CONSIDERATIONS REGARDING THE ESD TYPE TEXTILE WASTE RECOVERY

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The Textile and Clothing Industry affects the environment through the use in the manufacturing process of very large quantities of water, energy and chemicals. This Industry generates a lot of waste, due to the use of a very large number of chemicals and technological processes. Waste generation implies a loss of materials and energy and imposes high environmental and economic costs to society for their collecting, treatment and processing. A permanent activity of finding technological solutions for the textile waste processing is also supported by the implementation in the economic and social life of multifunctional and adaptive textile systems for whose manufacturing smart elements are used. The work presents aspects on textile waste preliminary processing in the form of knitted bilayer textile structures containing conductive yarns. During the garments manufacturing have resulted textile waste. For these waste were conducted technological experiments of preliminary processing. This processing of the textile waste as yarns, trimmings from knitted fabrics, trimmings from woven fabrics includes the following operations: sorting depends on base colors, cutting, opening. The opening process can be characterized by: opening efficiency; unopened yarns percentage; unopened patches percentage; the average length of recovered fibers. In order to assess the fibers structures aspect, has been used the electron microscopy by analyzing their longitudinal and cross section images.

Keywords: conductive yarns, textile waste recycle, electron microscopy

INTRODUCTION

The causal system in implementing the *Europe 2020* objectives includes technological objectives as general support of economic, social and educational development. Technological objective, which is in direct relation to the economic one, is based on the principle of sustainable growth and generates emblematic initiatives referring to: "Resource Efficient Europe" and "An Industrial Policy for the Globalization Era". In this context, the Textile & Clothing Sector has a special role that is associated with major environmental impacts (Clay, 2004).

Natural resources are consumed each year. Therefore, for the fibers production, about 132 million tons of coal and 6-9 trillion liters of water (Rupp, 2008). Cotton represents about 82.5% of consumption of natural fibers used in the textile industry (Shangnan and Plastina, 2010). Cotton crops require large quantities of water, for production of a T-shirt the consumption of water is about 2700 liters (Wallander, 2014). Also, natural resources are consumed for synthetic fibers production that represents about 60% of total fibers produced worldwide (Shangnan and Plastina, 2013). Globally, the Textile Industry consumes 1 trillion kWh yearly, 10% of the carbon footprint equivalent (Textile Exchange 2010 Global Market Report on Sustainable Textiles). Dyeing processes are also environmentally unfriendly activities, for dyeing of 1 kg textile fabric, 70-150 liters of water are used (Chakraborty *et al*., 2005; Babu *et al*.,

2007). Like all waste, the textile waste are generated throughout the entire lifecycle of the textile products, from the fibers production process, textile and clothing industry, consumers, industries and commercial services (Caulfield, 2009; Dziedziczak, 2015).

Resource saving: 4.2 trillion gallons of water would be saved, that's enough to supply 27.8 million homes (Cuc, 2011; Chavan, 2014); 17 million tons of CO_2 would be saved, that's equivalent to taking 3.5 million cars off the roads; 7.5 million cubic yards of landfill space will be saved, that could fill the Empire State building 5.8 times.

With the implementation of textile fibers with advanced characteristics, the matter of textile waste gained new dimensions by the need of technological capacity of recovered fibers exploitation, through defining of new value-added products and not least by establishing the physical-mechanical characteristics of the products for new niches in the market.

MATERIALS AND METHODS

Conductive fibers and yarns are means for development of textile products meant for use in cases where uncontrolled static discharges may cause quality, health and safety issues. Type bilayer approach of the knitted structures for ESD garments allows delimitation of the accidental discharge track from the controlled discharge track of electrostatic charged fabric. The outer layer is mainly dissipative providing protection against short circuit and limiting the amount of static electricity that can be dissipated to the working environment, and the inner layer is mainly conductive, ensuring controlled draining of static electricity. An additional requirement for the inner layer is to ensure the comfort for the user.

The knitted structures for ESD garments, included the following variants:

- 100% cotton yarns;
- 100% wool yarns;
- Nega-Stat P210, 112dtex multifilament conductive yarns with trilobal carbon core and surface from polyester and Nega-Stat type P190, 156dtex;
- nylon yarns with surface saturated with carbon particles.

During the garments manufacturing have resulted textile waste. For these waste were conducted technological experiments of preliminary processing at MINET SA Ramnicu Valcea.

EXPERIMENTAL

The preliminary processing of the textile waste as yarns, trimmings from knitted fabrics, trimmings from woven fabrics includes the following operations: sorting depends on base colors, cutting, opening.

Sorting of the recyclable textiles is done manually, depending on the cleaning degree, fibers composition, color, type of materials and their destination.

Cutting of the textile waste is done to reduce their size, ensuring a good opening. If the recyclable textile materials contain chemical fibers, they are sprayed with substances to neutralize electrostatic charges and to eliminate the danger of ignition.

Opening is an operation carried out progressively, with increasingly intensities, which results in getting the opened material (M_D), which is composed of both recovered fibers (M_{D1}) as well as unopened yarn ends (M_{D2}) and small pieces of unopened fabrics (M_{D3}).

$M_D = M_{D1} + M_{D2} + M_{D3}$
Shares of the 3 components after opening are:
$P_1 = M_{D1} / M_D .100$
$P_2 = M_{D2} / M_D .100$ $P_1 + P_2 + P_3 = 100\%$
$P_3 = M_{D3} / M_D .100$

The number of opening drums is selected considering the following aspects: feed speeds of waste from one drum to another are equal; the density and gauge of the nails is increasing; drums speeds is increasing; the quantity of fed material, from one group to another, is decreasing.

