrected R2 indicates how much of the total justified by eight independent variables.

Table 3 shows the analysis of variance. In this table, the linear regression model is equal to 9.163 and its probability is 0.000.

Table 4 is a table of different regression coefficients. The first part of the unstandardized coefficients, the Standardized Coefficients second part, the third part of the t test and the fourth part show a significant level.

It can be observed the results of the table above in the following linear programming.

$$Y=14708.496-0.159X1-0.369X2-0.222X3+1.975X4-0.039X5-0.464X6-0.671X7+0.487X8 \quad (5)$$

First, we define the equation of degree 2, based on the least squares error method, in the next step we enter the data in MATLAB software and obtain the coefficients and Constant. It can be observed that the results of this multiple non-linear programming in the equation below:

Table 1

VARIABLES ENTERED/REMOVED[b]			
Model	**Variables entered**	**Variables removed**	**Method**
1	X8, X5, X2, X1, X6, X3, X4, X7[a]	0	Enter

Note: [a] all requested variables entered; [b] dependent variable: Y.

Table 2

MODEL SUMMARY				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. error of the estimate**
1	0.668[a]	0.446	0.397	412.62226

Note: [a] predictors (constant), X8, X5, X2, X1, X6, X3, X4, X7.

Table 3

MODEL SUMMARY						
Model		**Sum of squares**	**df**	**Mean square**	**F**	**Sig.**
1	Regression	1.248E7	8	1560074.677	9.163	0.000[a]
	Residual	1.549E7	91	170257.133	-	-
	Total	2.797E7	99	-	-	-

Note: [a] predictors: (constant), X8, X5, X2, X1, X6, X3, X4, X7; [b] dependent variable: Y.

Table 4

COEFFICIENTS[a]					
Model	**Unstandardized coefficients**		**Standardized coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
1 (Constant)	14708.496	2346.467	-	6.268	0.000
X1	–0.159	0.288	–0.054	–0.554	0.581
X2	–0.369	0.261	–0.191	–1.413	0.161
X3	–0.222	0.154	–0.223	–1.443	0.152
X4	1.975	0.509	0.638	3.882	0.000
X5	–0.039	0.449	–0.009	–0.087	0.931
X6	–0.464	0.163	–0.283	–2.844	0.006
X7	–0.671	0.264	–0.454	–2.544	0.013
X8	0.487	0.200	0.527	2.433	0.017

Note: [a] dependent variable: Y.

$$yhat = 2.0541\,x_1^1 - 0.00013252\,x_1^2 - 23.7037\,x_2^1 + 0.0018983\,x_2^2 + 6.2478\,x_3^1 - 0.00065553\,x_3^2 + 34.312\,x_4^1 - 0.0075388\,x_4^2 - 12.7307\,x_5^1 + 0.0041743\,x_5^2 - 23.2139\,x_6^1 + 0.0010944\,x_6^2 - 8.5695\,x_7^1 + 0.00057286\,x_7^2 - 1.8156\,x_8^1 + 0.00010694\,x_8^2 + 0.00010694194161.4895 \quad (6)$$

After applying multiple regressions, a comparison of Real Data (Taiwan) and multiple regressions taking 100 samples of real data.

MAPD (Between Multiple nonlinear regression and Real Data (Taiwan)) =

$$MAPD = \frac{\sum |A_t - F_t|}{\sum A_t} = \frac{22635.76203}{923954.1383} = 0.0244987939 \cong 0.02 \quad (7)$$

Also, equation (8) shows the multiple nonlinear regression equation:

$$yhat = 2.0541\,x_1^1 - 0.00013252\,x_1^2 - 23.7037\,x_2^1 + 0.0018983\,x_2^2 + 6.2478\,x_3^1 - 0.00065553\,x_3^2 + 34.312\,x_4^1 - 0.0075388\,x_4^2 - 12.7307\,x_5^1 + 0.0041743\,x_5^2 - 23.2139\,x_6^1 + 0.0010944\,x_6^2 - 8.5695\,x_7^1 + 0.00057286\,x_7^2 - 1.8156\,x_8^1 + 0.00010694\,x_8^2 + 0.00010694194161.4895 \quad (6)$$

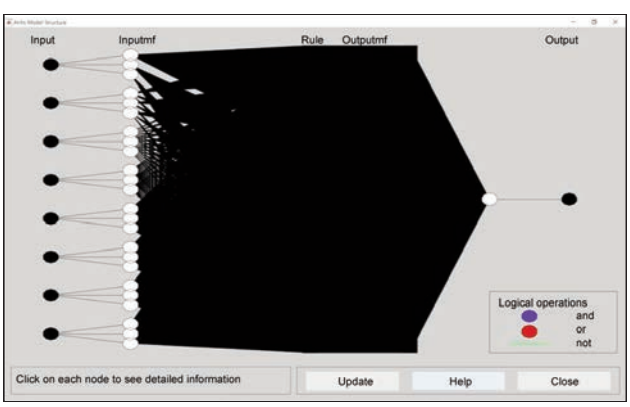

Fig. 1. Adaptive Neuro-Fuzzy Inference Systems (ANFIS) model structure (MATLAB software)

In order to verify the suitability of the model, we checked residual against fit-fitted value in the in the following charts (figures 1–3).

MAPD (Between Multiplenonlinear regression and Real Data (Taiwan)) =

$$MAPD = \frac{\sum |A_t - F_t|}{\sum A_t} = \frac{22635.76203}{923954.1383} = 0.0244987939 \cong 0.02 \quad (9)$$

MAPD (Between multiple regression and Real Data (Taiwan)) =

$$MAPD = \frac{\sum |A_t - F_t|}{\sum A_t} = \frac{29001.92638}{923954.1383} = 0.0313889242 \cong 0.03 \quad (10)$$

As you can see, nonlinear regression is better than linear regression in the prediction.

Also, equation (11) shows the multiple regression equation (figure 4).

Y=14708.496-0.159X1-0.369X2-0.222X3+1.975X4-0.039X5-0.464X6-0.671X7+0.487X8 (11)

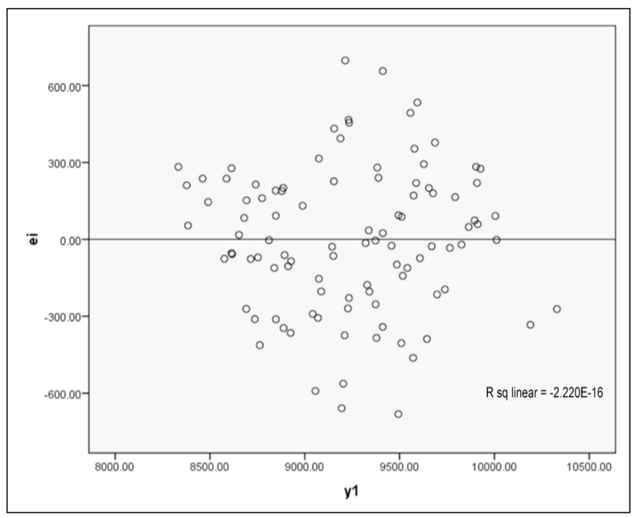

Fig. 2. Residual against fit-fitted value

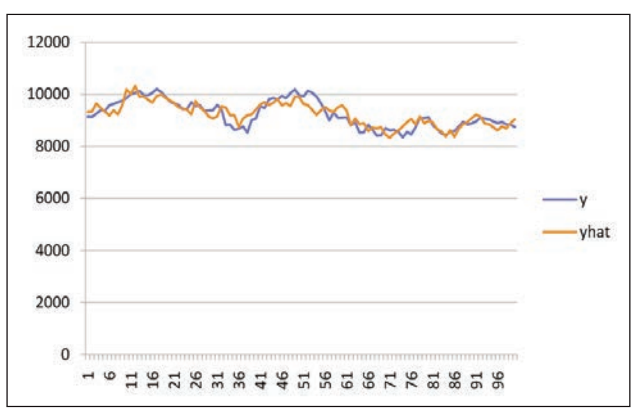

Fig. 3. Results of nonlinear regression and actual data

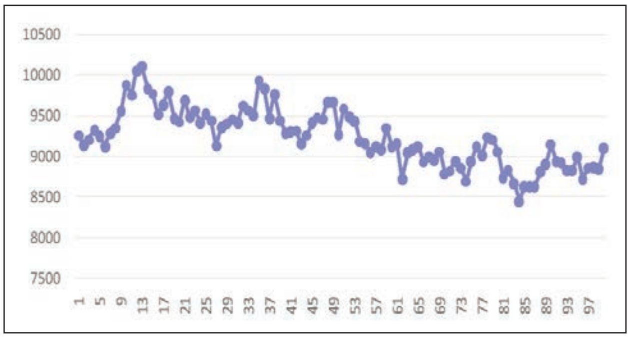

Fig. 4. Results of multiple regression prediction graph

CONCLUSIONS

The apparel and textile manufacturing industry in Taiwan represents an essential sector with a significant positive impact on sustainable economic growth. In addition to existing literature, this research article provides a new robust nonlinear regression-based model for stock exchange prediction for Taiwan stock market. The financial data series used for the econometric analysis include the period from January 2000 to July 2018 for 13 main stock markets from countries all around the globe, such as: Taiwan, Spain, Poland, Hungary, Romania, Canada, USA, Japan, Germany, France, UK, India, and China. The final multiple regression equation provides a new and original prediction model for Taiwan's main stock market index. Strategic interaction and cooperation between international markets contribute to influencing the investment portofolio selection. Pinto et al. [21] suggested that that low-risk portfolios have consistently outperformed market index as well as high-risk portfolios. Moreover, in a globalized economy, the inter-linkages between stock markets are complex and can significantly influence Taiwan's sustainable development. In terms of sustainable development, Taiwan can be considered a Black Swan phenomenon considering the very high economic growth and industrialization progress. Despite all recent improvements, environmental concerns still remain very high for Taiwan. Sustainable development is a great challenge for the global economy considering both local and global prospects for humanity. Emerging countries, especially low-and middle-income countries face severe problems such as: demographic dynamics, high degree of poverty, poor quality education, migration, environmental degradation, social inequality, high levels of urbanization, health system deficiencies, rapid technological change and unsustainable economic growth. Independent specialized organizations places Taiwan in the emerging markets category based on internationally-agreed standards. However, although it is considered an emerging country, Taiwan has a GNI per capita which exceeds $12,056 for the past several years so it is included in the first class category of high-income economies. The economic growth of Taiwan has been unpredictable and fulminant over the past decades given its great impact, which are basic characteristics of Black Swan phenomena. Thus, although Taiwan was once known as the “Garbage Island”, is currently one of the most attractive markets. In the development process of Taiwan it must be pointed out that a sustainable economic growth is necessary to achieve major objectives such as social justice, poverty alleviation and natural environment protection. On the other hand, it is very important to stimulate economic growth and technological progress by attracting foreign investment and foreign capital. Hawaldar et al. [22] argued that sustainability represents a complex concept that has gained increasing popularity among consumers around the world.

