Textile fibres in product design

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ABSTRACT – REZUMAT

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High-performance fibres, especially carbon and glass fibres are used typically in many industries due of their performance. In addition to being widely used in industry, these fibres have attracted the attention of designers in recent years. In this research, a selection of innovative products that have received awards in international design competitions such as RedDot and IF and the use of carbon and glass fibres have been examined.
Research topics and objectives in the textile engineering literature include fibre production and performance analyses, but there are limited studies on their use and their impact in daily life. In this research, the use of high-performance fibres designed in innovative consumer products will be demonstrated to provide information on how these fibres meet everyday people as consumers to improve their lives. This research also aims to create common studying areas for two different disciplines.

Keywords: *glass fibre, carbon fibre, industrial product design, material selection, interdisciplinary*

Fibrele textile în proiectarea produselor

Fibrele de înaltă performanță, în special fibrele de carbon și sticlă, sunt utilizate în multe industrii datorită performanței lor. Pe lângă faptul că sunt utilizate pe scară largă în industrie, aceste fibre au atras atenția designerilor în ultimii ani. În cadrul acestei cercetări, a fost analizată o selecție de produse inovatoare, care au primit premii la concursuri internaționale de design precum RedDot și IF, ce includ fibre de carbon și sticlă.
Subiectele și obiectivele de cercetare din literatura de inginerie textilă includ producția de fibre și analize de performanță, dar există studii limitate privind utilizarea și impactul acestora în viața de zi cu zi. În cadrul acestei cercetări, va fi analizată utilizarea fibrelor de înaltă performanță în produse inovatoare de consum, pentru a oferi informații despre modul în care aceste fibre au impact asupra consumatorilor, în creșterea calității vieții. Această cercetare vizează, de asemenea, crearea unor zone comune de studiu pentru două discipline diferite.

Cuvinte-cheie*: fibră de sticlă, fibră de carbon, proiectarea produselor industriale, selecția materialelor, interdisciplinar*

INTRODUCTION

In recent years, there are many products in the market with the same specifications. Because of these designers want to create differences in the product's view. Products increasingly personalized and desired has been one of the decisive characteristics in the industrial product design. Individuals associate their identities with the product to represent their uniqueness. Material selection is one of the basic parameters to make difference in the products. Design is not an only visualization process. As well, designers create working with engineers and researchers [1].
Today products are personalized day by day and users start to accommodate products with their identity. Material is one of the main parameters of product design. Different materials differentiate the aesthetic and symbolic value of the product [2].
Material identification and material selection are important stages of product design. Materials are not a tool for product design. Also, they are used for determining the performance of products. Composite materials, which started to be used in product design in the 1940s, are increasingly preferred day by day. Carbon and glass fibres are one of them.
Nowadays, textiles have gone beyond their traditional usage as fabric. As a result of interdisciplinary research in textiles intersecting with composite material science, polymer science, and electronics science, high-performance fibres were developed after being widely used in construction, aircraft and automobile sectors.
The general function of textile structures is to wrap the body and protect it from external factors. Advances in textile research and development have extended the function of this material to the use of artificial vessels made of fibre. This material, which is called technical textile, is waterproof, breathable and has high-performance properties such as being antibacterial, as well as protecting against chemicals and biological organisms, ten times more durable than concrete in an earthquake [3].
The benefits of technical textiles go beyond heavy industries such as aircraft and automobile manufacturers. The use of these materials should not be limited to automotive or any other major industry. Although these materials are not widely used, they

have also been incorporated in consumer products. Design products with different innovative features include fibre-reinforced composites. The use of composites reinforced with textile fibres completes the target of the market competition of the manufacturers and meets the needs of the user with many positive features provided to the product. These products range from chairs to coffee bottles. Their importance is to be an interface that the engineering fibre encounters and serves the public good with its high performances. Therefore, this research was necessary to demonstrate the effect of textile engineering on product design with fibre-reinforced composites. The importance of composite materials reinforced fibres in the product is to realize new materials and material features for new products.

EXPERIMENTAL WORK

Structure and properties of carbon fibres

Carbon, the main components of coal and other organic compounds is non-metallic. It was introduced to the world in 1963 by the Great Britain, with its high strength and superior rigidity properties. Production started in 1968. The density of the carbon fibre varies between 1.6 and 2.2 g/cm^3 depending on the raw materials used and treatment temperature. The density of raw material used to produce carbon fibre is between 1.14 and 1.19 g/cm^3. The modulus fibres increase with the temperature of graphitization [4]. Composite materials made from carbon fibres are five times more resistant to steel constructions and their weights are 1/5 of it. Likewise, they are 7 times more durable of "6061 Aluminum" used in aeronautic sector and 2 times harder and 20% lighter. Fatigue of carbon fibre is better than all known metals if the composite material is covered with a suitable resin, thus obtaining good corrosion resistance. The electrical conductivity of far-based carbon fibres is three times more than copper [5].

