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Properties and Potential Application of the Mulberry Silk Noil Blended Rotor Yarns for Home Textile Applications

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Abstract: ***Silk is the encapsulation of extravagance with regards to texture, whether it's for robes, sheets, or dresses. The costliest silk is Mulberry silk, which is acquired from the case of the Mulberry silkworm. These silkworms are brought up in imprisonment with ideal natural conditions to raise the most beneficial silkworms and produce the greatest silk. Silk creation costs have gone up with the presentation of engineered textures like polyester. Noil is an exceptionally short fiber, "Silk noils" are got from the loss in carding, combing and spinning of silk. At present great financial advantages are acquired by creating mulberry silk noil, cotton and polyester blended yarns by rotor spinning. 13s yarn count were produced in three blend ratios. The yarn produced on the open end system has been tested for quality parameters such as count strength product, yarn imperfections, hairiness, water drying time, evaporation, and absorbency. The goal of the investigation is to decide the appropriateness of mulberry silk noil yarns in home textile applications. In particular this type of yarn is used as weft yarn in towel manufacturing.***

Keywords: Absorbency, cotton, mulberry silk noil, polyester, vertical wicking

I. INTRODUCTION

Home textile occupies a major position in global textile industry as it is known to be non apparel textile product having non industrial utilities. India occupies a promising role in the growth of home textile sector. Silk has main advantages like soft, lustrous, shiny, pleasing to eyes and more absorbency. Area of applications of silk is curtains, pillow cover, bed spread etc.

Silk is a natural protein fibre and India is the top producer of silk yarn in the world. In spite of the abundance in availability of silk. Many research workers attempted to improve the aesthetics of the silk fabric by blending with other textile fibres. But, the improvement in aesthetics is insignificant and blending with other textile fibres escalated the product cost. Hence, a technically and commercially viable development in silk materials which can augment the consumption is envisaged. There is a huge potential for diversified life style products manufactured with natural textile products. Though silk waste materials are already in use for this application. With the development of mulberry silk noil yarn a new range of life style products can be manufactured at low cost.

Silk is regarded as the queen of textile fibers. Excellent properties like its natural texture, strength, fineness, water absorbency, dyeing affinity, thermotolerance, insulation properties makes it a great demand in the textile industries .

The cost of production is highly affected due to the waste and by products generated at several stages of silk yarn manufacture. The industrial economy is also affected due to this wastage factor. Thus the silk waste can be regenerated as spun silk by blending and spinning them. (1).As a result of twisting and winding, 500 tons per annum is recorded in india.90% of it is the waste acquired from mulberry silk. (2). The hard waste of silk is used in making of carpets. The unpredictable availability of both natural and man-made fibres coupled with worlds growing population calls for a serious consideration of utilizing all the available silk waste. Silk waste and cotton slivers were blended in three different blend ratios (65/35, 50/50 and 35/65). (3). Blending of silk and wool is a way to incorporate better appearance and strength in the woolen fabric and increase the utility of silk fabric. The yarn can be used for production of warmer varieties of fabrics. The combined effect of warmth and comfort of wool with high strength, luster and good hand property of silk can be successfully achieved through blending to increase its market value (4). Silk waste from the reeling silk prepared into slivers and cut up into short lengths suitable for the short staple (cotton spinning) system (5).

Mulberry silk wastes in different ratios were processed on handloom system for opening, carding and combing. Spinning of pure and blended fibres was done on Bhageshwari charkha to prepare single ply yarn suitable for weaving purpose. Yarn count of the yarns prepared from Rambouillet wool and mulberry silk waste blend decreased with increasing proportion of silk fibre waste in yarn.

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Yarn twist per inch decreased with increasing proportion of mulberry silk waste. Strength was found to improve by blending as compared to that of pure Rambouillet wool. It was found that strength increased with increasing proportion of mulberry silk waste in yarns. From the economic point of view, processing silk and wool blend on the cotton system works out to be cheaper, without requiring change in machine set up resulted in spinning of stronger and finer yarns (6).