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Updating the Clothing Technician Profile through synergies between industry and vocational and educational training

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ABSTRACT – REZUMAT

Updating the Clothing Technician Profile through synergies between industry and vocational and educational training

The importance of the textile and clothing sector in the European manufacturing industry, particularly in terms of the economy and employability, is very representative and crucial. To act upon urgent need felt by the textile and clothing industry and qualification gap, the CosTUmE project, in alignment with the Skills Agenda for Europe, created and updated the Clothing Technician profile and skills, facilitating the mobility of qualified people in the EU.
This paper presents several aspects concerning the field and desk research developed in order to map the qualifications needs and the Work Based Learning Practices (WBL) in the textile and clothing sector. Also, this work presents the tools developed in order to enable people to make better career choices in UE and help them to find higher quality jobs and improve their life chances: Clothing Technician profile and qualification, ECVET Matrix, Tutorial guide for EU mobility and Training package.

Keywords: *clothing, technician, profile, education, labour market*

Actualizarea profilului Tehnicianului îmbrăcăminte prin sinergii între industrie și formare profesională

Importanța sectorului de textile și de îmbrăcăminte în industria prelucrătoare europeană, în special în ceea ce privește dezvoltarea economică și capacitatea de angajare, este reprezentativă și crucială. Pentru a acționa în funcție de nevoile urgente resimțite de industria textilă și de îmbrăcăminte și de lipsa de calificare, proiectul CosTUmE, în conformitate cu Agenda de competențe pentru Europa, a creat și actualizat Profilul și calificarea Tehnicianului îmbrăcăminte, facilitând mobilitatea persoanelor calificate în UE.
Această lucrare prezintă aspecte referitoare la cercetarea de teren și documentară realizată în scopul identificării nevoilor de calificare și a practicilor de învățare la locul de muncă (WBL) în sectorul de textile și de îmbrăcăminte. De asemenea, această lucrare prezintă instrumentele dezvoltate pentru a le permite oamenilor să facă alegeri profesionale mai bune în UE, să își găsească locuri de muncă de calitate superioară și să-și îmbunătățească șansele în viață: profilul și calificarea Tehnicianului îmbrăcăminte, Matricea ECVET, Ghidul pentru mobilitatea în UE și Pachetul de formare.

Cuvinte-cheie: *îmbrăcăminte, tehnician, profil, educație, piața muncii*

INTRODUCTION

According to Davis, in today's knowledge-based society, where intellectual capital is an organization's most competitive asset, learning is serious business [1].

The importance of the textile and clothing sector in the European manufacturing industry, particularly in terms of the economy and employability, is very representative and crucial. But despite the enormous employment potential, the sector is unattractive to young people and lacks skilled labour. As referred by European Union, 2017, "textile and clothing sector faces a low attractiveness level, which causes difficulties in attracting new employees, especially younger workers, feeding the already significant skills' gaps among the entire sector's supply chain" [2].

Fast technological change, competitiveness and the growing number of workers close to retirement age require an attentive and active sector, to respond to the challenges in a concerted and dynamic way. Knowledge and skills thus become key factors for the sustainable development of the sector and anticipating skill's needs as well as promoting cooperation between industry and vocational and educational training is critical.

According to Helyer, in a rapidly evolving, highly technological world employees increasingly need to develop skills categorized by these various elements [3]. Vocational education and training have been adapting to a changing society, where the need for knowledge is strong.

In Portugal, Spain and Romania the VET system offers several profiles/qualifications in the clothing field, which are disproportionate or insufficient to accomplish today's companies needs and challenges: quick response capability, high quality of the products, eco-friendly solutions, digital competences, I&D+I, work-based learning methodologies for workers.

These challenges require human resources with new (technical and transversal) competences and qualifications.

Fig. 1. Field-based research tools

To face such challenges and act upon urgent need felt by the textile and clothing industry and qualification gap, we designed the CosTUmE project, in alignment with the Skills Agenda for Europe, in order to:

• Identify needs, trends and patterns in demands for skills and jobs (skills intelligence) for T&C sector;
• Improve the attractiveness, quality and relevance of training in the clothing area;
• Create and update a Clothing Technician profile and skills more visible and comparable facilitating the mobility of qualified people in the EU;
• Increase the textile and clothing sector attractiveness and capture of talents, contributing, at the same time, to increase the employability of young people;
• Produce information to enable people make better career choices in UE and help them to find higher quality jobs and improve their life chances;
• To reinforce networking, partnerships and VET policy coherence among different stakeholders at European, regional and country levels among project implementation and after the end of the project.

Following the above challenges, the CosTUmE project was implemented between the three countries, which were united under 2 years of structured work in Key Action 3 of the Erasmus+ program. The extensive effort of the consortium and a great number of consultations with key stakeholders of the sector provided the answers that the EU field needs towards the revitalisation of the clothing sector.

METHODOLOGY

Desk & Field Research

The main objective of the current research was to do an in-depth analysis and a vast fieldwork carried closely with textile and clothing stakeholders from the three countries involved (Portugal, Spain and Romania), to map the qualifications needs and the Work Based Learning Practices (WBL) in the textile and clothing sector.

In the desk-based research, the different partners compiled important information on the different profiles related to the clothing technician profile, to compare common competences, modules and training units. In this research it was also compiled information regarding the European and National Qualifications Framework and relevant competent entities, as well as the WBL good practices by country.

Field-based research aimed to collect field evidences and validate assumptions from the desk research within the textile and clothing sector at national and EU level on:

- validation with companies' representatives that the existing Clothing Technicians' profile is not suitable for the new demands of the sector;
- identify the new competences that should integrate the Clothing Technician training curricula.

In the field-based research, it was carried out questionnaires for companies and VET providers (figure 1). In the three countries, we had 95 surveys answered by companies (which in total represent 10.083 workers) from the clothing sector and 38 surveys answered by VET providers.

In the past 5 years, companies have been adopting different strategies since the number of companies who had deceased, increased or maintained its workforce, are similar. However, majority of respondents foresees an increase in their workforce in the upcoming 5 years, which explains the difference between the number of companies who hired new employees after their VET qualification, and those who are looking for new employees (figure 2).

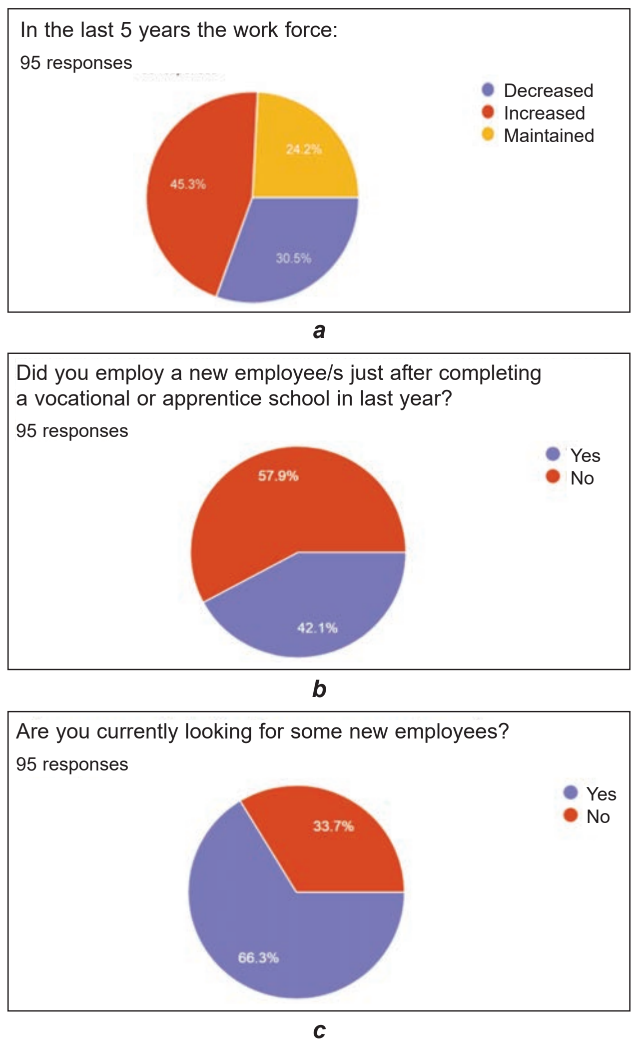

Fig. 2. Companies' strategies for employment: *a* – workforce evolution; *b* – new employees hiring; *c* – new employees searching

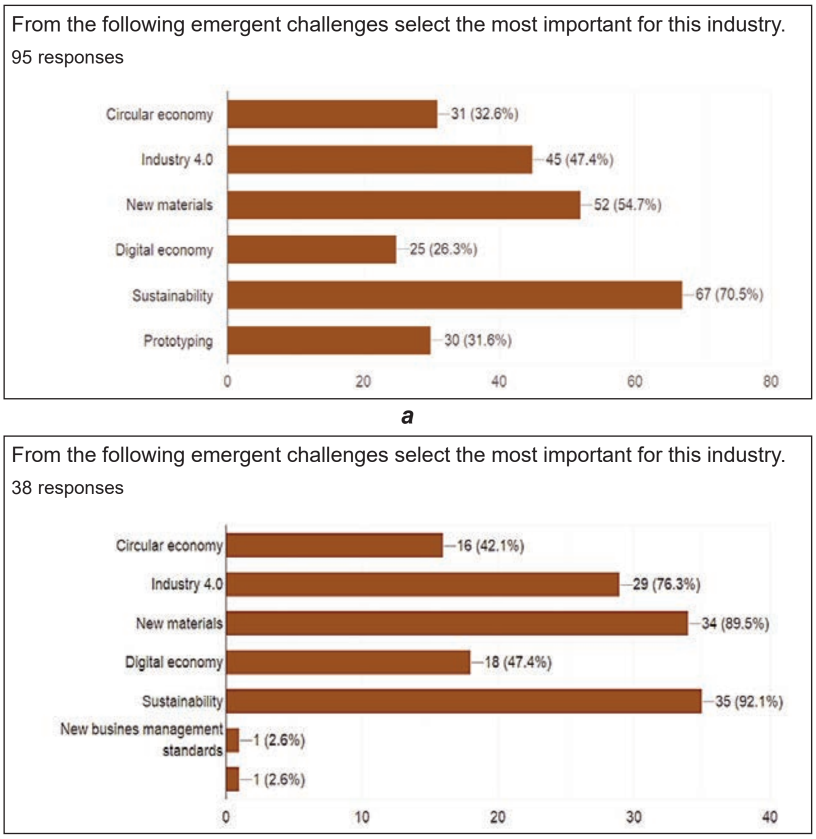

Fig. 3. Emergent challenges: *a* – companies' opinion; *b* – VET providers' opinion

The following urgent challenges were appointed: sustainability, use of new materials in products, digitization and industry 4.0, replacement of older workers, low attractivity of youngers, lack of specialized training offer and trainings/internship programmes too short or do not provide the expected results (figure 3).

