

Smart textiles for occupational safety health at oil stations and offshore platforms in the Black Sea

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ABSTRACT – REZUMAT

Smart textiles for occupational safety health at oil stations and offshore platforms in the Black Sea

The article shows that in order to develop smart textiles, elements of knowledge about the application part in the field are needed to create a model, to describe and propose how to obtain the information necessary to perform statistical analysis of data. The acquired results will serve in making feasible decisions of techno-medical-sanitation and sustainability through safety equipment. The experimental, scientific and practical contribution refers to the design of a model of “optimal sustainable techno-medical-sanitary equipment” by using smart textiles.

With the help of this model, it is possible to resort to parametric iteration/reiteration, aiming at the achievement, the value and qualitative fulfilment imposed to a general objective function of sustainable techno-medical-sanitary when smart textiles are used.

The developed model goes through further processing in “soft” information programming mode, and then, there will be the possibility and probability of its use as a calculation tool.

Keywords: textile industry, smart textiles, optimal sustainable medical technology, oil stations, offshore platforms

Textile inteligente pentru protecția sănătății lucrătorilor de la stațiile petroliere și platformele offshore din Marea Neagră

Articolul evidențiază faptul că, pentru dezvoltarea textilelor inteligente sunt necesare cunoștințe suplimentare în vederea creării unui model, pentru descrierea, obținerea și prelucrarea datelor în vederea efectuării analizei statistice. Rezultatele obținute vor fi utilizate în luarea unor decizii fezabile de salubritate tehnico-medicală și sustenabilitate, prin proiectarea și realizarea îmbrăcămintei de protecție. Contribuția experimentală, științifică și practică se referă la proiectarea unui model de „îmbrăcămintă tehnico-medical-sanitară”, prin utilizarea textilelor inteligente. Cu ajutorul acestui model se poate utiliza iterarea/reiterarea parametrică, astfel încât să se obțină valorile și cerințele calitative impuse acestor tipuri de material, atunci când se utilizează textilele inteligente. Modelul dezvoltat va fi îmbunătățit în modul de programare a informațiilor „soft”, acest lucru permițând utilizarea acestuia ca instrument de calcul.

Cuvinte-cheie: industria textilă, textile inteligente, tehnologie medicală durabilă, stații petroliere, platforme offshore

INTRODUCTION

At present, energy, including hydrocarbons, mainly participates in the energy mix and in the consumption of transport fuels. However, globally, energy is being resized, undergoing a “transitional” reconsideration.

The main directions of evolution in the distribution of petroleum products [1–3], with analytical emphasis on the area of human protection, labour, health, show that the average incidence rates of malignant neoplasms affecting hematopoietic and lymphoid tissues decrease with distance from the source of emission (for example, in the first 75 m in the vicinity of an oil distribution station), but depend fundamentally on the textile protective equipment used by workers.

There is no ideal situation in which a technical scheme for “air-steam inlet-fuel outlet” in an oil station or at the marine drilling wells to ensure the perfect fit [4–6]. Research in the field refers to descriptive statistical elements, binomial distribution elements or

Poisson distribution in micro-environments/micro-environments, in fuel distribution stations, fuels, in the area of drilling wells and spaces in their infrastructure. The participation of smart textiles in the defence of health is a fundamental way of action [7–10].

In fact, in order to develop smart textiles, elements of knowledge about the application part in the field are needed, to obtain a model, to describe and propose how to acquire the information necessary to perform statistical analysis of data, to reach results that are interpreted to serve to make feasible decisions of techno-medical-sanitation and sustainability through work clothing protection.

From a toxicological perspective, irregular biological events are recorded at petroleum distribution stations and also on offshore hydrocarbon platforms [5], indicating the effects of exposures. In essence, it is recommended that, starting from the major risks and dangers associated with petroleum products in exploration-extraction and distribution (highly flammable

products), protection operations, using smart textiles, be specific, special and safe.

