STUDY ON RECYCLING COTTON FABRIC SCRAPS INTO YARNS

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Rezumat: Dezvoltarea unei noi conştiinţe ecologice a crescut constant interesul pentru reciclare. Reciclarea deşeurilor textile are atât avantaje pentru mediu, cât şi avantaje economice, cum ar fi conservarea resurselor naturale, reducerea poluării aerului, apei şi solului şi reducerea spaţiilor depozitelor de deşeuri. Scopul acestei lucrări a fost evaluarea filabilităţii amestecurilor ce conţin fibre reciclate de bumbac, obţinute prin tălierea şi defibrarea resturilor rezultate la croirea îmbrăcămintei. Amestecuri din bumbac reciclat şi bumbac virgin în proporţiile 20/80, 40/60, 60/40, precum şi din bumbac virgin 100 % au fost prelucrate în fire cu densitatea de lungime de 37 tex, 29.4 tex şi 25 tex ale căror proprietăţi au fost comparate.

Cuvinte cheie: resturi, deşeu textil, bumbac reciclat, fir filat cu rotor.

Abstract: The development of a new ecological consciousness has constantly increased the interest in recycling. Recycling textile waste has both environmental and economical benefits such as conservation of natural resources, reduction of air, water and land pollution, and reduction of the landfill deposits. The objective of this research work was to evaluate the spinnability of blends containing recycled cotton fibres obtained by cutting and shredding of scraps generated from the garment manufacturing. Blends of 20/80, 40/60, 60/40 recycled cotton/virgin cotton fibres and all-cotton virgin fibres were processed into rotor yarns of 37 tex, 29.4 tex and 25 tex linear density whose properties have been compared.

Keywords: scraps, textile waste, recycled cotton, rotor yarn.

1. INTRODUCTION

Due to the accelerated growth of the world population and shift in the consumer behaviour towards fast fashion, textile production and consumption have increased considerably, leading to a higher amount of textile wastes. The textile waste can be divided into two categories: pre-consumer (or post-industrial) and post-consumer waste. While the pre-consumer waste is generated in the manufacturing process of fibres, yarns, fabrics, garments and carpets, the post-consumer waste consists of worn-out or outdated textile products that the owner no longer needs [1]. Waste disposal is one of the most serious environmental problems the society is facing. Both waste incineration and waste dumping in landfills have negative environmental impact. Even if the textile waste can be used as an efficient fuel in the waste-to-energy facilities, burning waste can cause emissions of CO_2 (greenhouse gas). Therefore, incinerating waste may be appropriate only if there is no better alternative. Dumping waste in landfills also affects the environment by emissions of hazardous substances to soil and ground water. The best solution to avoid waste disposal is recycling textile waste by reusing clothing and household textiles or by mechanical processing into new generations of textiles. More than half of the post-consumer waste is given to charities and reused as second-hand products. Another part is converted into wiping and polishing cloth. A small part of the post-consumer waste and the pre-consumer waste are shredded into fibres and then converted into yarns for weaving and knitting [2, 3, 4].

Recycling textile waste brings both economical and environmental benefits. Waste should be treated as a resource of raw material that saves natural resources (natural fibres like cotton, wool and crude oil used to produce synthetic fibres). Reclaiming textiles contributes significantly to reducing air, water and land pollution generated by waste disposal and, in the case of cotton, by plant farming. Cotton growing requires substantial amounts of pesticides, insecticides, and chemical fertilizers and large amounts of water with negative impacts on environment and water resources. The landfill space required for waste disposal is substantially reduced. Recycling reduces energy and water consumption. When compared to virgin fibres, recycled fibre manufacturing avoids some energy intensive and polluting processes such as dyeing and scouring. Unlike raw wool, recycled fibres do not require thoroughly washing using large amounts of water. Moreover, coloured textiles are reused without further

dyeing. This reduces the demand for dyes and fixing agents and the environmental impact [5, 6, 7,].

In the studies published previously [8, 9, 10, 11], the reuse of secondary fibres from the ginning, opening, cleaning, and carding process has been reported. About 50 % of this category of waste consists of good fibres. The objective of this research work was to evaluate the spinnability of blends containing recycled cotton fibres obtained by cutting and shredding of clippings generated from the garment manufacturing. This category of waste contains shorter fibres than the above mentioned category that makes it more difficult to spin. To increase quality, recycled fibres have been blended with cotton virgin fibres. Yarns of 37 tex, 29.4 tex and 25 tex linear density have been spun from blends of 20/80, 40/60, 60/40 recycled cotton/virgin cotton fibres and all-cotton yarns.