To make use of silk waste for better applications and to increase its commercial value, an effort was made to produce blended yarn using silk waste. Many researches on blending of mulberry silk wastes with other fibres have already been done. Some researches on blending of Mulberry silk waste with wool are also available. (7). Blending of silk and wool is the way to incorporate better appearance in the woolen fabric and to increase the utility of silk fabric. The yarn can be used for the production of warmer varieties of fabrics. The combined effect of warmth and comfort of wool with high strength, luster and good hand property of silk can be successfully achieved through blending (8).There has been a great demand for silk mixed/blended fabrics in the recent times due to the increased prices of raw silk. If the silk is blended with cheaper fibres, the cost can be reduced so that the resultant fabric can have all the desirable properties.

The properties of a fibre are governed by its chemical as well as physical structure. The resultant properties of blended products depend upon the proportions of the fibre blended (9). Dexin tested, compared and theoretically analyzed nine silk/polyester and silk/wool blended fabrics made from various blending ratio. Following conclusions were deduced: Silk/polyester blended yarn (only 35 per cent polyester fibre) can improve considerably the crease recovery and the durability of fabrics, the air permeability and the drape of fabrics can be improved with the selection of fibre materials, cloth set and weave, the crease recovery abrasion resistance and air-permeability of silk/wool blended fabrics are superior to the pure silk spun fabrics (10).

Rotor spun yarns were produced. The physical and mechanical properties of the produced yarns including linear density, tensile strength, evenness, imperfection, hairiness, frictional and abrasion resistance were studied and found that by increasing the silk fibre ratio, the yarn elongation and abrasion resistance significantly increased. However, silk fibre blend ratio has no significant influence on yarn imperfection, frictional and evenness properties. It also showed that the tensile strength of silk waste/cotton blended rotor spun yarn at 50 per cent silk fibre blend ratio, was significantly higher than that of 100 per cent cotton as well as two other blended yarns. Silk from waste rotor spin yarn had the highest tensile strength as compared to other yarn samples.

Also, by the increasing silk blend ratio, a slight reduction of yarn linear density and yarn hairiness deterioration occurred. Concerning the higher speed of rotor spinning compared with ring spinning system, the rotor spinning system is however more economical than ring spinning system.

Rotor spinning technology was evaluated for the spinning of polyester cellulosic blended yarns. It had been observed that unlike 100 per cent cotton, there was no improvement in yarn evenness and imperfections as compared to ring spun yarns. However, the mixing cost can be reduced by using uncombed cotton as well as comber noil or flat strips. Yarns up to 24s can be obtained at a comparatively lower cost by rotor spinning.

Air jet yarns generally have a harsher feel and the technology could be economical provided the initial cost of the machine was kept low. (11).Similarly, the influence of twist factor and rotor speed was studied on the properties of polyester ring and rotor yarns spun from polyester fibres of circular and trilobal cross sections. The results showed that the fibre profile plays a key role in determining the mechanical and surface properties of all polyester, polyester-viscose and polyester-cotton yarns, as evidenced by the fact that both ring and rotor yarns spun with trilobal polyester fibres have lower tenacity, higher breaking extension, more twist liveliness, lower work of rupture and higher flexural rigidity. Furthermore, lesser yarn-to-metal friction, higher dye pick up and low hairiness can be obtained for blended yarns having polyester fibres of non- circular cross section. Both twist factor and rotor speed strongly affect all the yarn properties and the behavior was similar for all the yarns (12).

Terry towel is a texture with circles on a superficial level possibly a couple of sides of the texture that can retain immense measure of water contrasted with regular structure. (13). Terry towel texture is one of the principle customer merchandise being utilized by individuals around the world. Terry towels are utilized in different spots including washroom, sports, pool, kitchen, sea shore, and so on with various water ingestion qualities. The absorptive limit of terry textures overwhelmingly relies on the material.(14). Among different normal strands, cotton fiber is the most far and wide material utilized for the creation of terry textures because of its qualities, for example, high retentiveness, hypoallergenic properties, and soon Afterward, rises the utilization of material, artificial cellulose (bamboo, modular, Lyocell, and so on) and different strands.(15). New materials utilized in terry texture creation incorporate zero-bend yarns, which are being delivered utilizing cotton and PVA strands. PVA filaments are ordinarily disintegrated during the completing cycle to improve the yarn qualities and execution. The resultant terry texture is exceptionally delicate and voluminous, which assists with expanding the water ingestion during its utilization. (16)