RELATED LITERATURE

A World Health Organization report in 2014 points out that globally, due to handling, mishandling of petroleum products (including in the exploration-extraction perimeters) 2.3 million lives are lost and are affected properties worth over 4.5 billion euros. Volatile organic compounds are components of a heterogeneous group of chemicals that can cause adverse health effects (asthma, migraines, inflammation of the mucosa) and benzene is the characteristic of cancer risk [7, 8, 11].

The maximum allowed/maximum benzene content is regulated in Europe (Directives 2000/69/EC and 2008/50/EC). Evaluating the exposure of an organism, system or population/subpopulation to a hydrocarbon agent and its derivatives is a phase of the risk assessment process. [3]. There is always a scenario of exposures [2], through typical events or through potentially conscious, direct, negligent exposure [12, 13]. Identifying the type and nature of adverse effects marks the danger, which must also be assessed in the context of the risk assessment steps. The remedy, the incipient, immediate prevention remains the avoidance of contact with hydrocarbons and, especially, the avoidance of the use of gasoline as a degreaser and the accidental washing of hands, arms, etc.

In common practice, known as the standard for assessing the health risks caused by such exposure, the assessment, measurement of the presence and action of benzene, toluene, ethylbenzene and xylene (BTEX) is used. These components, once measured, complete the aggregate approach of quantifying the effects on exposure to the entire fuel/hydrocarbon. It is found that benzene has a carcinogenic effect and toluene [1], ethylene and xylene induce relatively non-carcinogenic health risks [14]. On the other hand, short-term exposure to gasoline is complementary to: i) skin irritation and ii) sensory dysfunction. They cause influences on the central nervous system (CNS), having as outputs conditions for fatigue, dizziness, headache, loss of coordination. All of these conditions are immediate, especially among genetically sensitive people.

According to the US Agency for the Registration of Toxic Substances and Diseases (ATSDR), there are more than 150 chemicals in gasoline, even in small amounts of benzene, toluene, xylene, ethylbenzene and traces of contaminants such as lead. Gasoline production is the result of process steps such as: i) chemical separation/fractional distillation, ii) molecular conversion/rearrangement and iii) final treatment. In some countries, leaded petrol has been banned (for example, in 2006 in South Africa) and its aromatic content has been increased from 34% to 40% (Octane Figure). In the US, the occupational safety and health standard for benzene is 3.2 mg/m^3

in an 8 hours shift. In Europe, the limit of benzene content is set at 3.2 mg/m^3 (1 ppm) in 6 hours TWA, and in South Africa, it is 16 mg/m^3 (5 ppm) in 8 hours of exposure. Prolonged exposure to benzene, even at low levels, under conditions of professional operation, induces the risk of DNA degradation/damage and leads to acute myeloid leukaemia or myelodysplastic syndrome [11].

EXPERIMENTAL WORK

Methods, classification and specific remarks

Our research aims at the network characterization of Petroleum Distribution Stations [8, 14], Offshore Platforms and intelligent textile systems recommended for use among workers. The experimental, scientific and practical contribution refers to the design of a model of "Sustainable Techno-Medical-Sanitary Optimum" $\{M(\text{TMSD})\}$ by using smart textiles. With the help of this model, it is possible to resort to parametric iteration/reiteration, aiming at the achievement, value and qualitative fulfilment imposed to a general objective function F (TMSD) of sustainable techno-medical-sanitary when using smart textiles.

The developed model continues to go through the processing in "soft" information programming mode, and later, there will be the possibility and the probability of its use as a calculation tool. The model has non-controllable values (*inputs*), transformation and obtaining controllable values (*outputs*), imposed for minimum costs and efficiency, safety, maximum sustainability (maximum techno-medical-sanitation for sustainability).

The $\{M(\text{TMSD})\}$, model, which expresses the influence of the presence of smart textiles, has the potential for iterative and repetitive valences for all situations, cases of physical and chemical aggression, excessive temperatures, etc. from oil stations but also in other areas (for example, on offshore exploration-exploitation platforms in the Black Sea) [13, 15, 16], in a limited range (0,1). In the offshore area, we are dealing with the toxicity of elements dissipated from hydrocarbons, but also with extreme weather (winter, wind, frost, excessive sun exposure, etc.) which motivates the call for smart textiles to equip workers for protection.