The opening process can be characterized by:

- opening efficiency (70-80%);
- unopened yarns percentage (30-50%);
- unopened patches percentage (3-20%);
- the average length of recovered fibers (depending on their fibrous composition and the condition of waste/ 7-85 mm).

The percentage of unopened yarns is a parameter that contribute to increase the average length of recovered fibers. Regarding the unopened patches, the value obtained requires a careful analysis to establish the classic or unconventional technological processing flow, as well as the components of blending formula (recovered fibers/ bonding fibers).

The selection of cutting and opening technological parameters in correlation with the processing method and the characteristics of resulted material takes into account the following factors:

- type of processed raw material and processing method;
- cost - quality - efficiency balance;
- the accuracy of the sorting operation;
- technical evaluation of the equipment;
- establishing the number of opening modules;
- technological parameters processing optimization in correlation with structural and physical-mechanical characteristics of recovered fibers.

RESULTS AND DISCUSSIONS

The technological adjustments were taken into account fiber structure preservation, getting a reduced content of opened yarns and patches as well as a length of recovered fibers that allows further processing on classic and unconventional technologies. The physical-mechanical properties of opened material are shown in table 1.

Table 1. Basic characteristics of the opened material

No.	Characteristics	Value	Standard
1.	Average length	27,77 mm	STAS 12206/1983
	CV	19,23%	
2.	Unopened patches	17,47%	STAS 12206/1983
3.	Unopened yarns	47,96%	STAS 12206/1983

By analyzing the longitudinal and cross section aspect of the fibers structures, made by electron microscopy, stand out:

- a high opening degree of knitted waste (fig. 1);
- insignificant damages of the fibers on longitudinal surface (fig. 2);
- melts at the end of recovered fibers (fig. 3);
- broken cotton fibres (fig. 4).

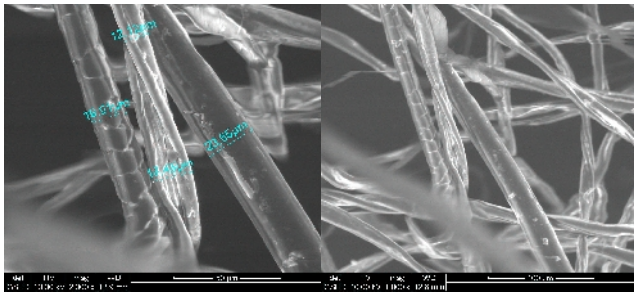

Figure 1. Opened fibres

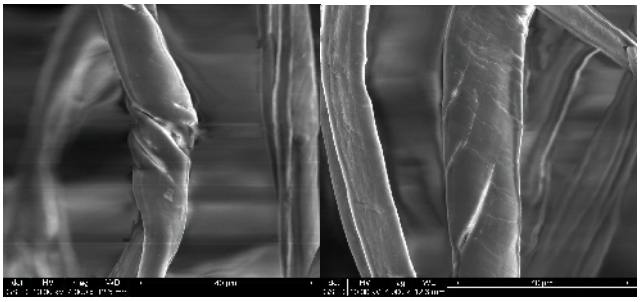

Figure 2. Damages of the fibers

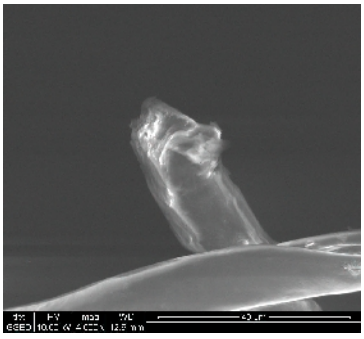

Figure 3. Melted fibre

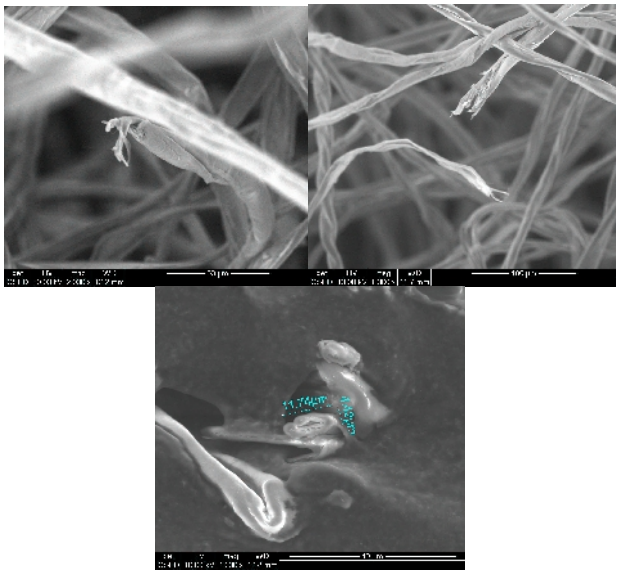

Figure 4. Broken cotton fibres

CONCLUSIONS

- The textile industry is facing a new emerging mind-set, with increasing awareness and appreciation of the resources already available today.

- Three key criteria have been identified in order to reduce the amounts of textiles in final waste disposal: i) reduced consumption of new textiles, ii) prolonged lifespan of existing textile products, and iii) reuse and recycling of textiles that no longer fit for its first intended use.

- The preliminary processing experimentations (cutting, opening) of the textile waste with conductive yarns content demonstrate technological potential of these recovered fibers which can be processed into unconventional textile elements.

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