The top 5 relevant technical competencies appointed by companies were: "interpret technical sheets and procedure manuals", "in depth knowledge of the production process", "organization of the production process", "develop technical patterns", "elaboration and control of time norms during the operative process" (figure 4).

In the top 5 relevant technical competencies appointed by VET providers, we also found "ensure quality and technical standards", "integrate the norms of safety, hygiene, health and environmental protection in the exercise of professional activity", "manufacture, modification, adjustment and repair of garments/products", "operate different production machines" (figure 5).

Companies appointed "teamwork", "communication and oral skills" and "work management" as the three most relevant transversal competencies. VET providers also have included "foreign language" in this list (figures 6 and 7).

Focus groups

The results of the surveys were validated and discussed in three focus group sessions, held in the three countries, with the participation of 39 people, of which 29 represented companies or VET providers external to the project.

In these focus group sessions, new technical competences were identified: "knowledge of production equipment settings", "participates in solving all technical problems in the production process", "use pattern design software for clothing", "identifying and anticipating problems through market research", "knowing the safety rules for operating the machines and protect the workers", "knowing the parameters and the characteristics for operating the machines".

New transversal competences were also identified: ability to "learning and assimilation of information" and to "adapt to repetitive and routine tasks".

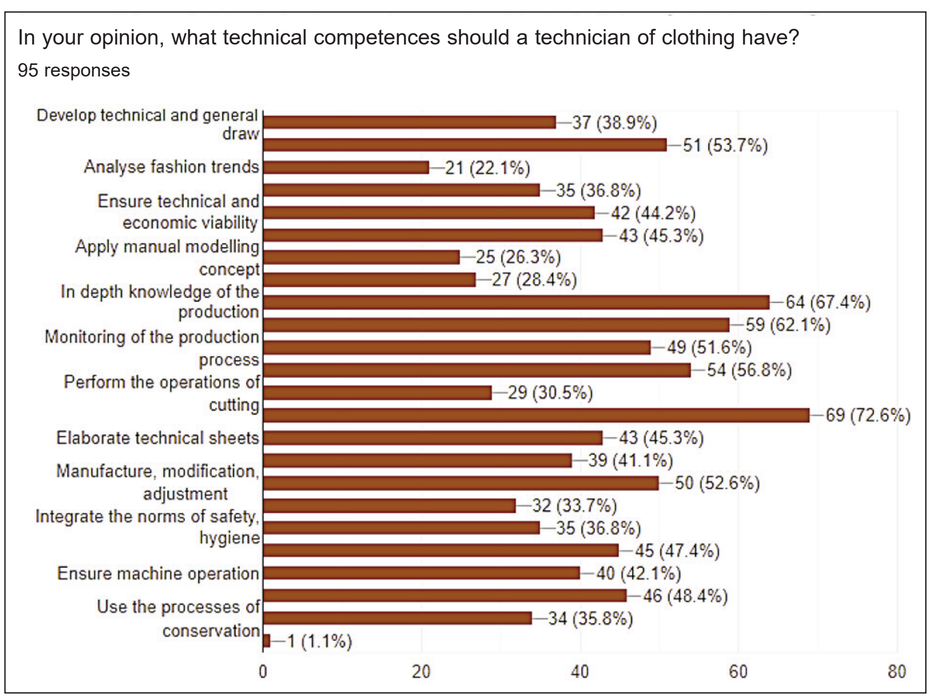

Fig. 4. Relevant technical competencies appointed by companies

Obviously, the list of competences identified as important were balanced with the existing resources and, above all, with the number of hours provided for the training of this technician.

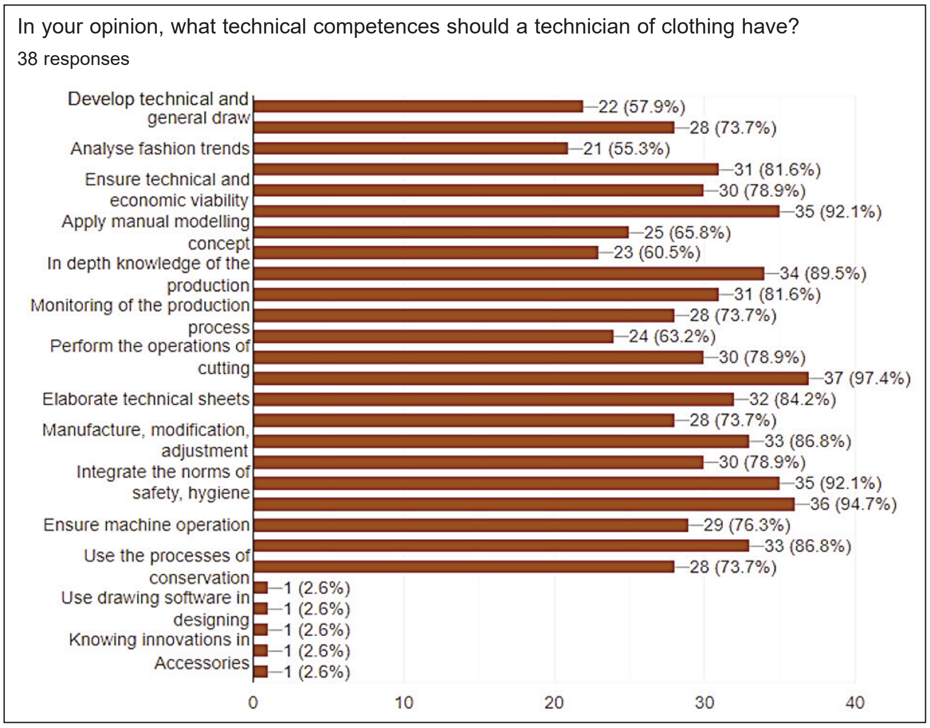

Fig. 5. Relevant technical competencies appointed VET providers

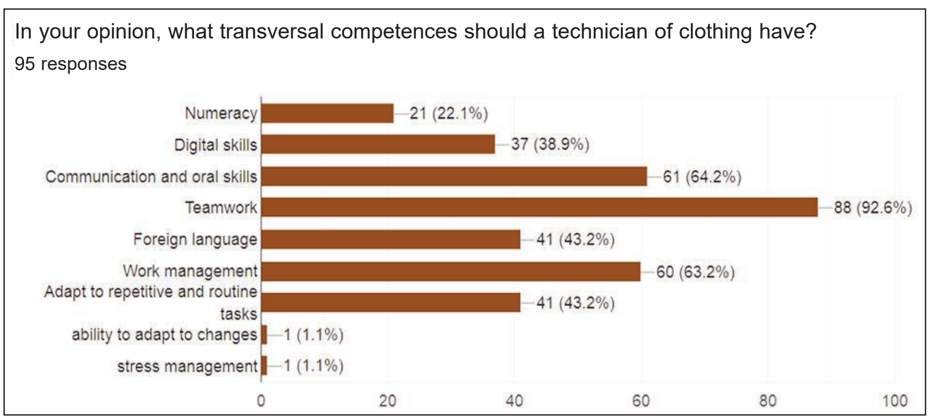

Fig. 6. Relevant transversal competencies appointed by companies

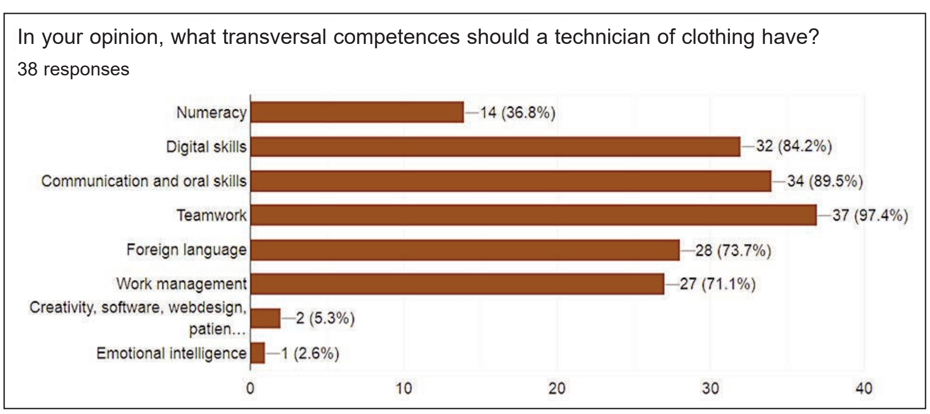

Fig. 7. Relevant transversal competencies appointed by companies

In this focus group it was also discussed possible measures to attract youngers to the sector, having been listed the importance of the recognition and valorization of the profession, the adjustment of leadership style by supervisors and superiors, the improvement of working conditions and working environment, as well as the importance of dual training.

