EVALUATION OF SOME PHYSICAL PROPERTIES OF NEW DEVELOPED "SAXCELL" BLENDED WOVEN FABRICS

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ABSTRACT: *As consumer demands increase, environmental concerns also inevitably arise. Within the textile production chain, each processing step has its own environmentally harmful impact on nature. Every fiber, yarn bobbin, meter of fabric, chemical used, consumer lifecycle of each textile item, and recycling or waste stage of every T-shirt leaves its own footprint. Conventional natural fiber types such as cotton, wool, silk, and linen have their own environmental footprint related to their cultivation, processing steps, and consumer use. Similarly, traditional synthetic-based man-made fiber types have their own footprint in terms of raw material sourcing and degradation time in nature. Recycling in the textile industry holds paramount importance in the global pursuit of sustainability. Cellulose based recycled fibers have been preferred by the consumers lately as they provide sustainable products with high comfort and satisfying mechanical properties. There are different recycling methods currently discussed in various forums namely as "mechanical, thermo-mechanical and chemical recycling. SaXcell is a new cellulose based recycled fiber made from used cotton textiles. In the eco-friendly SaXcell process, the used cotton textiles are dissolved in a closed loop system where the water and chemicals used are chemically recycled during the process. The pulp obtained from SaXcell process is converted into fibers by lyocell wet spinning. Utilizing SaXcell based products are believed to be contributing to textile industry with a sustainable and circular production manner. This study has been performed in order to perform a comparative study for woven fabrics produced from new developed "SaXcell" yarns varying in different blend ratios in terms of some mechanical properties such as tensile strength, tear strength, seam slippage. As the results are satisfying , this study may encourage the producers and the consumers for utilizing of new developed 'SaXcell' fibre with different fibre blends which may create alternative sustainable textile products.*

Keywords: *SaXcell, sustainability, chemically recycling process, woven fabric.*

PROCENA NEKIH FIZIČKIH SVOJSTVA NOVIH RAZVIJENIH „SAKSCELL“ MEŠANIH TKANINA

APSTRAKT: *Kako potražnja potrošača raste, neizbežno se javlja i zabrinutost za životnu sredinu. U okviru lanca proizvodnje tekstila, svaki korak obrade ima svoj ekološki štetan uticaj na prirodu. Svako vlakno, kalem od prediva, metar tkanine, upotrebljena hemikalija, životni vek potrošača svakog tekstilnog predmeta i faza recikliranja ili otpada svake majice ostavljaju svoj trag. Konvencionalni tipovi prirodnih vlakana kao što su pamuk, vuna, svila i lan imaju svoj ekološki otisak koji se odnosi na njihovu kultivaciju, korake obrade i upotrebu potrošača. Slično tome, tradicionalni tipovi veštačkih vlakana na bazi sintetike imaju svoj otisak u pogledu izvora sirovina i vremena degradacije u prirodi. Reciklaža u tekstilnoj industriji ima izuzetan značaj u globalnoj potrazi za održivošću. Reciklirana vlakna na bazi celuloze su u poslednje vreme preferirana od strane potrošača jer obezbeđuju održive proizvode sa visokim komforom i zadovoljavajućim mehaničkim svojstvima. Postoje različite metode reciklaže o kojima se trenutno raspravlja na različitim forumima, naime „mehanička, termo-mehanička i hemijska reciklaža. SaKscell je novo reciklirano vlakno na bazi celuloze napravljeno od korišćenog pamučnog tekstila. U ekološki prihvatljivom SaKscell procesu, korišćeni pamučni tekstili se rastvaraju u sistemu zatvorene petlje gde se voda i hemikalije koje se koriste hemijski recikliraju tokom procesa. Pulpa dobijena SaKscell procesom se pretvara u vlakna mokrim predenjem liocela. Veruje se da korišćenje proizvoda zasnovanih na SaKscell-u doprinosi tekstilnoj industriji na način održive i kružne proizvodnje. Ova studija je sprovedena da bi se izvršila uporedna studija za tkane tkanine proizvedene od novorazvijenih „SaKscell” prediva koje variraju u različitim odnosima mešanja u pogledu nekih mehaničkih svojstava kao što su zatezna čvrstoća, čvrstoća na kidanje, klizanje šava. Kako su rezultati zadovoljavajući, ova studija može podstaći proizvođače i potrošače da koriste novo razvijena 'SaKscell' vlakna sa različitim mešavinama vlakana koja mogu stvoriti alternativne održive tekstilne proizvode.*