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II. MATERIALS & METHODS

A. Materials

The main objective of this investigation is to develop new range of Home Textile applications with mulberry silk noil rotoryarn. The mulberry silk noil yarn is to be developed by rotor spinning technique with cotton and polyester fibers.The rotor spinning system is economical compared with ring spinning system due to its higher speed. In this research work we developed three types of blended mulberry silk noil with cotton and polyester rotor yarns for 13s count and the average twist per inch of the yarn is 17. The blend ratio of type 1 yarn is (50% mulberry silk noil/50% cotton), Type 2 (50% mulberry silk noil/50% polyester),type 3 (70% mulberry silk noil/20% polyester/10% cotton).The yarn and fabric will be tested for CSP, Yarn Imperfections, Hairiness, Absorbency, Drying Time, Evaporation and wicking behaviour respectively. The developed yarns will be converted into fabric(towel) by weaving process, and converted into Home Textile. Warp count 10s Weft count 13s for three types of towels and the terry pile length 10mm.

B. Methods

The three different types of towel fabrics were tested in a conditioning chamber at 65 ± 2 % relative humidity and 27 ± 2° C. The various absorption characteristics were studied in this work. The yarn properties were analyzed by using international standard test methods, Yarn count determined by ASTM D 1907, Yarn physical properties are determined by ASTM D 1425, Water absorbency determined by AATCC 79, Spreading determined by ASTM D 7024, and Wicking determined by AATCC 197, Drying time and evaporation ratings are determined by in-house test methods.

III. RESULTS AND DISCUSSION

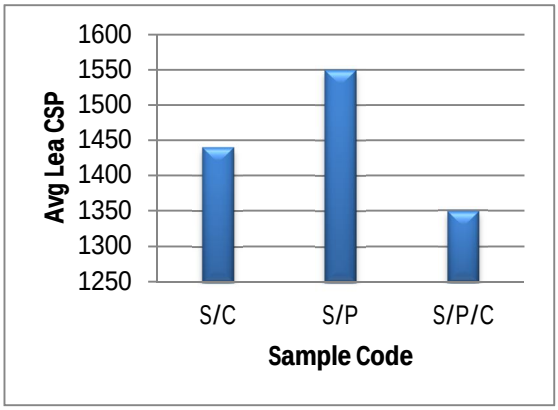
An explanation about the absorption characteristics in this study are summarized below. In tables 1 to 5 various physical characteristics of developed rotor yarns are showed.

IV. PHYSICAL PROPERTIES

A. Count Strength Product

Table 1 Yarn count strength product values of three types of yarns

Avg Lea CSP for Type-1	1440
Avg Lea CSP for Type-2	1550
Avg Lea CSP for Type-3	1350



Note: S/C-Mulberry silk noil 50% + Cotton 50% blended rotor yarn
S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 1 Average count strength product values of mulberry silk noil with cotton, polyester in different blend ratios.

Figure 1 results shows that mulberry silk noil with polyester blended rotor yarn has good CSP rating. Average CSP was observed in mulberry silk noil with cotton blended rotor yarn. Poor CSP was observed in mulberry silk noil, polyester and cotton yarns because these yarns contain 70% mulberry silk noil.So when mulberry silk noil % was increased the CSP of the yarn has reduced.

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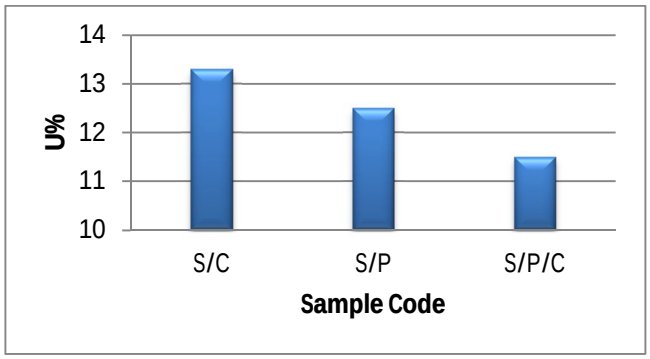
B. Uniformity Ratio

Table 2 Yarn count strength product values of three types of yarns

U% for Type-1	13.3
U% for Type-2	12.5
U% for Type-3	11.5



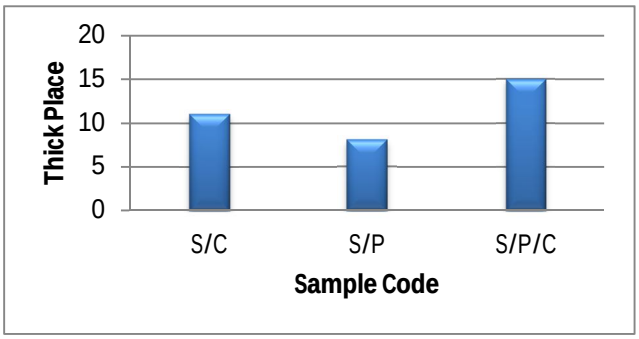
Note: S/C-Mulberry silk noil 50% + Cotton 50% blended rotor yarn
S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 2 U% values of mulberry silk noil with cotton, polyester in different blend ratios.