Carbon fibres are used in the automotive industry mostly. This is determined by the global fibre producers. A lot of leading firms in the automotive sector such as BMW, Lamborghini, and Mercedes Benz use carbon fibre composites in their designs increasingly. The main reason for this is to reduce vehicle weight. Carbon fibre is used in the construction of car body and gear. Being lightweight and stainless increase the applicability of this fibre in industrial products [5]. Furthermore, exhaust filters are combined with carbon fibre which has capable of absorbing the stench. When automobile moves, gas emissions are captured and sent back to the fuel tank [6].

Structure and properties glass fibres

Glass can be produced in many forms from the quartz crystal to fog mosque. Glass which has an amorphous structure shows the polymeric structure. Silicon atom indicates a three-dimensional structure with turning by 4 oxygen atoms. Silicon is a lightweight and non-metallic material. Silicon located in nature in the form of silica with oxygen. For obtaining glass, silica sand is heated around 1500 °C with additives, while they dry. After that, it is allowed to cool and a rigid structure is obtained.

Glass fibres have many features: high tensile strength, weight per unit higher than steel, low thermal resistance. They do not burn but they macerate at high temperature. Also, they are resistant to chemicals. They do not conduct electricity. So they are used in case of needed electrical insulation [7].

Transition of composites to product design

Since the 1940s, designers and industry have quickly become aware of fibre-reinforced composites [8]. Charles Eames first recognized the properties of composites and became the first designer to use it. In fact, plywood is also a composite, but Eeames and Eero Saainen used this material in the chair they designed for a furniture competition in 1944, and they saw with this design that the limitations in plywood led to searching for different materials. Eames, who was searching for chair material, discovered glass fibre. The glass fibre provided the designer with lightness, durability and freedom in design. In addition, another feature of this material that affects the designer is its low price because this means that designs reach larger markets [9].

In the past few years, designers have witnessed the technical success of carbon fibre and started to experience it in the same way. Sylvain Dubisson's table composite and Alberto Medo's Light Chair (both products belong to 1987) are a turning point in this technology, and only one blocker was the high production cost. When this situation is prevented, both designs will have a commercial success [8].

METHODOLOGY

For this research, it is used qualitative research and has three stages.

Literature review

Some keywords are used such as Product design, Textile fibres, composite materials, carbon fibre, glass fibre, design-material relationship, new product development.

Sampling

To evaluate the relationship between fibres and product design some award-winning products with carbon and glass fibre reinforced were selected from RedDot and IF international design competition (table 1).

To select these products the databases of the competitions have been scanned with the key word "Carbon fibre and glass fibre" between 21th and 25th of January, 2014 [10, 11]. After this selection, a table was created which includes information about products. This information is found from the website of RedDot and IF features which are related to carbon and glass fibre are signed. Table 2 presents only an example of the developed table.

Table 1

INTERNATIONAL DESIGN COMPETITIONS	
Logo	**Detailed presentation**
reddot design award	The Red Dot Design Award is an international product design prize awarded by the Design Zentrum Nordrhein Westfalen in Essen, Germany. There are prize categories for product design agencies and design concepts. The oldest of the three awards, the Red Dot Award: Product Design had been known as Design Innovation until 2000. The competition is open to several fields of manufacturing, including but not limited to furniture, home appliances, machines, cars and tools [10].
	IF Product Design award started in 1954 and are organized annually by the IF International Design Forum. More than 2000 products from 32 different nationalities enter the competition every year. These products are evaluated by experts and are entitled to receive the IF seal according to the superior design quality. Named as the best of the best, IF Gold awards are also known as design Oscars. Starting from 2015, IF Design award will be divided into 5 different disciplines. These are product, communication, packaging, interior design and professional concepts [11].