2. MATERIALS AND METHODS

Scraps from garment manufacture were sorted according to their type and colour and shredded into "shoddy" fibres. For conversion of cotton clippings into fibres a tearing line consisting of a guillotine cutter, a pneumatic mixing chamber and a rag tearing machine has been used. The shoddy fibrous material, characterized by high content of short fibres, low mean fibre length, small yarn pieces and neps, is difficult to be spun alone. Therefore blends with primary fibres must be done. Virgin cotton fibres of 0.172 tex liner density, 29.5 mean length, and 20.4 cN/tex tenacity have been used as carrier fibres. The primary material had a 17 % short fibre content and 1.2 % impurities content.

The recycled cotton and virgin cotton fibres were hand blended in a mixing bed. Three variant of blends have been obtained: 20/80, 40/60, and 60/40 recycled cotton/virgin cotton fibres. The blends have been processed employing standard rotor spinning technology that included a blowroom line (one bale opener and a scutcher), a card, two drawframe passages and a rotor spinning machine. The spinning parameters were as follows: 7,500 rpm opening roller speed, OK-40 opening roller wire, 37,000 rpm rotor speed. The twist has been set corresponding to a twist factor (αm) of 150. Rotor spun yarns of 37 tex, 29.4 tex and 25 tex linear density have been spun. For comparison purposes yarns from 100 % virgin cotton fibres with similar linear densities have been obtained.

3. RESULTS AND DISCUSSIONS

The tearing line effectively broke down the fabric scraps into fibres so that no piece of fabric was found among the output fibrous material. However, the presence of small pieces of yarn in the output material was quite substantial. It is known that a high content of yarn pieces into the fibrous material adversely affects both the spinning efficiency and yarn quality. Because the flat card is the last machine where the yarn pieces can be shredded into fibres, an analysis of the content of yarn pieces into lap and card sliver has been done. The results are presented in Table 1.

As can be seen in Table 1, the percent of yarn pieces gradually decreases from the fibrous material to the card sliver as a result of their opening or removing into waste. As expected, the higher the content of the recycled fibres in the blend is, the higher the content of the yarn pieces in the lap or sliver is.

The recycled cotton/virgin cotton fibre blends have been converted into yarns of 37 tex, 29.4 tex and 25 tex linear density. The minimum twist that ensured good spinning stability corresponded to a metric twist multiplier of 150, which meant an increase in twist by 12 % to 23 % when compared to twist of all-cotton yarns. The characteristics of yarns containing recycled fibres have been compared to the characteristics of all-cotton yarns.

Figure 1 presents the count irregularity of the yarns. Even if the content of recycled fibres in the yarn increases from 20% to 60%, one cannot detect a clear trend in the evolution of count irregularity.

Figure 2 shows the tenacity of yarns. For all yarn counts, as the content of recycled fibres increases, the tenacity of yarns decreases. The magnitude of decrease lies between 3 % and 30 %. Because the recycled cotton fibres are shorter than virgin cotton, they twist around each other less times and do not contribute much to the yarn strength.

Table 1. **The content of yarn pieces in the fibrous material, lap and card sliver**

Characteristic	Blend variant		
	20/80 recycled cotton/virgin cotton fibres	**40/60 recycled cotton/virgin cotton fibres**	**60/40 recycled cotton/virgin cotton fibres**
Yarn pieces in the fibrous material [%]	32.53		
Yarn pieces in the lap [%]	6	13.06	18.1
Yarn pieces in the card sliver [%]	0.33	1.06	1.4

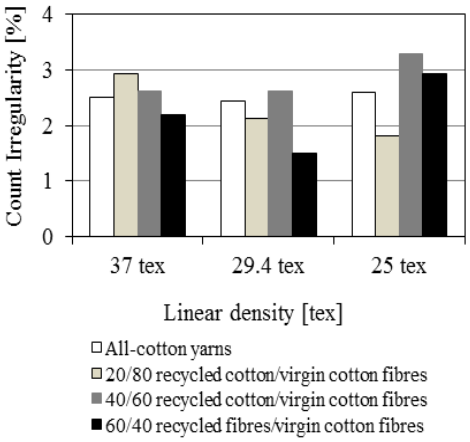

Fig. 1. Count irregularity of yarns.

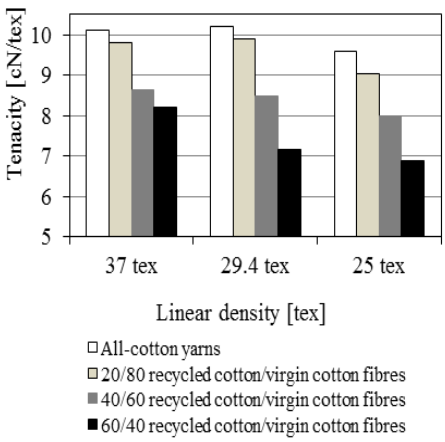

Fig. 2. Tenacity of yarns.