Figure 2 shows that the U% of the mulberry silk noil with polyester and cotton blended yarns. Good U% ratings were observed on the mulberry silk noil with cotton, mulberry silk noil with polyester and mulberry silk noil, cotton and polyester blended yarns.

C. Thin and Thick place

Table 3 Yarn thick and thin place values of three types of yarns

Thick Place (+50%) for Type-1	11	Thin Places (-50%) for Type-1	0
Thick Place (+50%) for Type-2	8	Thin Places (-50%) for Type-2	0
Thick Place (+50%) for Type-3	15	Thin Places (-50%) for Type-3	0



Note: S/C-Mulberry silk noil 50% + Cotton 50% blended rotor yarn
S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 3 Thin place values of mulberry silk noil with cotton, polyester in different blend ratios.

Figure 3 shows the thick places of the mulberry silk noil, cotton and polyester blended yarns. The results indicate that all three types of yarns possess good ratings.

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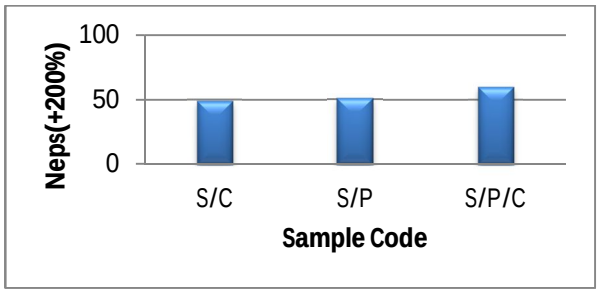
D. Neps

Table 4 Neps values of three types of yarns

Neps (+200%) for Type-1	49
Neps (+200%) for Type-2	51
Neps (+200%) for Type-3	60



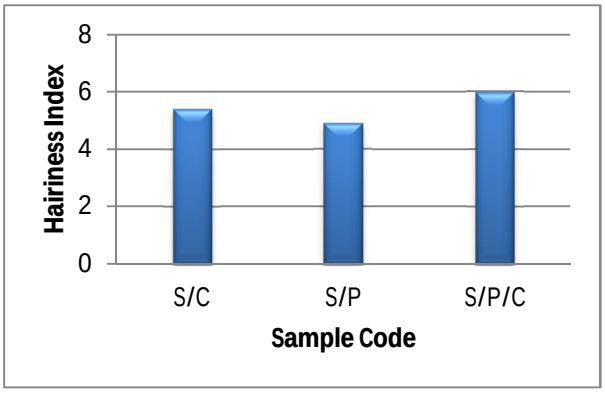
Note: S/C-Mulberry silk noil 50% + Cotton 50% blended rotor yarn
S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 4 Neps % values of mulberry silk noil with cotton, polyester in different blend ratios.

Figure 4 shows that neps % of mulberry silk noil with cotton and polyester blended yarns. The results reveal that the amount of neps present in the yarns is very less. The ratings of the yarns are good.

E. Hairiness Index

Table 5 Hairiness Index values of three types of yarns

Hairiness Index for Type-1	5.4
Hairiness Index for Type-2	4.9
Hairiness Index for Type-3	6.0



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S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 5 Hairiness Index values of mulberry silk noil with cotton, polyester in different blend ratios.

The hairiness index values of the mulberry silk noil with cotton and polyester rotor yarns are more or less the same with less hairiness. The three types of yarns are at a satisfactory level.

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F. Grams per Square Meter

The weight of fabric in grams per square meter is termed as GSM.GSM plays a important role in the textile area. Higher the GSM heavier the fabric and lower the GSM lighter in the fabric. The GSM values of the samples are mentioned in table 6.

Table 6 grams per square meter values of plain, honey comb and terry towels.