RESULTS AND DISCUSSIONS

Clothing Technician Profile and Qualification

The profile answers to a lack of training that exists in this area considering the needs that the companies have of qualified Clothing Technicians with competences in the scope of the management and organization of the work, modelling, sewing, new materials, industry 4.0 technologies, etc.

Based on the information received from stakeholders during the networking sessions organised in the three countries (Portugal, Spain and Romania), the partners elaborated a new Clothing Technician Profile and Qualification. In general, the profile integrated transversal contents related with soft skills, technical contents and apprenticeship.

The training curriculum for profile followed the subsequent structure:

- Identify the output profile (table 1);
- Identify transversal contents;
- Transform specific professional competences into units of knowledge;
- Identification of the objectives per each unit;
- Identification of the contents per each unit;
- Identification of the training hours per each training;
- Establish an assessment system of learning;
- Allocate ECVET points for each unit.

Table 1

CLOTHING TECHNICIAN PROFILE		
Competence Units	1	Planning the production
	2	Organizing the production
	3	Monitoring the production process
	4	Executing technical sheets
	5	Performing procedure manuals
	6	Using pattern making tools (manual and digital)
	7	Operating manufacturing machines
	8	Undertaking the finishing of garments and accessories
	9	Using quality and technical standards

The contents and the duration of the units defined were different in each partner country, because the partners followed the national structure of the professional profiles. However, it was ensured the recognition and transferability of the profile/qualification.
The profile was developed in accordance to EQF and taking into consideration the existing ECVET recommendations. By combining study and work, apprenticeships and work-based learning (WBL) certainly offered to trainees an important opportunity to acquire work experience while enhancing skills in close alignment with employer needs [4]. Work-based learning could help to reduce skills mismatch and ease transition from education to work. In this sense, the profile integrated contents in real work context. With learning outcomes and Work-based learning methodology, the consortium ensured that learners acquire the knowledge, skills and competences with direct relevance for the labour market.
According to Helyer, the modern workforce requires workers with adaptable and entrepreneurial attitudes, who are willing to learn continuously [3]. Table 2 presents some of the main benefits of the WBL for trainees, companies and educational organizations.
During pilot training action, trainers evaluated the new profile/qualification and discussed the whole training concept, the scheme and the methodologies defined to undertake the new Clothing Technician Profile. Based on their recommendations, the Clothing Technician Profile was improved.

ECVET Matrix

The ECVET Matrix promoted the recognition of a new professional profile and qualification by the national regulatory entities that meet EQF requirements [5, 6]. The matrix includes precise guidelines with the profile match process in Portugal, Spain and Romania and describes the following aspects:

- framework/regulatory Entities for the European/ National Qualifications Framework;
- purpose of level descriptors;
- ECVET system in participating countries [7];

Table 2

BENEFITS OF WORK-BASED LEARNING (WBL)	
Learner/ trainee	Opportunity to align theoretical learning with the expectations of the future profession. Allows the acquisition of a deeper knowledge through experimentation.
Companies	It allows to have better informed and more effective workers, thus improving the overall efficiency of the company and ensuring its competitiveness in the future. It can significantly contribute to the development of the workforce in sectors where there are identified skills gaps, or where occupations or sectors are among the least favoured.
VET providers	Training programmes become more attractive to trainees. In addition, they make it possible to create richer and more structured training programmes promoting sustained learning. Partnerships with companies can also provide access to technologies that would not otherwise be possible.

- distributed UC for the point of view of knowledge, skills, responsibility and autonomy, learning outcome, assessment criteria and output;
- profile match for the point of view of qualification designation, area, level of qualification, body awarding the qualification or competent authority, credit system, quality assurance procedures and qualification documents.

ECVET points are a numerical representation of the overall weight of learning outcomes in a qualification and of the relative weight of units in relation to the qualification. Allocation of ECVET points to a qualification is based on using a convention according to which 60 points are allocated to the learning outcomes expected to be achieved in a year of formal full time VET [8].
To define the duration of the profile and the allocation of ECVET points, the partnership has developed a method of analysis based on importance degree: labour market, complexity and training hours (figure 8). The matrix is a useful document that can help other VET providers in definition of new profiles.

Tutorial guide for EU mobility

Mobility and exchange are relevant and contribute substantially to the development of the European education system, in terms of quality and networking [9, 10]. Mobility is an excellent way for students to improve the use of a foreign language, autonomy, responsibility, social competences and develop different knowledge related with clothing area in different context which will improve the employment prospects.
The European Union recognizes the importance to support cross-border mobility of learners and workers and lifelong learning across Europe and supports the mobility through mobility programmes, through

Technological Training

Clothing Technician Profile and Qualification Training framework

Competence's unit (CU)	Training/module	Labour market	Complexity	Training hours	ECVET points
CU1 Planning the production	Raw materials	+	+	+	1
	Determination of provisioning	++	++	+	1
	Storage Management	++	+	+	1
	Technical information for industrial clothing	+	++	++	1
CU2 Organizing the production	Production schedule	+++	+++	+++	3
	Layout methods	+++	+++	+++	3
	Production control	++	++	++	2
CU3 Monitoring the production process	Quality control in processes	+	++	+	1
	Occupational risk protection and environmental protection	++	+	++	1
CU4 Executing technical sheets	Technical data sheets development	++	++	++	2
CU5 Performing procedure manuals	Technical manuals and procedures	+	+	+	1
	Working methods	++	+++	+++	3
	Work measurement	++	+++	+++	3
CU6 Using pattern making tools (manual and digital)	Manual pattern making - initiation	++	++	++	2
	Cutting fundamentals	++	++	+	1
	CAD - pattern making initiation	++	++	+	2
CU7 Operating manufacturing machines	Fabrics cutting technology	+	++	+	1
	Technical and clothing products assembling technique	++	+++	+++	3
CU8 Undertaking the finishing of garments and accessories	Products finishing process	+	++	+	1
CU9 Using quality and technical standards	Fabrications necessary technical documentation	+	++	+	1
	Semi-finished components and finished products quality control	+	++	+	1
Transversal training	Interpersonal communication and assertiveness	+++	+	+	1
	Team leadership and motivation	+++	+	+	1
	English language - textile industry	++	++	++	1
	Time management and work organisation	+++	++	++	2
	TOTAL				40
	Apprenticeship in labour context	+++	++	+++	20
	TOTAL (Technological training + Apprenticeship in labour context)				60

Labour market: + low importance to extreme importance +++

complexity: + low complexity to extreme complexity +++

training hours: + less to more +++

Fig. 8. Clothing Technician Profile and Qualification – ECVET points

establishing national centres, the first points of contact for any person or organisation interested in working or learning across Europe.

The Tutorial Guide for mobility aimed to present the importance of mobility across the Europe, the mobility documents, the European and national entities that support mobility and VET providers and companies that are available to host apprenticeships. It is a guidance that may facilitate future mobility processes across the Europe.

In the Clothing Technician Profile the period of apprenticeship was defined in accordance with national specifies. The tutorial guide integrates concrete orientations for VET institutions and students to understand how they can participate in a mobility period. The tutorial guide also includes the contact of different existing VET institutes in the three partner countries, as several contacts from several textile companies that usually host apprenticeships or are open to receiving apprenticeship in future.

The qualification profile should be recognized and validated through Europass, ensuring the principles of European Transparency and Recognition. The tutorial guide offers the main orientation of the mobility, mainly: Europass mobility (registration of any period of time that its holder spent in another European country for education and vocational training purposes (European learning pathway) and Europass Certificate Supplement (for people holding an official vocational education and training certification or equivalent) [11–14]. Therefore, the learners can personalize their training path according to their experience and knowledge.

Training Package about Clothing Technician Profile and Qualification for trainers

Choosing and applying the most appropriate teaching/training techniques and methods according to the objectives of a training is a crucial factor for learning success. Therefore, it is important to define which methods and techniques are best suited to the objectives, the target audience and the context in which the training takes place.

An active teaching/training method places the learner at the centre of the learning process, creates a favorable environment for learning and is defined by dynamic, creative and collaborative activities. The choice of the best techniques makes it possible to encourage the best learning behaviours.

An innovative training package and a concerted train the trainers for delivering the Professional Profile and Qualification have been performed. On one side, the main aim was to support and provide resources to trainers of the textile and clothing sector in order to empower them in delivering this new Clothing Technician profile, and on the other side implementing a training action for trainers.

In this sense, the tasks performed are divided in 2 phases, in the first phase all resources have been developed by all partners in order to define the training contents which will be taught in this new profile focusing in aspects defined in previously work such as "Planning the production", "Organizing the production", "Monitoring the production process", "Executing technical sheets", "Performing procedure manuals" or "Operating manufacturing machines".

The methodologies and resources presented in this toolkit serve as inspiration and guide for the implementation of the Clothing Technician profile/qualification by each VET provider.

The training package is structured in three parts. The first part presents the Clothing Technician Profile and the relationship between the competence units, the second part presents the main active methodologies of teaching/training, and the last part presents a set of activities consisting of a case study, a group dynamic and a practical case for each competence unit. In total, 27 activities were developed to help future trainers to implement the Clothing Technician Profile and Qualification.

The relationships matrix allows establishing connections within each Competence Unit, among the training modules that it encompasses, and also connections between modules of different Competence Units. In this manner, it can be operationalized the link between contents and objectives of the Competence Unit (blocks of training modules) according to the Clothing Technician profile. It can be also operationalized the schedule stemming from the connections definition, e.g., precedences and simultaneity between modules (figure 9).