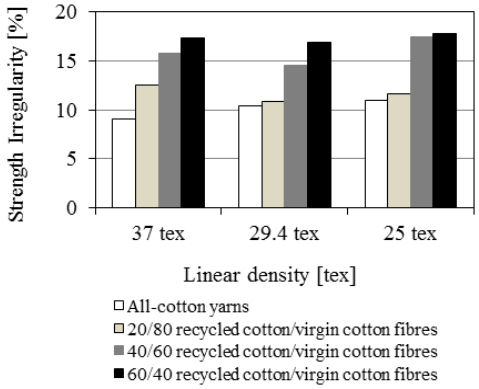

Fig. 3. Breaking strength irregularity of yarns.

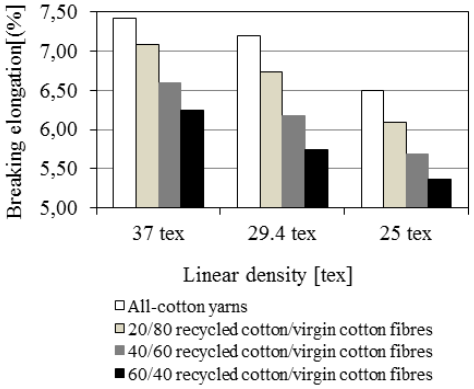

Fig. 4. Breaking elongation of yarns.

The CV of breaking strength of recycled cotton/ virgin cotton blended yarns is higher than the CV of breaking strength of all-cotton yarns (Figure 3). An increase in the content of recycled fibres led to an increase of breaking strength irregularity of yarns.

Figure 4 shows the influence of recycled fibre content on the yarn breaking elongation. When the content of recycled fibres in the yarn increases, the yarn breaking elongation decreases. It is known that the short fibres are not fixed into the yarn structure. When the yarn is stressed, the short fibres slip against each other and mainly the long fibres supports the effort resulting in a lower yarn breaking elongation. As yarns become finer, their elongation at break decreases as a result of the reduction of the number of fibres in the yarn cross-section.

All-cotton yarns showed a lower mass irregularity on short terms than the recycled cotton/virgin cotton blended yarns (Figure 4). This behaviour can be explained by the fact that the cotton fibres are longer and less variable in length than the recycled fibres. With the increase of recycled fibre content in the yarn, the yarn unevenness increases. With the exception of 25 tex yarn from 20 % recycled cotton/80 % virgin cotton, as yarns become finer and the number of fibres in the yarn cross-section decreases, the mass irregularity of yarns increases. Because the mass irregularity of the finer yarns (29.4 tex and 25 tex) is high, the application of these yarns could be those products that require absorbency rather than strength and uniformity, such as gauze bandages destined for external medical use.

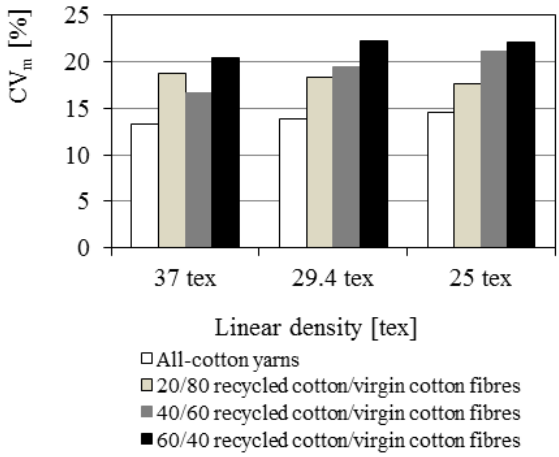

Fig. 5. CV of mass of yarns.

4. CONCLUSIONS

The production of virgin cotton has a very negative impact on environment and water resources. Cotton farming requires substantial amounts of pesticides, insecticides, chemical fertilizers and water. The reuse of cotton waste can conserve the natural resources and reduce pollution from agriculture and waste disposal. Due to increased ecological consciousness the disposal of waste is increasingly replaced by waste recycling.

The objective of this research work was to evaluate the spinnability of blends containing recycled cotton fibres obtained by cutting and shredding of scraps generated from the garment manufacturing. Blends of 20/80, 40/60, 60/40 recycled cotton/virgin cotton fibres and all-cotton virgin fibres were processed into rotor yarns of 37 tex, 29.4 tex and 25 tex linear density. Results indicate that as waste percent increases, yarn tenacity and breaking elongation decrease, while yarn tenacity irregularity and mass irregularity on short terms increase. A possible application of these yarns with content of reclaimed cotton could be gauze bandage fabrics. Such fabrics have a short lifetime and their requirements involve absorbency rather than high strength and uniformity.

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