Table 2

FEATURES OF PRODUCTS RELATED WITH CARBON OR GLASS		
Year	**Products**	**Properties**
2008	 1E58 Axtion® DP Prosthetic Foot	The 1E58 Axtion® DP prosthetic foot combines materials and form in an appealing design with a three-dimensional surface. It is functional, efficient and suitable for sports activities. Supported by the dynamic heel element, the hybrid construction of carbon and polyurethane absorbs the shock from heel strike to foot flat, thus providing more comfort while on the move. The dynamic carbon-fibre plate extends to the toe area and ensures a good energy return at the forefoot during use.
2010	 Swix Triac® Ski Pole	The innovative advancement of the Swix Triac® Nordic ski poles presents a range of technical improvements. The new hand-strap grip system ensures power transfer without loss of energy. Moreover, a new retention system allows for optimized adjustment to various hand sizes. With its triangularly shaped carbon-composite construction, the shaft is very light, and the carefully considered material selection results in optimal rigidity and strength. Also, the Swix Triac® is conceived to accommodate a change of baskets to adapt to varying snow conditions.
2011	 Element Collar	The element Collar necklace is made of small diamond pieces and carbon fibre. The concave inner surface is ergonomic, conforms to the user's neck.
2012	 The Concept Speedmax	Speedmax is pushing the boundaries of carbon fibre material by optimizing aerodynamic properties. The use of high quality carbon fibre has reduced the weight of the product to a minimum.
2013	 SR3 Pro Carbon	The SR3 Pro Carbon provides high comfort with its thin, carbon, high-positioned seat and filler under the sit-bones.
2014	 ThinkPad Ultralight Backpack	The interior is reinforced with carbon fibre rods to ensure that it has the shape of the back.

Descriptive analysis

Descriptive analysis is a qualitative research method. The descriptive analysis consists of four stages.

- establishing a framework for analysis;
- placing the data generated frame;
- data are defined and supported with quotations if deemed necessary;
- interpretation of data obtained.

In this study, tables are created and the information obtained from tables was divided into various categories and all data obtained were evaluated by examining separately. These categories are years and product groups.

RESULTS

Determination of the rise and fall according to the year of production

The first grouping is according to years. When this grouping is done, years started giving the award in the competition were accepted as the beginning in RedDot using composite material reinforced via carbon fibre started in 2007. From 2007 to 2008 there was a rising and after that a decline in 2009. But using carbon fibre in products increased rapidly to 2013 (figure 1, *a*).

In IF using composite materials reinforced via carbon fibre started in 2004. The use of materials increased and decreased in 4 years, and increased again from 2008 to 2013. While passing from 2013 to 2014, there was a decrease (figure 1, *b*).

The reason is increasingly recognized materials. Designers want to make a difference in their products and start trying new materials for their products. When 2014 was examined, it was clearly observed that there is a rapid fall, from 7 products to 3 products in RedDot. The cause of this fall is closely related to the concept of sustainability. In 2004, there is a new product Creative Aurvana Live! 2 (figure 2, *a*). This product was produced using bio-cellulose and this material provided high-performance features. This is an important step for a sustainable world.

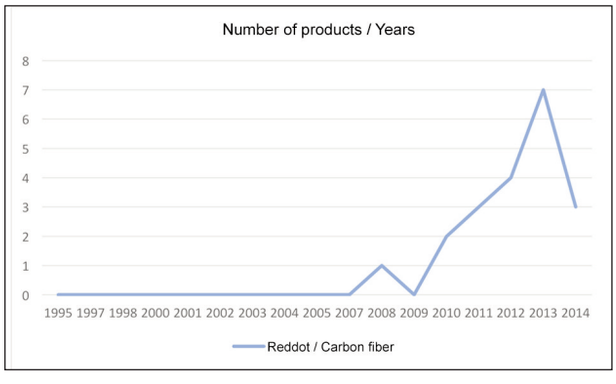
It is possible to attribute the reason for this decline to the realization of composite materials reinforced with natural fibre in IF, just like in the Red Dot competition. The product named The Pencil (figure 2, *b*) launched in 2014, confirms this hypothesis. This product uses a material called Wopex. This material is a natural fibre reinforced composite material with 60% cellulose.

In RedDot using composite materials reinforced via glass fibres started in 2004. The graph in figure 3, *a* has an unstable trend. Because this material has not high-performance features and there is a lot of material instead of composite material reinforced with glass fibres.

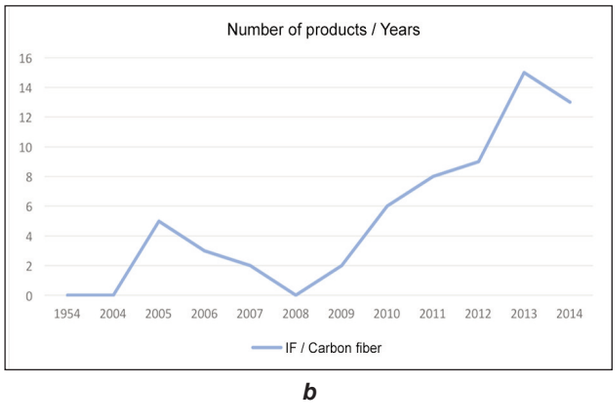
In IF using composite materials reinforced via glass fibre started in 2004. This material, which is constantly increasing and decreasing, shows an unstable trend (figure 3, *b*). The reason is that the material do not show high performance features just like the Red Dot competition.