Once all contents were developed by each partner, the train the trainer's action was carried out in every country, so at the end three training actions were performed. The results were gathered to improve the work done. In each country, this Train the Trainers action was implemented by 13 trainees in Portugal, by 10 trainees in Spain and by 11 in Romania. The results showed that above 80% of trainees consider

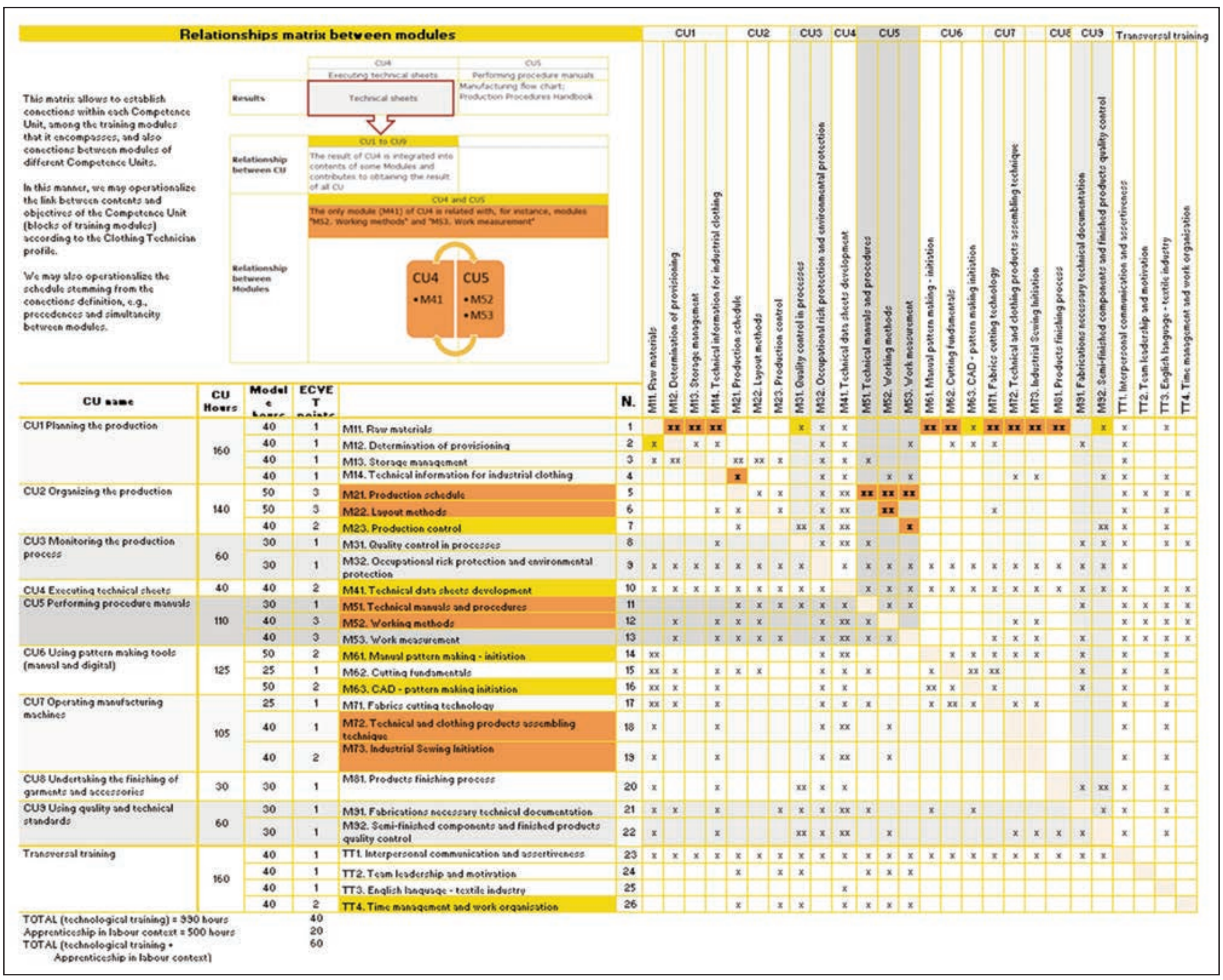

Fig. 9. Relationships matrix between Competence Units

the training action good or very good, and most of them as adequate in duration. As an improvement point, trainers suggested to reduce some Cutting modules and introduce a new module regarding Industrial Sewing. In addition, almost all trainees considered that the design and the didactic resources developed were of very high quality and very useful for teaching.

The results presented above can be accessed at https://clothingtechnician.eu/.

IMPACT AND SUSTAINABILITY

A dedicated work enclosed a great deal of outreach actions from the partners to disseminate the results achieved. Even early in the start of CosTUmE, communication strategies were conscripted that made sure that the progress was shared, the opportunities of engagement have been well known and the results of the project accessible to every interested individual and organisation. This extensive effort managed to mobilise more than 13 Representatives from the national authorities, 209 Representatives of the textile and clothing companies, 172 VET experts and 98 Sectorial social partners to take part into the CosTUmE activities and in real time contribute to the development and validation of the answers to the challenges identified. Moreover, the partnership made sure to implement wide events for the dissemination of the results, and kept making extensive use of the online media to gain the interest of the target groups in global level and break the barriers of distance.

All the above, allowed CosTUmE to reach the finalisation of the project work and conquer two major achievements that elevate its impact:

- the officialisation of collaboration between partners and the National Agencies for the Qualifications;
- the recognised contribution with an updated skillset and programs to the EU field of the clothing sector.

More than ever, CosTUmE remains available and “ON”, accessible at https://clothingtechnician.eu/ to provide its invaluable results to every interested, and keep alive the ever-growing networking around the initiative.

CONCLUSIONS

In recent years, teaching methodologies have been increasingly improved, so there is a growing range of different options available to VET institutions. This reality has led to passive learning approaches becoming less valued.

Also in the context of COVID19 pandemics, the teaching methodologies are changing learning environments around the world, providing renewed academic performance.

The rapid transformation we are witnessing, be it technological, social, or in values, among others, has driven the need for adjustment and improvement. If on one hand we have a society looking for the most successful student/trainee to help in becoming more competitive on economic grounds, on the other hand we have students/trainees with a will to know and to be a part of this process. This reality has led managers/directors and teachers/trainers to rethink teaching and learning models and methods.

During the desk and field research, it has been identified a clear need to reschedule the learning plan of the professionals trained in this field of expertise and to implement more WBL practices, something that the trainers and the people in the industry see as vital for a satisfactory subsequent incorporation to the industry. Also, it was concluded that companies should also start or reinforce the following actions as a way of attracting youngers to the sector:

- Recognition and valorisation of the profession;
- Adjustment of leadership style by supervisors and superiors;
- Dual training;
- Improvement of working conditions (working hours, salaries, permanent contracts, pay leave conditions, provide benefits in products, life-work balance);
- Improvement of working environment (greater proximity between employees, employees feel good and valued, team buildings, rewarding ideas for improving the workplace, recreation areas).

Finally, companies should demonstrate commitment and involvement in these challenges and create an environment & conditions that will bring out the best of the employees and make pressure on the authorities competent so that effective measures are adopted.

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The importance of the peritoneal dialysis catheter material in order to perform optimum dialysis in veterinary medicine

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ABSTRACT – REZUMAT

The importance of the peritoneal dialysis catheter material in order to perform optimum dialysis in veterinary medicine

This study was conducted on 44 dogs, aged between 10 months and 15 years, weighing between 0.9 and 8.5 kilograms, during 72 months. We created four batches of 11 dogs each. First batch received silicone peritoneal catheters with two Dacron cuffs, second batch received silicone peritoneal catheters without Dacron cuffs, third batch received polypropylene peritoneal catheters with two Dacron cuffs and fourth batch received polypropylene peritoneal catheters without Dacron cuffs. All the dogs were treated with the same peritoneal dialysis solution, at the same interval, in the same doses and at the same temperature and all the peritoneal catheters were straight Blake. In dogs from the first batch, we experienced minimum subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 90 days. In the second batch, we experienced constant and reduced subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 90 days. In the third batch, we experienced medium subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 45 days. In the fourth batch, we experienced important subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at most 15 days. The study conclusion is that the best peritoneal catheter it is represented by the silicone peritoneal catheters with two Dacron cuffs.

Keywords: *peritoneal, dialysis, catheter, veterinary*

Importanța materialului cateterului de dializă peritoneală pentru efectuarea dializei optime în medicina veterinară

Acest studiu a fost realizat pe 44 de câini, cu vârste cuprinse între 10 luni și 15 ani, cu o greutate cuprinsă între 0,9 și 8,5 kilograme, pe parcursul a 72 de luni. S-au creat patru loturi a câte 11 câini fiecare. Primul lot a fost tratat utilizând catetere peritoneale din silicon cu două manșete de Dacron, al doilea lot a fost tratat utilizând catetere peritoneale din silicon fără manșete de Dacron, al treilea lot a fost tratat utilizând catetere peritoneale din polipropilenă cu două manșete de Dacron și al patrulea lot a fost tratat utilizând catetere peritoneale din polipropilenă fără manșete de Dacron. Toți câinii au fost tratați cu aceeași soluție de dializă peritoneală, la același interval, în aceleași doze și la aceeași temperatură, iar toate cateterele peritoneale au fost de tip Blake drept. La câinii din primul lot, s-au observat scurgeri minime subcutanate de soluție de dializă peritoneală, iar cateterele au fost permeabile timp de cel puțin 90 de zile. La al doilea lot, s-au observat scurgeri subcutanate constante și reduse de soluție de dializă peritoneală, iar cateterele au fost permeabile timp de cel puțin 90 de zile. La al treilea lot, s-au observat scurgeri subcutanate medii de soluție de dializă peritoneală, iar cateterele au fost permeabile timp de cel puțin 45 de zile. La al patrulea lot, s-au observat scurgeri subcutanate semnificative de soluție de dializă peritoneală, iar cateterele au fost permeabile timp de cel mult 15 zile. Concluzia prezentei lucrări este că, în mare parte, cel mai bun cateter peritoneal este cateterul realizat din silicon cu două manșete de Dacron.

Cuvinte-cheie: *peritoneală, dializă, cateter, veterinar*

INTRODUCTION

Dialysis represents the separation process of a colloidal dispersion substance from molecular dispersion particles, based on the property of certain membranes to retain only colloidal particles [1].

Peritoneal dialysis has the main indication in numerous cases of intoxications and metabolic misbalances. It can be also used in order to remove some dialyzable toxins, such as ethylene glycol, barbiturates, ethanol, propoxyphene and hydantoin, and in cases of electrolyte imbalances, the most representative one being hyperkalemia [2].

Patients showing acute nonanuric uremia, with blood urea nitrogen (BUN) over 100 mg/dl or with creatinine levels higher than 10mg/dl can be treated using peritoneal dialysis [3].

Peritoneal dialysis is totally contraindicated in patients with fibrosis or abdominal malignant tumors and peritoneal adhesions [4].