The special attention paid to the variable $(\text{TSMD})_{\text{max}}$, refers to the need to identify unsuitable situations in the system of distribution stations and on the Offshore Platforms of hydrocarbon-derived fuels. It is concluded that the optimal $\{(TMSD)\}$, for any variant, accompanies the "utility" but between "utility" and "optimal techno-medical-sustainable health" there can be disarticulations, different meanings (divergent increases/decreases). The use of smart textiles starts from the general framework and the achievement of comparative advantages, especially competitive in the field for efficiency, safety and sustainability.

Integrated interactive preventive model with probabilistic statistical testing for obtaining sustainable techno-medical-sanitary solutions by using intelligent textiles

Mathematical modelling requires the use of mathematical concepts and terms. [6]. A quantitative model for obtaining sustainable techno-medical-sanitary solutions using smart textiles aims at the graphic composition of the block scheme and, further, the corresponding equational formalization. The equations can be algebraic, transcendent and differential, integral or integro-differential which, through their formalizing role, can confirm some working hypotheses, of finding and interpreting. On this basis, the complex integrated interactive-preventive model with probabilistic statistical testing for obtaining sustainable techno-medical-sanitary solutions by using smart textiles is presented (figure 1).

In figure 1, the meanings of the notations are as follows: (ΔA) is impairments, (E) – oil exploitation/production (petroleum products), (Z_{pe}) – post-exploitation areas (oil/oil products in stations, offshore platforms), (A_s) – techno-sanitary impairments, (A_e) – techno-epidemiological (epidemiological) disorders, (OM) – Stations, Offshore platforms, (T_{sc}) – case study locations, (Z_{rm}^{ei}) – areas with oil resources of interest (Offshore Stations and Platforms) [7], M – management by using smart textiles, (C) – leadership through the use of smart textiles, (O_g) – organization by using smart textiles, (MC | IP) – complex interactive-preventive model with probabilistic statistical testing of the use of smart textiles, (S_i) – solutions (contributory/interactive part of the research) by using smart textiles. The advanced recommendation, on this occasion, is to emphasize the systemic and systematic concern for the inclusion of the aggregate covering parameter $\{[TMSD]\}$ in the implicit, intrinsic, technical-functional configuration of technological flows in Petroleum Stations and Offshore Smart Textile Platforms. In this context, this mathematical construction is intended for the application extension by the subsequent realization of the computerized

model, programmed, so that a specific software in the field is finally available.

Smart textiles are able to detect and react to changes in the environment. Some textiles react to external stimuli (chemical, electrical, thermal or otherwise) from the environment and provide practical results. We consider textile materials with the potential to collect, retain energy. Smart textiles, in turn, are becoming viable sources of energy. For example, the use of piezo-, pyro-, ferro- and dielectric materials in textiles induces the “intelligence” in question. However, methods are needed to manufacture different piezometric fabrics, in the context of the usual realization of woven, knitted and composite structures. In the already classical view, an intelligent system is an assembly that structurally articulates a sensor, a processor and an actuator, which manages control data. In general terms, we can speak of “portable electronics”, respectively of functional fabrics. They can be used to:

- Thermal storage for temperature regulation. For example, including microcapsules with paraffin in the fabric structure, either by coating or by the spinning process, if the waxy material changes its phase on the solid-liquid-solid alignment, heat absorption and release are achieved. Such a temperature variation formalizes the microclimate in the comfort zone. In addition, if we are dealing with textiles that store and/or change shape under external stimuli and reach or return to their original shape, they show that temperature adjustments occur.
- Thermal reactions of textiles through variations in permeability. On this basis, the transition temperatures of a kinetic nature, related to molecular chains, are recorded.
- The colour of the textile changes due to an external stimulus. This transformation induces temperature variations and comfort adjustments. Photonics, in this case, refers to the aggregation of electrochromic materials (e.g., optical fibres, LEDs) with textile fabrics.

Some wires, made of textile material, represent supports for sensors, telecommunication, heating.