Plain bath towel GSM	Honey comb bath towel GSM	Terry bath towel GSM
120	180	380

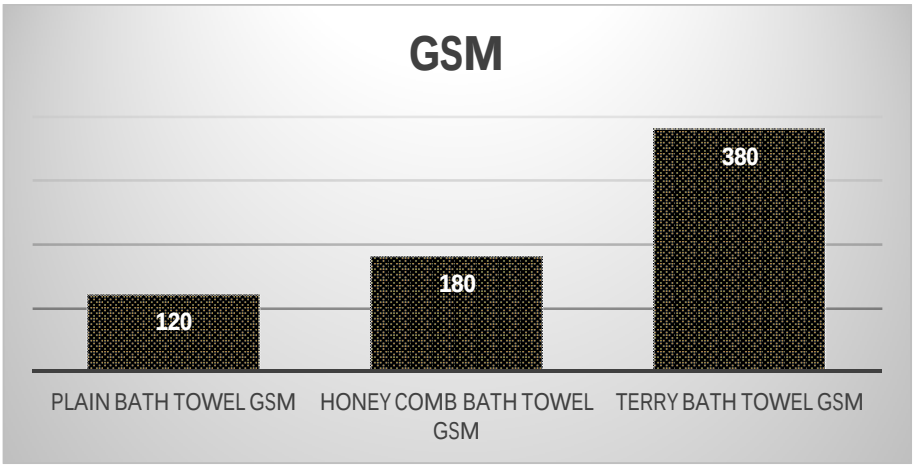

Figure 6 Grams per square meter values of plain bath towel, honeycomb bath towel and terry bath towel

Figure 6 shows that grams per square meter results of plain, honeycomb and terry towels. When compared these towels based on structure and more yarn consumption of terry towel has higher GSM. The higher GSM plays an important role in absorbency properties.

V. MOISTURE PROPERTIES

A. Water Absorbency

Table 7 water absorbency for plain, honey comb and terry bath towels using their blend ratio weft yarns

Towel Type	50% mulberry silk noil/50% cotton rotor weft yarn	50% mulberry silknoil/50 % cotton rotor weft yarn	70% mulberry silk noil/20% polyester/10% cotton rotor weft yarn
Plain bath towel	Droplet completely penetrate -3 seconds	Droplet completely penetrate -6 seconds	Droplet completely penetrate -2 seconds
Honey comb towel	Droplet completely penetrate -20 seconds	Droplet completely penetrate -30 seconds	Droplet completely penetrate -10 seconds
Terry towel	Droplet completely penetrate -1 second	Droplet completely penetrate -3 second	Droplet completely penetrate -<1 second

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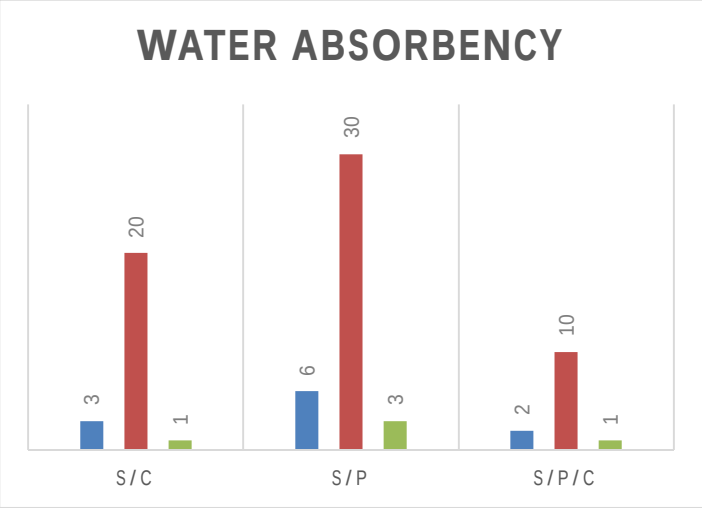

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S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 7 water absorbency for plain, honey comb and terry bath towels

Figure 7 shows that water absorbency for plain, honey comb and terry bath towels. The time taken by a dropping of water to penetrate in when placed on the fabric is recorded and the results are mentioned in table 7.

When compared to mulberry silk noil with cotton, mulberry silk noil with polyester and mulberry silk noil, polyester and cotton blended weft yarn used in the terry towel has immediate absorbency that takes place in less than 1 second. In the blend ratio point of view, when the amount of mulberry noil % increased the absorbency also increased and also the mulberry noil with cotton combination was also good when compared to mulberry noil with polyester combination.