The ideal peritoneal dialysis catheter permits an adequate administration and a complete evacuation of the dialysate, it generates minimum subcutaneous losses, it prevents infection both in the subcutaneous tissue and in the peritoneal cavity [2].

Acute dialysis catheters are placed under local anaesthesia, percutaneously, using a stiletto and heparinization is immediately required. The acute dialysis catheters are usually straight and they have multiple orifices at the distal end. Acute dialysis catheters usually have no Dacron cuffs used to protect the patient against bacterial infection and migration of the catheter. That for, their usage may lead to peritonitis in a high rate, in case of extensive use [5]. Chronic peritoneal dialysis catheters have certain models, both extraperitoneal and intraperitoneal, created especially to minimize blockage and to reduce secondary effects. Chronic peritoneal dialysis catheters are made of rubber, silicon or polyurethane [6].

Chronic peritoneal dialysis catheters are designed with one or more Dacron cuffs used to protect the patient against bacterial infection and migration of the catheter. In case of extensive use of catheters without Dacron cuffs, this may lead to a high peritonitis rate. These catheters are placed under general anaesthesia [7].

The peritoneal dialysis catheter is fixed in place, after the placement, by suturing it to the skin with a monofilament non-absorbable thread 4/0 to 2/0 range. Roman sandal suture and the Chinese finger-trap are the two most commonly used sutures [8].

Polypropylene (PP) is the most used monofilament thread for suturing the peritoneal dialysis catheter in place. Polypropylene, also known as polypropene, used in a wide variety of applications, is a thermoplastic polymer. It is produced via chain-growth polymerization from the monomer propylene. Its properties are similar to polyethylene, but it is more heat resistant and slightly harder. Polypropylene is a white, mechanically rugged material with a high chemical resistance. Polypropylene is the second-most widely produced plastic (after polyethylene) and it is often used in labelling and packaging [2].

In human medicine, once surgically placed, peritoneal dialysis catheters could be used for dialysis after minimum 10 to 14 days [9].

This 10 to 14 days interval allows the wound to heal and to create a scar around the two Dacron cuffs. This will minimize the dialysate leakage around the insert site of the catheter. For medical reasons, in veterinary medicine, peritoneal dialysis starts immediately after the peritoneal dialysis catheters placement. This is done because most of the cases are severe emergencies and cannot be postponed for such a period of time [10, 11].

In the present study, we have tested peritoneal dialysis catheters made from silicone with two Dacron cuffs, silicone peritoneal catheters without Dacron cuffs, polypropylene peritoneal catheters with two Dacron cuffs and polypropylene peritoneal catheters without Dacron cuffs.

MATERIALS AND METHODS

This study was conducted on 44 canine patients with AKI (Acute Kidney Injury), both males and females all of them being treated using peritoneal dialysis. The study was conducted between June 2014 and June 2020. All patients were tested for other associated pathologies and none of the selected patients presented other morbidities of infections of the peritoneal cavity or at the skin, around the catheter placement area.

All dogs enrolled in this study were aged between 10 months and 15 years, weighing between 0.9 and 8.5 kilograms. We created four batches of 11 dogs each. First batch received silicone peritoneal catheters with two Dacron cuffs, second batch received silicone peritoneal catheters without Dacron cuffs, third batch received polypropylene peritoneal catheters with two Dacron cuffs and fourth batch received polypropylene peritoneal catheters without Dacron cuffs.

All canine patients were treated using the same peritoneal dialysis solution, at the same interval, in the same doses and at the same temperature and all the peritoneal catheters were straight Blake.

In all groups, the peritoneal catheters were placed on canine patients being under general anaesthesia and the all the catheters were placed using a surgical procedure. After the catheter placement, the catheters required immediate heparinization. The surgical placement of the catheter is needed in order to inspect the abdominal cavity and for the omentectomy. The omentectomy was also important and it is recommended in order to avoid the catheter blockage by the omentum. In order to reach the bottom of the Douglas pouch, all peritoneal dialysis catheters were cut, using a surgical scissor. In order to do this, the peritoneal catheters were pre-measured and inserted into the peritoneal cavity after being cut. The abdominal cavity was surgically closed with an absorbable monofilament suture material and the last suture, or a separate suture point, was placed through the distal (abdominal) Dacron cuff of the peritoneal catheter, in the catheters with Dacron cuffs and around the catheters in those without Dacron cuffs. After this, the anterior end of the peritoneal catheter was passed under the skin, through a subcutaneous tunnel, on the lateral side and it was exteriorized through the skin, 3–5 cm away from the main incision line. This way, the proximal Dacron cuff was located under the skin in the catheters with two Dacron cuffs.

The peritoneal catheters were sutured at the skin using a 4/0 to 2/0 non-absorbable monofilament suture material, depending on patient size. We placed Roman sandal sutures in all patients.

After the placement of the peritoneal catheters, the surgical wound was dressed using antiseptics and the peritoneal catheters received special catheter bandaging. All patients received a special corset to prevent them to reach the peritoneal catheter and to prevent them from pulling it from the peritoneal cavity. The owners of every canine patient received the same training regarding the catheter handling, patient care and wound dressing.

The first treatments were performed in the Clinic and, after the first 3 days, all canine patients were sent home with specific instructions and training for the owners, the therapy being continued by the owners.

Fig. 1. Placing of the silicone peritoneal catheter with two Dacron cuffs in dogs with AKI

Fig. 2. Placing of the silicone peritoneal catheter without Dacron cuffs in dogs with AKI

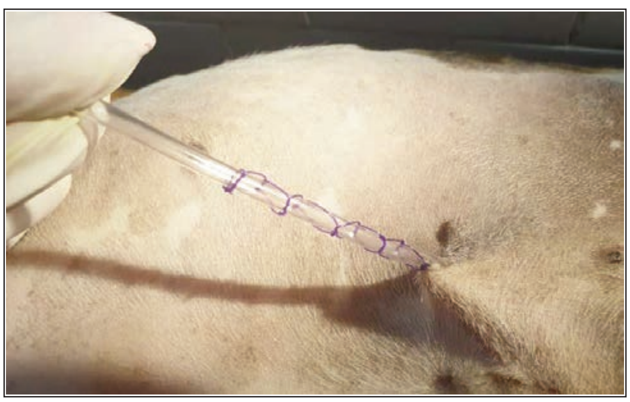

Fig. 3. Placing of the polypropylene peritoneal catheter with two Dacron cuffs in dogs with AKI

Fig. 4. Placing of the polypropylene peritoneal catheter without Dacron cuffs in dogs with AKI

We have used the same peritoneal dialysis products, from the same pharmaceutical company in all canine patients. The fluid exchanges and all the dwelling times were identical in all canine patients.

RESULTS AND DISCUSSIONS

Analysing all the recordings from all the canine patients undergoing peritoneal dialysis, we have reached numerous data. All canine patients were carefully followed until they were complete recovered or until the end of treatment (death).

All canine patients from the first group, treated using silicone peritoneal dialysis catheters with two Dacron cuffs and sutured using Roman sandal suture held the catheters in place for at least 90 days (11 out of 11, 100%) and experienced minimum subcutaneous leaks of peritoneal dialysis solution. The catheters were permeable throughout the entire period.

In the second batch, 10 out of 11 patients (90.90%), having placed silicone peritoneal catheters without Dacron cuffs experienced constant and reduced subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 90 days.

All patients from the third group, having placed polypropylene peritoneal dialysis catheter with two Dacron cuffs and sutured using Roman sandal suture held the catheters in place for at least 45 days (11 out of 11, 100%) and experienced medium subcutaneous leaks of peritoneal dialysis solution. The catheters were permeable throughout the entire period.

In the fourth batch, 9 out of 11 patients (81.81%), having placed polypropylene peritoneal catheters without Dacron cuffs experienced constant and important subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 15 days.

The most important disadvantage of the permanent polypropylene dialysis catheters, comparing to the silicone peritoneal catheters is a shorter working duration for the procedure, which is really important. Also, the importance of the two Dacron cuffs is a major factor in the leakage of the peritoneal dialysis solution.

CONCLUSIONS

Using silicone dialysis catheters with two Dacron cuffs needs a wider incision for the catheter placement, more labour for the procedure, with higher costs, but is has less risks.

In the present study, all canine patients from the first group, treated using silicone peritoneal dialysis catheters with two Dacron cuffs and sutured using Roman sandal suture held the catheters in place for at least 90 days (11 out of 11, 100%) and experienced minimum subcutaneous leaks of peritoneal dialysis solution. The catheters were permeable throughout the entire period, this finding being similar with the research of Thornhill J.A. [5].

10 out of 11 patients (90.90%), having placed silicone peritoneal catheters without Dacron cuffs experienced constant and reduced subcutaneous leaks of

peritoneal dialysis solution and the catheters were permeable for at least 90 days, similar with the studies of Viţălaru, B. Al., 2020 [1].

All patients from the third group, having placed polypropylene peritoneal catheter with two Dacron cuffs and sutured using Roman sandal suture held the catheters in place for at least 45 days with medium subcutaneous leaks of peritoneal dialysis solution. The catheters were permeable throughout the entire period.

9 out of 11 patients (81.81%), having placed polypropylene peritoneal catheters without Dacron cuffs (fourth batch) experienced constant and important subcutaneous leaks of peritoneal dialysis solution and the catheters were permeable for at least 15 days.

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Microbial degradation of an industrial azo-dye and FT-IR analysis

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ABSTRACT – REZUMAT

Microbial degradation of an industrial azo-dye and FT-IR analysis

The presence of dyes in wastewaters from the textile industry, even in concentrations of less than 1 mg/l, significantly affects the aesthetic properties and transparence degree of public effluents, with direct repercussions on the environment. Cerioporus squamosus White-Rot-Fungi (WRF) strain was used for bio-augmentation of MBBR carriers (consisting of a mix of 88% High Density Polyethylene, 5% talcum and 7% cellulose). Cerioporus squamosus, also often encountered as Polyporus squamosus, is a basidiomycete bracket fungus, able to cause "white rot" on decaying wood. The bio-functionalized carriers were used for treatment of a synthetic wastewater sample, of Bemacid ROT (Bezema) azo-dye. Azoic dyes represent one of the most important classes of synthetic dyes used in the textile industry, accounting for over 60–70% of the dyes used in this industry. In the case of reactive groups of azo dyes (-N=N-), due to the low degrees of fixation on the fiber, there are losses of dyes in solution of up to 50%. Infrared spectral (FT-IR) analysis was carried out for determination of functional groups involved in biodegradative processes. Thus, the obtained IR spectra, different from those of initial Bemacid ROT dye, the disappearance or decrease of the signal specific to azoic bonds from the initial sample, the formation of new functional groups, the disappearance of intermolecular hydrogen bonds simultaneously with increase of transmittance values for amino groups, resulted in highlighting the degradation of Bemacid ROT dye by the bio-augmented HDPE carriers.