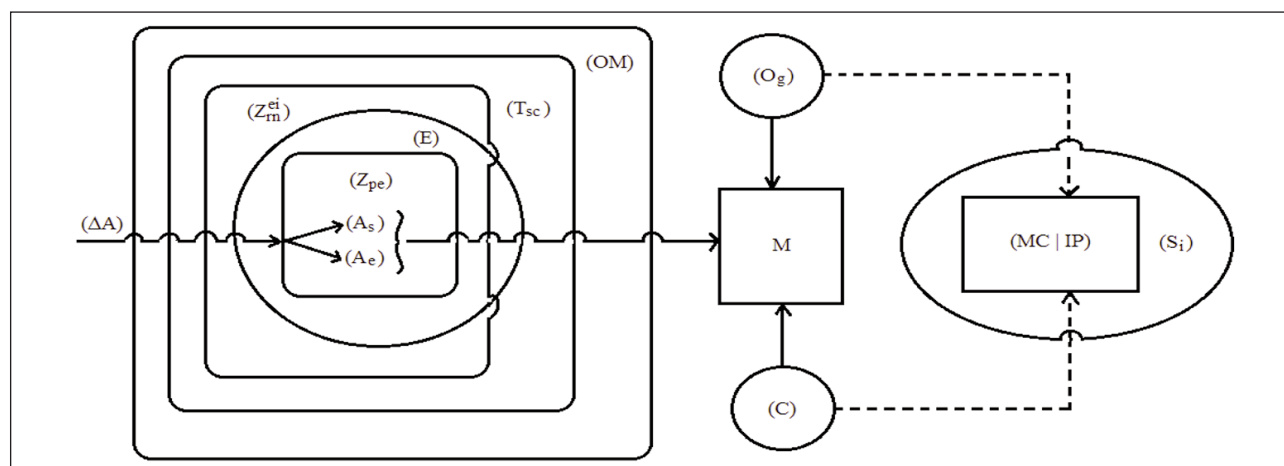


Fig. 1. Integrated interactive-preventive complex model with probabilistic statistical testing for obtaining sustainable techno-medical-sanitary solutions by using smart textiles [11]

Different textiles can be sensitive to stress, with instantaneous changes, becoming rigid or flexible to shocks. In this context, biomimetics can also be mentioned, representing similarities, similarities, imitations of biological reactions characterized by eco-natural properties (chameleonism). Smart textiles are components of protective textiles that increase overall socio-economic and health performance, sustainability [11].

RESULTS AND DEBATES

New characterization of intelligent/smart textile material in oil stations and offshore platforms

Textile-based triboelectric nanogenerators (T-TENGs) combine the functions of energy retention and self-powered detection with advantages of breathability and flexibility. This technological alignment is significant for the rapid progress in smart textiles because in the modern era the insistent requirements in the field are for versatility and multi-scenario practicability. In combination with fire-retardant conductive cotton fabrics, coated with polytetrafluoroethylene and a separator, a fire-retardant and environmentally friendly textile triboelectric nanogenerator (FT-TENG) is developed, which is equipped with fire resistance and special energy collection capabilities [9, 16]. As such, self-assembled layer-by-layer cotton fabrics have outstanding self-extinguishing performance.

In order to simply and efficiently increase the conversion capacity of portable thermoelectric textiles, a two-step in situ method is adopted. The fabrication of photo-thermo-electric textiles with a double surface takes place, one surface made of polypropylene fibres and another surface with a photo-thermal layer (PPy), respectively a thermoelectric layer (PEDOT). PPy is adapted to obtain temperature effects [15]. The PPy layer increases the photothermal conversion efficiency of the prepared fabric. The optimized photothermal fabric can improve the voltage generated from 294.13 to 536.47 μV under infrared light, and its power density is up to 13.76 nW/m^2 . A flexible photothermal strip composed of prepared fabric, covered with Ag particles and textile substrates with low thermal conductivity, shows an output voltage of 2.25, 0.667 and 0.183 mV and output power of 0.7031, 0.0636 and 0.0049 nW under IR light (sunlight, respectively on the arm).

Photothermoelectric fabrics have the potential of a smart portable device for light conversion and wealth [12]. There are already textile sensors [4] for wireless monitoring equipment. The sensors, made entirely of textile, have the interface for data flow, their electronic storage and transmission potential.