Determination of usage by product group

The composite material reinforced via carbon fibre is widely used in sports equipment according to RedDot. This material has high-performance features and this product group requires the strength of resistance and durability (figure 4, *a*).



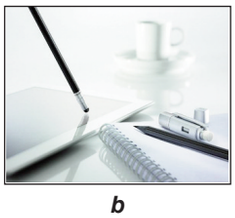
a



b

Fig. 1. Using composite materials which are reinforced with carbon fibre in: a – RedDot; b – IF according to years

a

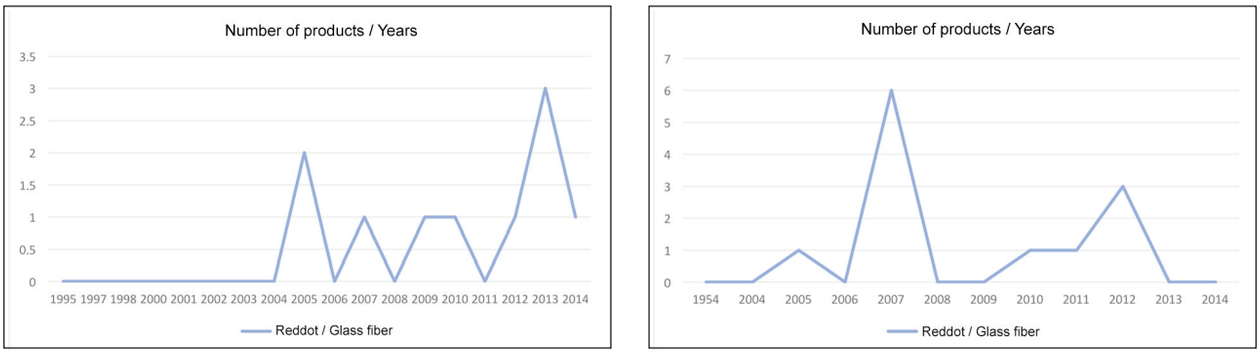


b

Fig. 2. *a* – Creative Aurvana Live! 2 [10]; *b* – The Pencil [11]

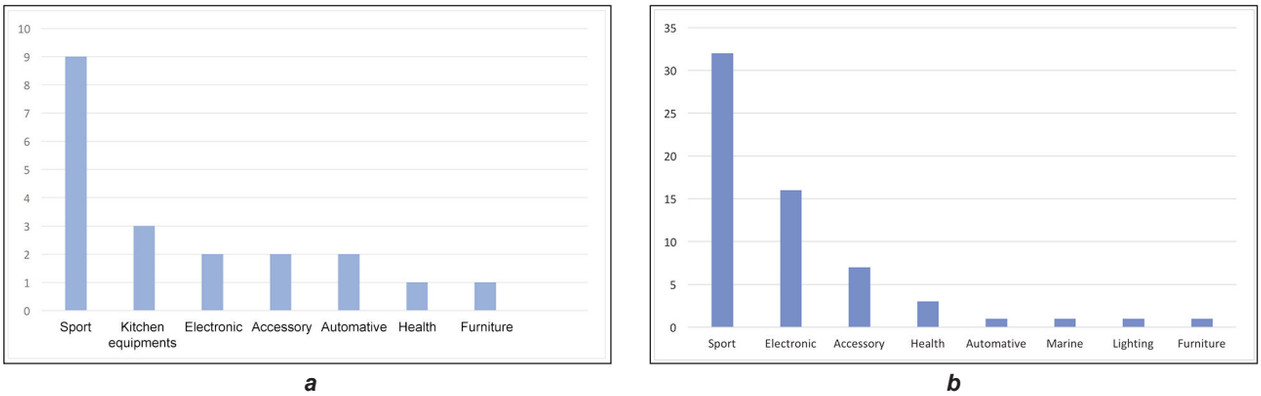
The composite material reinforced via carbon fibre is used in sports equipment widely according to IF because of lightness. The surprising point here is that when the literature research is done, the sector that was encountered the most in the use of composite materials reinforced with carbon fibre has fallen to the last places in shipping and automotive (figure 4, *b*).