Keywords: *microbial degradation, azo dyes, IR, fungi, Cerioporus squamosus*

Degradarea microbiană a unui colorant azoic industrial și analiza FT-IR

Prezența coloranților în apele uzate din industria textilă, chiar și în concentrații mai mici de 1 mg/l, afectează semnificativ proprietățile estetice și gradul de transparență al efluenților publici, cu repercusiuni directe asupra mediului. Tulpina fungică Cerioporus squamosus (White-Rot-Fungi) a fost utilizată pentru bio-augmentarea suporturilor polimerice MBBR (fabricate dintr-un amestec de 88% polietilenă de înaltă densitate, 5% talc și 7% celuloză). Cerioporus squamosus, deseori întâlnită sub numele de Polyporus squamosus, este o tulpină fungică de tip bazidiomicetă, capabilă să provoace „putregaiul alb" pe lemnul în descompunere. Suporturile bio-funcționalizate au fost utilizate pentru tratarea unei probe sintetice de apa uzată, de colorant azoic Bemacid ROT (Bezema). Coloranții azoici reprezintă una dintre cele mai importante clase de coloranți sintetici utilizați în industria textilă, reprezentând peste 60–70% din coloranții utilizați în această industrie. În cazul grupelor reactive ale coloranților azoici (-N=N-), datorită gradelor reduse de fixare pe fibră, există pierderi de coloranți în soluție de până la 50%. Analiza spectrală în infraroșu (FT-IR) a fost efectuată pentru determinarea grupelor funcționale implicate în procesele biodegradative. Astfel, spectrele IR obținute, diferite de cele ale colorantului inițial Bemacid ROT, dispariția sau scăderea semnalului specific legăturilor azoice din proba inițială, formarea de noi grupe funcționale, dispariția legăturilor de intermoleculare de hidrogen simultan cu creșterea transmisanței valorilor pentru grupele amino, au dus la evidențierea degradării colorantului Bemacid ROT de către suporturile polimerice bio-augmentate.

Cuvinte-cheie: *degradare microbiană, coloranți azoici, IR, fungi, Cerioporus squamosus*

INTRODUCTION

Biotechnological methods for removing pollutants from both wastewater and soil sources are rapidly promoting, with high efficiencies, novel technologies as viable solutions for controlling pollutants. Biotechnological treatment processes are easily scalable processes that can be implemented *in situ* and which do not generate significant amounts of secondary pollutants [1]. The presence of dyes in wastewaters originating from the textile industry, even in concentrations less than 1 mg/l, significantly affects both the aesthetic properties and the degree of transparency of public water effluents, with direct repercussions on the environment [2]. Colored textile effluents are often contaminated with toxic agents, sediments, suspended and dissolved solids that serve as deposits for dyes, altering the degree of turbidity of the water, its quality and the amount of dissolved oxygen [3]. Biodegradation can be defined as the set of physical-chemical and biochemical processes by which an organic substance is transformed by microorganisms, in a natural environment and conditions (self-treatment) or in an artificial environment and conditions (biological treatment), so that the substance loses its chemical identity. Wastewater treatment by MBBR (Moving Bed Biofilm Reactor) systems has gained a lot of popularity, in the last decades, as being a flexible alternative to the traditional method of wastewater treatment, characterized by lower sludge production, smaller installation footprint, low maintenance, independent performance regarding the rest of the component systems, resilient to toxic shocks [4].

Fourier Transform Infrared Spectroscopy (FT-IR) is a non-destructive analysis technique capable of recording near-infrared (NIR) and far-infrared (FIR) spectra, with applicability in the field of organic compounds synthesis, petrochemical engineering, pharmaceutical and food industry and basic research fields.

MATHERIALS AND METHODS

Bio-augmented carriers

FT-IR analysis was performed on the degradation compounds resulting from microbial activity of *Cerioporus squamosus* bio-augmented carriers, against Bemacid Rot industrial azo-dye, from Bezema. The bioremediation experiments were carried out in the experimental installation, at a final volume of 12 l, dye concentration of 200 mg/l, in distilled water, with an initial amount of microbial inoculum of 100 ml *Cerioporus squamosus*. At the same time, for the promotion and maintenance of microbial growth, the experiment was carried out with the addition of mineral salts and glucose as carbon source. The experimental installation was loaded with approximately 3 l of polymeric supports (88% HDPE + 5% talc + 7% cellulose), together with approximately 20 PUFs carriers, arranged in both the immobilized cage under the cover of the installation and in the reaction vessel. The process was carried out for 25 days, in controlled temperature (28°C) and continuous aeration, in a Lovibond thermoreactor (figure 1).

Fig. 1. Experimental installation used for bio-augmentation of HDPE carriers and dye biodegradation

FT-IR analysis

FT-IR analysis involves the acquisition of an infrared spectrum by collecting an interferogram of the sample of interest, using an interferometer, and then applying the Fourier Transform (FT) on the interferogram to obtain and display the spectrum. The spectra were recorded on an FTIR Excalibur FTS 3000 spectrometer (Digilab), with Merlin spectrum acquisition and processing software. The spectrometer uses a Michaelson interferometer (dynamically aligned Permatrac model), with a resolution of 0.25 cm^{-1}, KBr divider (7.800–375 cm^{-1}), ceramic source (air-cooled), DTGS detector, signal ratio: noise of 30.000:1, 40 mW infrared power, kinetic scanning rate of 40 spectra/second and temperature range between 10–300 K.

In order to record the infrared spectra, the following preparation methods were used for the pure dye solution, the aqueous dye solution resulting from the discoloration analyzes, mediated by the microbial strain, and for the KBr tablets:

1) **Dye solution**: For the pure dye, used as a control sample, 1 mg of the dye was dissolved in 1 mL of ethyl alcohol, of spectral purity. In the case of the aqueous solution, resulted from the biodegradation processes, over 5 ml of the sample were added 2–3 g of anhydrous Na_2SO_4, maintained until the complete absorption of water, then 1mL of absolute ethyl alcohol (spectral purity) was added and filtered on 0.45 µm Target filters. The obtained filtrate was introduced into CaF_2, KBr and KRS cuvettes.
2) **KBr pellets**: 1 mg of dye was grounded in an agate mortar with 100 mg of KBr powder of spectral purity, and then kept in the desiccator to completely remove any moisture traces. After grinding, the mixture was immediately compressed in the hydraulic press at a pressure between 12–15 atm, for about 15 minutes, obtaining KBr tablets with a diameter of 3 cm and a high degree of transparency, on which the FT spectra were recorded.

RESULTS AND DISCUSSIONS

The bi-dimensional structure and three-dimensional conformance of Bemacid ROT dye ((CAS EINECS: 276-115-7), C24H20ClN4NaO6S2, M = 583.0 g/mol) is showcased in figure 2.

In order to record the FT-IR spectrum (figure 3), the dye was dissolved in absolute ethyl alcohol, and

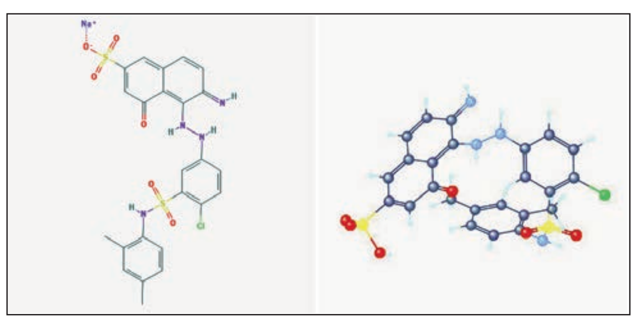

Fig. 2. Bi-dimensional structure of Bemacid ROT azo-dye

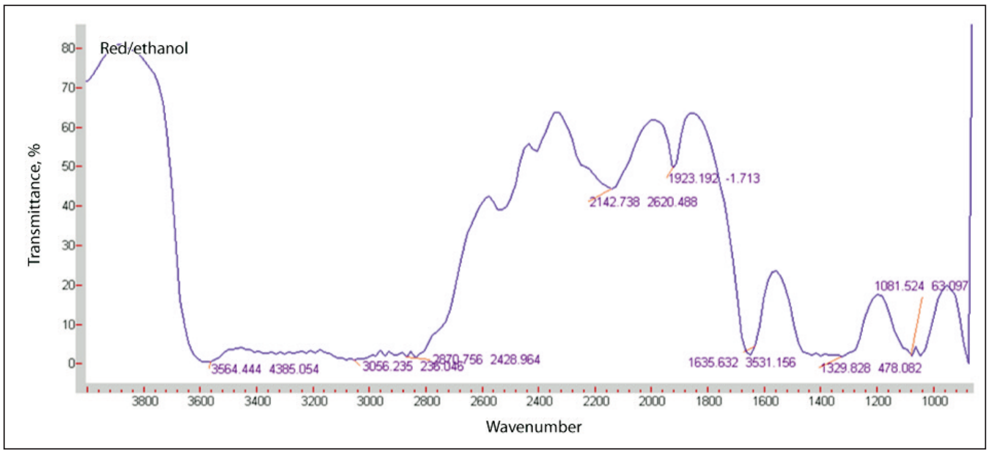

Fig. 3. FT-IR spectrum of Bemacid Rot N-TF dye, dissolved in absolute ethyl alcohol

placed in a CaF_2 cuvette with a window thickness of 0.121 μm. A CaF_2 cuvette with a window thickness of 0.122 μm was used as a reference.