Ključne reči: *SaKscell, održivost, proces hemijske reciklaže, tkana tkanina.*

1. INTRODUCTION

The need for textile recycling is driven by a convergence of challenges: climate change, biodiversity decline, population growth, and a surge in waste volumes (partly due to improved living standards in various countries). Heightened awareness of these issues, coupled with concerns over raw material production and the consumption of textile products, is fostering a new wave of consumers prioritizing sustainable goods. Numerous textile brands, retailers, and manufacturers have begun incorporating sustainability principles into their products and supply chains over recent years. The textile sector stands as one of the largest industries globally, impacting both people and the environment at various stages, spanning from production to disposal. Cotton has been used for many years in many different regions of the world. It is a strategic fibre owing to its wide usage leading to high employment opportunities in textile sector. Fabric production and usage are significant contributors to negative environmental impacts. They have a substantial effect on the environment, leading to a reduction in cotton cultivation and the use of water, farmland, fertilizers, and pesticides on a large scale. Extending the lifespan of cotton products helps promote a cleaner, healthier world. Regarding raw material usage, the textile industry consumed approximately 118 million tons in 2021, with 24 million tons being cotton and 80 million tons being plastic-based. Projections suggest this figure will rise to 144 million tons by 2030, propelled by population expansion, improving living standards in developing nations, and the ongoing surge of fast fashion and ultra-fast fashion. The escalating utilization of synthetic materials in textiles directly correlates with an estimated 9% annual influx of microplastics into oceans [1-4].

Textile manufacturers need to find a way to transform their business models towards a more sustainable future by reducing the requirement for virgin raw material. This can be succeeded by considering recycled textile materials with the closed loop system. There are many different recycling methods being applied to re-process the different types of waste materials such as mechanical, thermo-mechanical, chemical recyling. Upstream in textile processing today, the spinner is tasked to produce yarns with recycled materials and is expected to deliver comparable quality. However, the use of mechanically recycled fibers in spinning has specific quality considerations. Such fibers have a higher short-fiber and nep content and may often be colored, particularly if post-consumer material is used. Generally, plastics are broken down into their intermediate products in chemical recycling. This can be carried out down to the polymer or monomer level. Whether the process is based on polymers or monomers, these substances need to be purified for further processing. This is accomplished by filtration or separation processes. The pure polymers or monomers can be further processed in subsequent processes into new raw material, in which the monomers must first be brought back to polymer level. Fibers can then be spun from this raw material. Since the basis is purified polymer or monomer, the newly spun fibers achieve a quality almost comparable to virgin fibers. This is a major advantage of chemical recycling. If selecting chemical recycling, the type of waste is most important. At present, processes that go back to the polymer level are primarily used if the original material is cotton-based or MMCF (man-made cellulose fibers). The cellulose is extracted and a pulping process, as already used in conventional cellulosics processes, is applied. Typically, in chemical recycling, plastics are broken down into their intermediate components, which can extend to the polymer or monomer level. Regardless of whether the process focuses on polymers or monomers, these substances require purification for further utilization. This purification is achieved through filtration or separation techniques. The purified polymers or monomers can then undergo subsequent processes to transform into new raw materials, with monomers needing to be reverted to polymer level initially. From this refined raw material, fibers can be spun. Given that the foundation is purified polymer or monomer, the resulting fibers exhibit a quality nearly akin to virgin fibers, presenting a significant advantage of chemical recycling. When opting for chemical recycling, the nature of the waste material holds paramount importance. Presently, processes reverting to the polymer level are predominantly utilized when the original material is cotton-based or MMCF (man-made cellulose fibers). In such cases, cellulose is extracted, and a pulping process, akin to conventional cellulosic processes, is implemented [4-8].