B. Spreading Test

Table 8 water diameter of spread for plain, honey comb and terry bath towels using their blend ratio weft yarns

Towel Type	50% mulberry silk noil/50% cotton rotor weft yarn	50% mulberry silknoil/50 % cotton rotor weft yarn	70% mulberry silk noil/20% polyester/10% cotton rotor weft yarn
Plain bath towel	Diameter of spread after 1 minute - 4.7cm	Diameter of spread after 1 minute - 3.6cm	Diameter of spread after 1 minute -5.9cm
Honey comb towel	Diameter of spread after 1 minute - 3.5cm	Diameter of spread after 1 minute - 2.9cm	Diameter of spread after 1 minute -4cm
Terry towel	Diameter of spread after 1 minute - 2.4cm	Diameter of spread after 1 minute - 1.8cm	Diameter of spread after 1 minute -3cm

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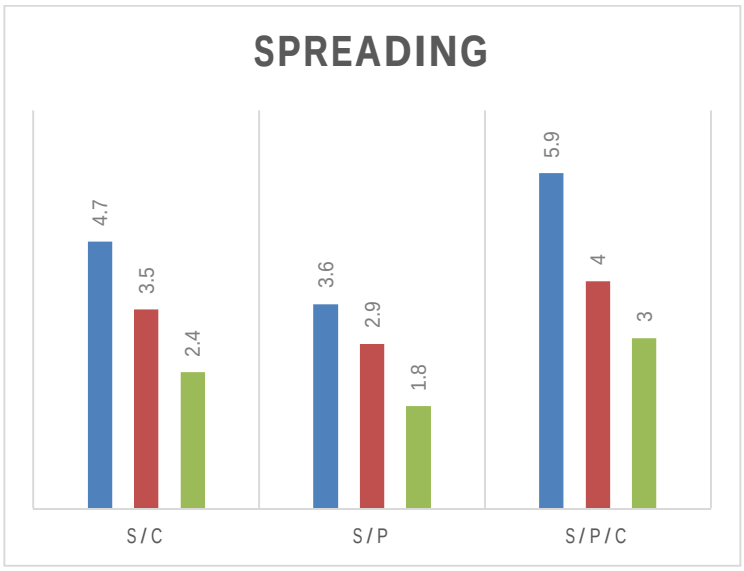
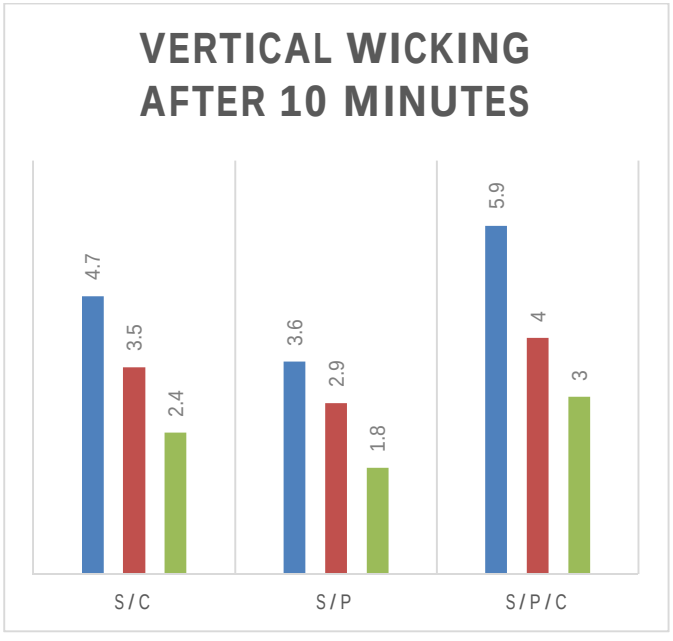


Note: S/C-Mulberry silk noil 50% + Cotton 50% blended rotor yarn
S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 8 Spreading rate of plain. Honey comb and terry bath towels.

Figure 8 shows that Spreading rate of plain, Honey comb and terry bath towels. The maximum diameter of spread after 1 minute on applying 1 ml of water is recorded and the results are mentioned in table 8. The towel structure influenced the spreading rate. Spread after 1 minute for thin bath towel get higher diameter at higher amount of mulberry noil % that is present in plain towel when compared to honey comb and terry bath towels.