As can be seen in figure 3, the FTIR spectrum shows poorly defined wide bands, especially in the 3600–2850 cm^{-1} region. The wide band located between 3600–3357 cm^{-1} is due to the overlap of the stretching vibration of the =N-H group, with the stretching vibration of the -OH group, the bands being extremely wide due to the possible interactions of the -OH and -NH_2 groups with the nitrogen from the azo bond of the Bemacid dye (formation of hydrogen bonds) [5].

The extensions of the C-H bonds, in the aromatic ring, are found in the 3100–3000 cm^{-1} range with a maximum located at 3056 cm^{-1}, and those of the -CH_3 groups, substituted on the aromatic ring, are located in the 3000–2850 cm^{-1} region with a maximum at 2870 cm^{-1}. It is possible that the wide but low intensity band located at 2142 cm^{-1} demonstrates either the presence of atmospheric CO_2 or the vibrations of the carbonyl group on the quinone ring, which due to interactions with the azo bond and possibly with the ethyl alcohol, used as solvent, has a benzenoid structure. The intense band situated at 1635 cm^{-1} can be attributed to both the bending of the N-H bond and the stretching of the C=C bond in the aromatic ring. The low intensity band at 1577 cm^{-1} can be attributed to the extension of the N-H bond in the -NH_2 group [6].

What is interesting to note is the broad band between 1550 cm^{-} and 1300 cm^{-1}, in the case of recording the spectrum in absolute ethyl alcohol (CaF_2 cuvette), a region where the vibrations characteristic of the azo bond overlap with those of S=O in R-SO_2-R. In the 1400–1300 cm^{-1} region, intense vibrations of the extension of the C-N bond appear, in the form of a wide band. The extent of the C-Cl bond in aryl-Cl is found at 1081 cm^{-1}.

In order to more accurately characterize the dye and to eliminate the effects of the solvent on it, the FT-IR spectrum was also recorded on KBr tablets (figure 4).

As it can be seen in figure 4, by recording the spectrum in KBr, much narrower and better defined bands are obtained. Thus, the broadband in the 3600–2850 cm^{-1} registered, in the case of the dye dissolved in ethyl alcohol, narrows on the 3350–3350 cm^{-1} range. In this region there are two bands, located at 3508 cm^{-1} and 3365 cm^{-1}: the band located at 3508 cm^{-1} is specific to the extension of the N-H connections, being accompanied by an intense band at 1577 cm^{-1}. This band also appears in the FTIR spectrum of the dye dissolved in ethyl alcohol, where, due to the interactions with the solvent, it is shifted to higher frequencies. At 3365 cm^{-1} the vibration of the O-H connection appears. In principle, it is difficult to distinguish between the vibrations of the N-H and O-H groups because they overlap in the 3500-3200 cm^{-1} region. Unlike the spectrum recorded in ethanol, on the spectrum in KBr, the peaks specific to the stretching vibrations of the -CH_3 groups no longer appear (figure 5) [7].

In detailing the spectrum on KBr, the intense band at 1621 cm^{-1} can be attributed to the bending vibrations of the aromatic ring. Focusing in the region, the stretching vibration of the -N=N- azo bond is

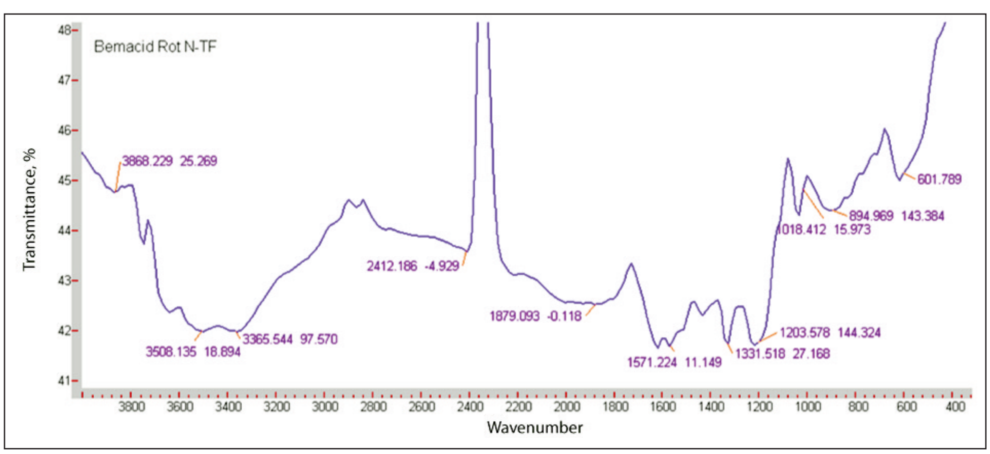

Fig. 4. FT-IR spectrum of Bemacid Rot N-TF dye, in KBr (reference: KBr)

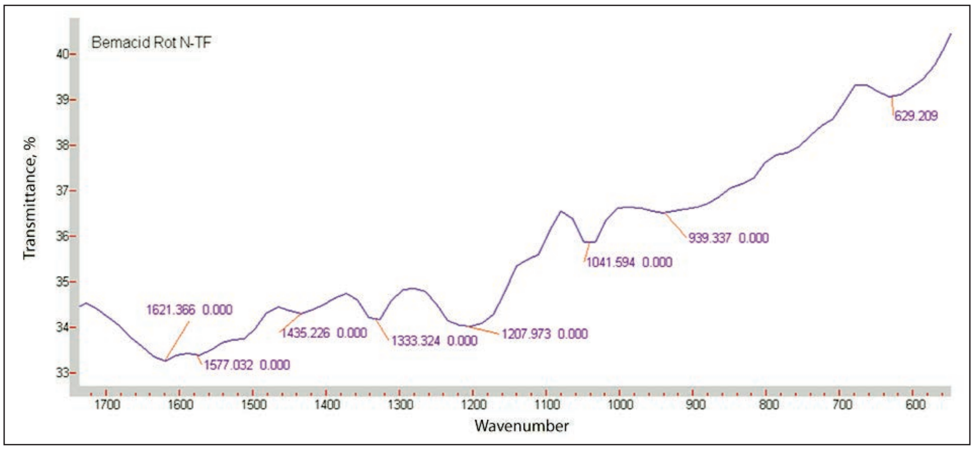

Fig. 5. Detail of FT-IR spectrum of Bemacid Rot N-TF dye, in KBr (reference: KBr)

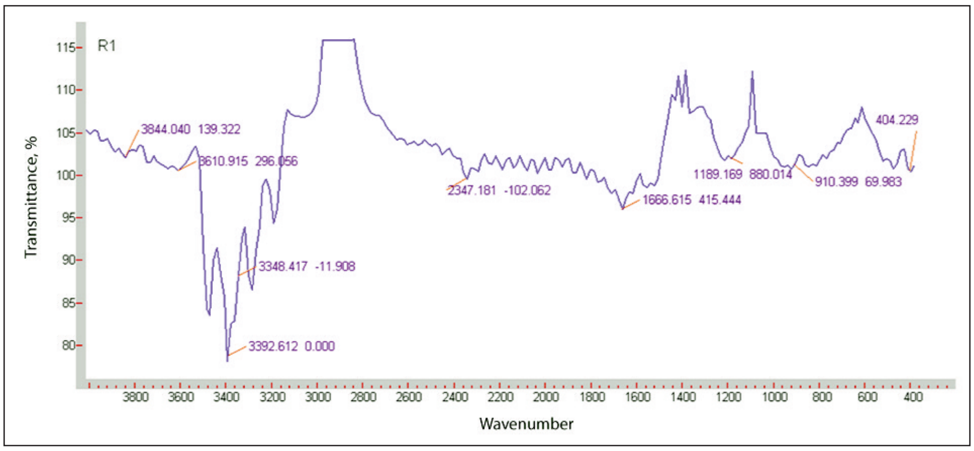

Fig. 6. FT-IR spectrum of sample dissolved in absolute ethyl alcohol (KRS cuvette, KRS cuvette reference)

observed, trans form, located at 1435 cm^{-1} in the form of a low intensity peak, probably due to the formation of hydrogen bonds with -OH and $-NH_2$, located in its immediate vicinity. The intense vibrations of the C-N bond extension are located at 1331 cm^{-1} and those of the =S=O bond, of aryl-SO_3, at 1203 cm^{-1}. The extent of the C-Cl bond in aryl-Cl is situated at 1081 cm^{-1} [8].

The FT-IR spectrum for the sample containing the Bemacid ROT N-TF dye, subjected to the biodegradation process, in the presence of the *Cerioporus squamosus* bio-augmented carriers is shown in figure 6.

The four well-defined peaks, located at 3500 cm^{-1}, 3392 cm^{-1}, 3342 cm^{-1}, 3348 cm^{-1}, indicate the vibrations of the -OH and -NH, groups existing on the naphthalene ring [9]. It can be noticed the absence of vibrations of the $-CH_3$ groups, present in the original dye solution, in the 2, 4 positions of the aniline ring and which normally should have appeared in the 3000–2800 cm^{-1} region. In addition, at 1666 cm^{-1}, a low intensity occurs, which can be attributed to the shear vibrations of the amino group, or the tensile vibrations of the aromatic C-N bond, demonstrating the presence of the substituted naftanilic ring [10]. Two peaks of low intensity are located at approximately 1189 cm^{-1} (symmetrical extent of the $-SO_2$-group) and 910 cm^{-1}.

CONCLUSIONS

Bio-augmented carriers (consisting of a mix of HDPE, talc and cellulose) were successfully bio-augmented, in a laboratory experimental installation, with *Cerioporus squamosus* WRF strain. The degradation products, resulted from the enzymatic degradation of Bemacid ROT textile azo-dye, were subjected to FT-IR analysis. The specific interactions between -OH and $-NH_2$ with the nitrogen from the azo bond (-N=N-), specific to textile dyes, could be identified, but also resulted amino groups, which can lead to the hypothesis of dye degradation, with amine formation. FT-IR determinations of the action of the microorganism (immobilized on the HDPE carriers) on azo dyes, highlighted the formation of hydrogen bonds with the azo bonds, thus indicating the partial degradation of marginal methyl groups by the microbial enzymes present in the reaction vessel. The completely different IR spectrum from the original dye demonstrates the degradation of the dye by the *Cerioporus squamosus* bio-agumented carriers, highlighting a great potential of the proposed solution, for the treatment of industrial textile wastewaters.

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