Today, there are some new considerable efforts for reducing the ecological hazard and waste generated during textile processing or developing sustainable and green materials. One of these promising approaches is to promote the usage of SaXcell fibre in textile products as virgin (100%) or with other blends. SaXcell, an abbreviation of Saxion cellulose, is a regenerated virgin textile fibre made from chemically recycled domestic cotton waste. The process to transfer domestic cotton waste into SaXcell fibre is a crucial step in the circular textile chain. SaXcell production (figure 1, figure 2) starts with sorting domestic cotton textile waste into an as pure as possible, well-defined waste stream. Next, the pure waste stream is grinded and non-textile components like zippers, nails and buttons are removed. The result is a dry mixture of textile fibres with different fibre lengths. All fibre lengths, long and short, are suitable as raw material for SaXcell. The dry mixture exists of different colours and is chemically decoloured and made suitable for the wet spinning process. Wet spinning can be done according Viscose or Lyocell processes. This means that the new fibre can be produced with few adjustments in the settings of machines on existing installations in Europe and Worldwide. The end product of this step is SaXcell, a regenerated virgin cellulose fibre. The fibre can be cut to specified lengths, spun into yarns and woven or knitted into fabrics. Colouring can take place at the fibre, yarn or fabric [9].

Figure 1: Cotton waste utilized for SaXcell fibre

Figure 2: Ecofriendly SaXcell Process [9]

2. MATERIAL

SaXcell blended yarns (50% combed cotton 50% SaxCell) of Ne 10/1 linear yarn density and 100% SaXCell yarns of Ne 30/1 and Ne 40/1 linear yarn density were produced by using the compact yarn production line. New developed compact drum spinning machine was utilized for the yarn production. Yarn quality parameters including coefficient of variation of mass (CV_m%), IPI (total number of thin, thick places and neps amount), hairiness, tensile and elongation values (%) were obtained from Uster Tester 5, Uster Tensorapid 4 by feeding cops of each system in the same order to the testers (Table 1). The tests were carried out under standard atmospheric conditions, and the samples were conditioned a minimum of 24 hours before the tests.

Table 1: Yarn properties of SaXcell fabrics

Yarn code	Yarn linear density	Yarn composition (%)	T/PM	CVm%	IPI	H	Elongation(%)	RKM (cN/tex)
SL30	Ne 30/1	100% Saxcell	860	11.3	40	4.29	9.2	29.3
SL40	Ne 40/1	100% Saxcell	1045	11.25	62	3.68	8.46	27.36
SL10	Ne 10/1	100% Saxcell	500	7.42	3.5	7.4	8.34	21.39
SLC10	NE 10/1	50%Saxcell 50% cotton	500	7	3	7.5	8.20	21.20

In order to analyse some mechanical properties of fabrics produced from SaXcell and SaXcell blended yarns, six different fabrics from different warp and weft yarn types were woven on ITEMA R9500 model weaving machine. Fabric constructional properties including the fabric weight, number of weft and warp yarns in 1 cm, fabric construction, weaving type were displayed in Table 2.

Table 2: Structural properties of woven fabrics

Fabric codes	Warp and Weft Yarn Composition	Woven type	Fabric weight (g/m^2)	Warp yarn count	Weft yarn count	Warp density (thread/cm)	Weft density (thread/cm)
F1	100% SaXcell	poplin	313	Ne 10/1	Ne 10/1	30	17
F2	100% SaXcell	Twill	167	Ne 30/1	Ne 30/1	30	17
F3	50% SaXcell 50% Cotton	Dobby woven	319	Ne 30/1	Ne 30/1	36	34
F4	50% SaXcell 50% Cotton	poplin	145	Ne 10/1	Ne 10/1	28	17
F5	50% SaXcell 50% Cotton	Twill	131	Ne 40/1	Ne 40/1	40	35
F6	100% SaXcell	poplin	145	Ne 30/1	Ne 30/1	28	17

3. METHOD

After the production of the woven samples, all fabrics were conditioned for 24 h in standard atmospheric conditions (at the temperature of 20±2°C and relative humidity of 65±2%). they were subjected to pilling, abrasion, fabric tenacity in warp and weft direction,

Tensile Strength

The tensile properties of 6 different fabric samples were measured with the Instron testing device according to ISO 13934-2 standard [10].