In order to verify the proposed model, the specialists from INCDTP designed and created a woven fabric with the following functional, mounting and adjustment parameters (table 1). The programming scheme for the creation of smart textiles is presented in figure 2. To increase the breathability and flexibility functions of the smart textile, the woven fabric has been coated with polyurethane. The testing is still going on in order to minimize the errors of the model.

Table 1

FUNCTIONAL AND MOUNTING PARAMETERS OF WOVEN FABRIC		
Parameters		Data/Values
Raw material	warp	100% PES
	weft	100% PES
Length density (dtex)	warp	83dtex/32fx1/850Z
	weft	110dtex/124f
Binding		weft semidouble with partial drawings D3/3 and D5/1
Warp density (yarns/10 cm)		420
Weft density (yarns/10 cm)		420
Width (cm)		175
Insertion speed (wm/min)		592
Index position		+1.5

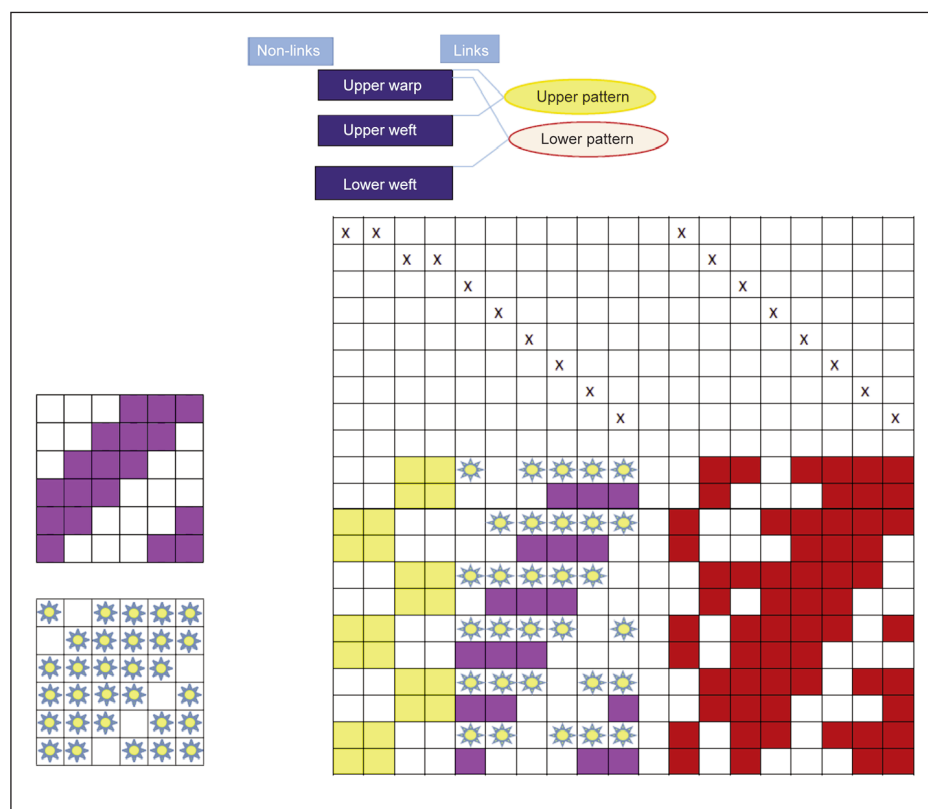


Fig. 2. Programming scheme

CONCLUSIONS

We find that in the textile industry there is the possibility of exchanging information with the help of smart textiles, a property already considered revolutionary. Textile incorporation technologies are “smart composition” type responses, and “smart textile composite” type solutions show the new performance of fabrics. So, smart textiles can feel, react and adapt to envi-

ronmental conditions. Therefore, clothing may become able to record, analyse, store, send and display data. The “new properties and utilities” type dimensions of smart clothing improve the comfort and performance of sustainable techno-medical-sanitary. General progress in the development of textiles by improving their functionality in relation to environmental conditions develops the textile market in the new global economy.

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