The composite material reinforced via glass fibres is widely used in the furniture sector according to



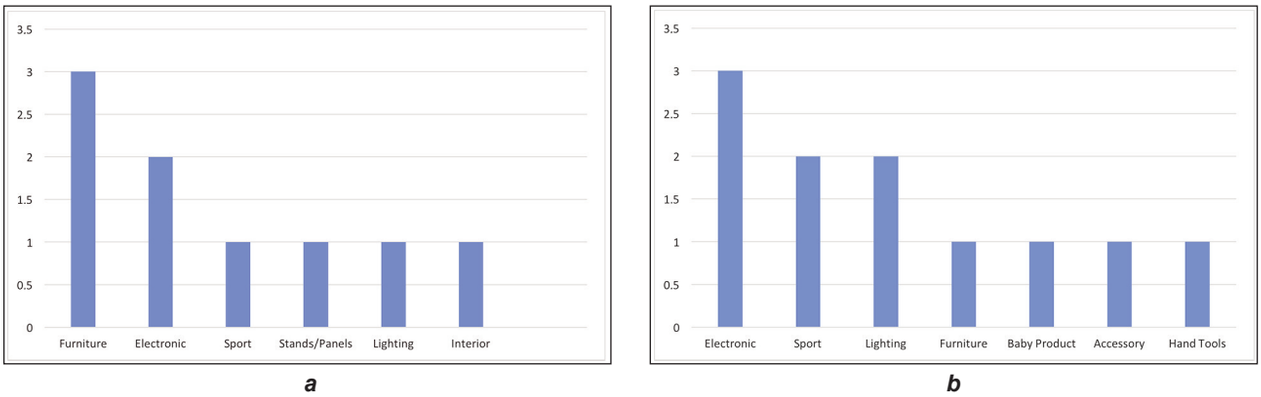
a ***b***

Fig. 3. Usage of composite materials reinforced with glass fibre in: *a* – RedDot; *b* – IF according to years



a ***b***

Fig. 4. Usage of composite materials reinforced with carbon fibre in: *a* – RedDot; *b* – IF according to product groups



a ***b***

Fig. 5. Usage of composite materials reinforced with glass fiber in: *a* – RedDot; *b* – IF according to product groups

Reddot (figure 5, *a*), because this material gives lightness features to products. The lightness is one of the basic parameters for furniture design. The composite material reinforced via glass fibres is used in the electronics sector instead of Alluminium according to IF (figure 5, *b*).

DISCUSSIONS

Design is not a linear process. This study is interdisciplinary coordination between textile and product design. Other coordination is suggested for example between materials science and product design based on this work. This study has been focused on the material, mostly new and technological materials. Therefore, the high design education with predictable performance characteristics should be involved in promoting better awareness and use of these materials. Today, the search for new materials continues with the same excitement. Even today, it seems impossible for a completely plastic aircraft to be possible. However, while 40 percent of composite-used aircraft have emerged today, they will all be reinforced with carbon or various fibres in the future and will be reinforced with ceramic engines and spread over a large area [9].

CONCLUSION

According to Mike Ashby, a designer who is aware of market needs and the best way of combining this awareness with the products is a good designer [12]. Designers are required to constantly renew and develop themselves. Therefore, designers must be aware of new technologies and follow scientific researches. Material selection is one of the important stages of product design. Making a difference in products is possible with using material selection. Today new technological materials are discovered instead of traditional materials. This study has come up from this point. Composite material reinforced with textile fibre had been firstly used in 1944 but they didn't spread because of both cost and lack of information. According to literature reviews, these composite materials are frequently used in automotive or aviation sectors which required high cost. But in daily-life products, traditional materials are preferred. In this study, a famous competition is selected and examined materials that contain carbon and glass fibres. It was clearly observed that carbon fibre has entered in our lives late but quickly. It has increased in graphs annually. Designers have had to become more aware of this material every day. This material has emerged for products that require much higher performance. For example, sports types of equipment.

But for a sustainable world, it has a decline in 2014 but it is not possible to be abandoned completely. When the glass and carbon fibre were compared, glass fibre is recognized mostly. Designers preferred this material when needed for their high-performance features.

Besides all of these, this study is very useful to see interdisciplinary coordination. According to textile disciplinary, research topics and objectives include fibre production and analysis and have limited knowledge of the use of these materials in product design. Engineers and researchers who belong to textile disciplinary will find some information about transferring some features of materials that they produce to the products. According to product design disciplinary, designers can recognize and learn new technological materials and use them in their products.

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