Tear Strength

Resistance to tearing of textiles is also an important characteristic for the fabrics.When a static load is applied to pre-cracked samples, a tearing area called “del zone” generates which arises from stretching and sequential breakage of yarn groups along the fabric. Tearing continues as the del zone moves forward in the tearing direction with further sliding of longitudinal yarns and stretching of transverse yarns. In order to get the tearing results of samples, Determination of tear force of trouser-shaped test specimens (Single tear method) was applied in warp and weft wise according to ISO 13937-2:2000 [11]

Seam Slippage Strength

Failure of the seams of the garment by breaking of the sewing thread or by seam slippage affects serviceability of the shirting fabrics. Seam strength relates to the force required to break the stitching thread at the line of stitching. Seam slippage strength of SaXcell blended fabrics were determined according to ISO 13936-1 standard by using Shimadzu tensile tester. For seam strength tests; rectangular specimens of 400 mm length and 100mm width were prepared. 5 specimens (350*100) with their long sides parallel to the weft of the fabric for determining warp seam strength and with their long sides parallel to the warp of the fabric for determining the weft seam strength according to ISO 13936-1: 2004 test standard by using Shimadzu tensile tester. The values of seam strength were recorded as the required load for failure of sewing zone. Test speed was set as 50 mm/min while the jaws' width was adjusted as 100 mm.

4. RESULTS AND DISCUSSION

Tensile strength

Tensile strength results of SaXcell blended fabrics in warp and weft wise are revealed in figure 3. According to figure 3, maximum tensile strength in warp wise was obtained from F3 coded dobby fabrics produced from 50% SaXcell 50% cotton blended yarns of Ne 30/1 linear density while minimum tensile strength was obtained from F5 coded twill fabrics produced from 50% SaXcell 50% cotton blended yarns of Ne 40/1 linear density. When it comes to tensile strength in weft wise, maximum tensile strength was provided from F3 coded fabrics produced from 50%SaXcell 50% cotton blended yarns of Ne 30/1 linear density whereas minimum value was found among F5 coded 2/2 twill fabrics produced from 50% SaXcell 50% cotton blended yarns of Ne 401 linear density.

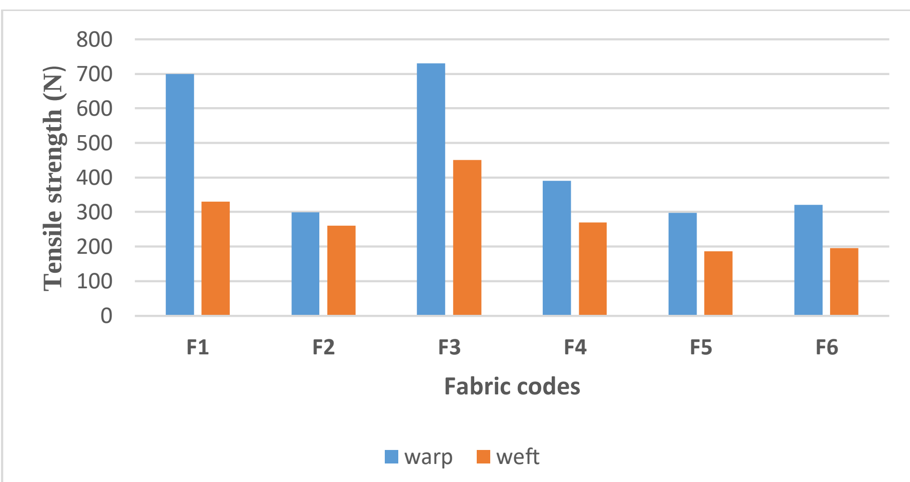

Figure 3: Tensile strength results

Tear Strength Results

Tear strength results of SaXcell blended fabrics are indicated below in Figure 4. According to Figure 4, maximum tear strength in warp wise was obtained from F3 coded dobby woven fabrics produced from 50 % SaXcell 50 % cotton blended yarns of Ne 30/1 linear density while minimum tear strength was found among F6 coded poplin fabrics produced from 100% SaXcell yarns of Ne 30/1 linear density. When it comes to tear strength in weft wise, maximum tear strength was obtained from F3 coded dobby wovens while minimum value was observed among F6 coded poplin fabrics produced from 100% SaXcell yarns of Ne 30/1 linear density. As a general evaluation, maximum tear strength results in warp and weft wise were retrieved from 50% SaXcell -50 % cotton dobby woven fabrics.

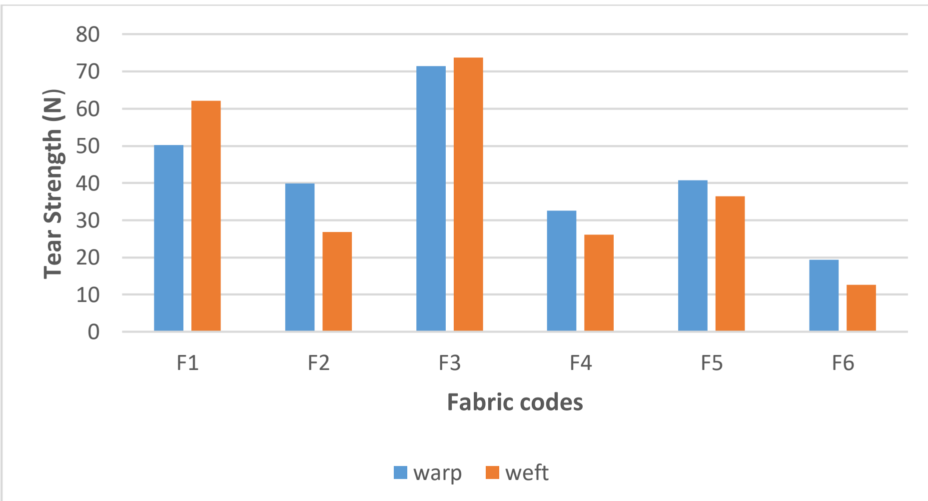

Figure 4: Tear strength results

Seam Slippage Strength

Figure 5 indicates seam slippage results of SaXcell blended fabrics. According to figure 5, maximum seam slippage strength in weft wise was obtained from F1 coded 100 % SaXcell poplin fabrics produced from Ne 10/1 SaXcell yarns while minimum value was observed among F2 coded 100 % SaXcell twill fabrics produced from Ne 30/1 SaXcell yarns. When it comes to seam slippage strength in warp wise, F2 coded 100 % SaXcell twill fabrics produced from Ne 30/1 SaXcell yarns provided highest seam slippage strength value while minimum value was obtained from F5 coded 2/2 twill fabrics produced from 50% SaXcell 50% cotton yarn of Ne 40/1 linear density. As a general evaluation the seam slippage strength results of SaXcell fabrics were found above the required value although there were some variations depending on the woven type and yarn linear density of the fabrics.

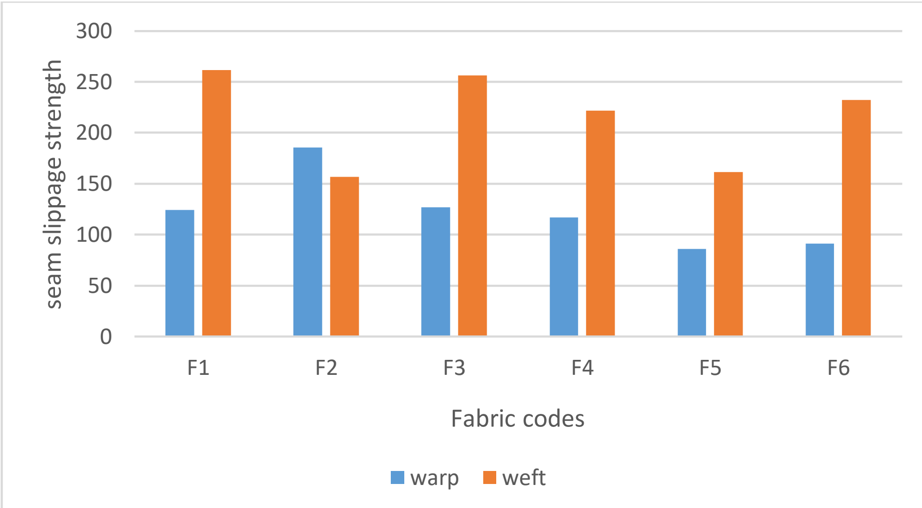

Figure 5: Seam slippage strength results of Saxcell fabrics

5. CONCLUSION

Rising consumer demands and growing environmental awareness have led to increased calls for sustainable textile materials. The intricate life cycle of textile products presents numerous potential environmental impacts within the framework of sustainability. While cotton fiber remains the favored primary material for textiles worldwide, it is imperative to minimize chemical residues throughout the entire production process, from cotton cultivation to the end products, in a sustainable manner.

SaXcell has been a new attempt for textile recycle process in a closed loop system with the sustainable manner. As the tensile, tear and seam slippage strength of woven fabrics produced from SaXcell have been satisfying this study may encourage the textile yarn producers for utilizing SaXcell in their yarn blends for a more sustainable textile production.

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