C. Wicking Test



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S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 9 vertical wicking rates of plain, honey comb and terry bath towels

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Table 9 vertical wicking rate for plain, honey comb and terry bath towels using their blend ratio weft yarns

Towel Type	50% mulberry silk noil/50% cotton rotor weft yarn	50% mulberry silknoil/50 % cotton rotor weft yarn	70% mulberry silk noil/20% polyester/10% cotton rotor weft yarn
Plain bath towel	Vertical Wicking Length-7.2cm After 10 minutes Vertical Wicking width-7.5cm After 10 minutes	Vertical Wicking Length-5.1cm After 10 minutes Vertical Wicking width-5.3cm After 10 minutes	Vertical Wicking Length-8.4cm After 10 minutes Vertical Wicking width-8.5cm After 10 minutes
Honey comb towel	Vertical Wicking Length-4.7cm After 10 minutes Vertical Wicking width-4.8cm After 10 minutes	Vertical Wicking Length-4.0cm After 10 minutes Vertical Wicking width-4.1cm After 10 minutes	Vertical Wicking Length-5.6cm After 10 minutes Vertical Wicking width-5.8cm After 10 minutes
Terry towel	Vertical Wicking Length-2.7cm After 10 minutes Vertical Wicking width-2.9cm After 10 minutes	Vertical Wicking Length-2.2cm After 10 minutes Vertical Wicking width-2.4cm After 10 minutes	Vertical Wicking Length-3.1 After 10 minutes Vertical Wicking width-3.4cm After 10 minutes

Figure 9 shows that vertical wicking rate of plain, honey comb and terry bath towels. The wicking statures estimated each moment for 10 min for an immediate assessment of the texture's wicking capacity. (17). A 3.5cm X 3.5cm sample is taken the distance travelled by water on dipping on end of the fabric it is recorded and reported in table 9.Fabric GSM plays an important role vertical wicking. Here the higher GSM of terry towel the water travel length after 10 minutes is less. But the GSM is low in plain bath towel of light weight and more permeability so that the water easily travels to the maximum of 8.5cm at mulberry noil/polyester/cotton combination weft yarns.

D. Absorption Test

Table 10 water pick for plain, honey comb and terry bath towels using their blend ratio weft yarns

Towel Type	50% mulberry silk noil/50% cotton rotor weft yarn	50% mulberry silknoil/50 % cotton rotor weft yarn	70% mulberry silk noil/20% polyester/10% cotton rotor weft yarn
Plain bath towel	After 10seconds weight the pickup of water -7.3ml	After 10seconds weight the pickup of water -5.5ml	After 10seconds weight the pickup of water -10ml
Honey comb towel	After 10seconds weight the pickup of water -19ml	After 10seconds weight the pickup of water -15ml	After 10seconds weight the pickup of water -22ml
Terry towel	After 10seconds weight the pickup of water -31ml	After 10seconds weight the pickup of water -26ml	After 10seconds weight the pickup of water -40ml

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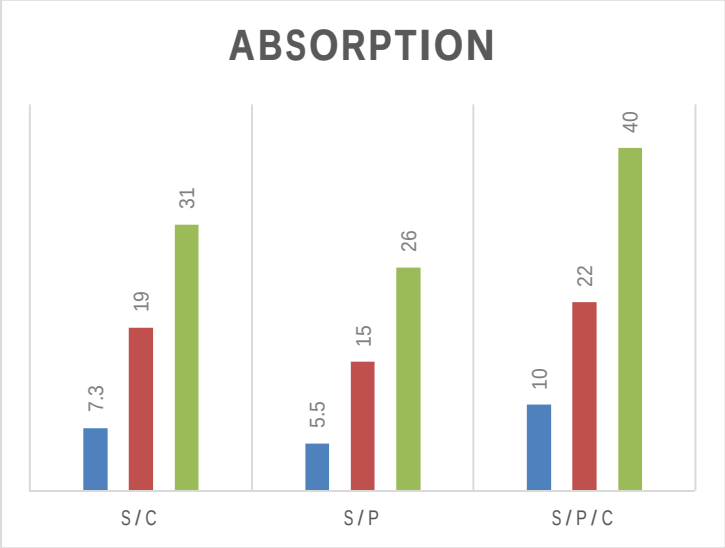

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S/P- Mulberry silk noil 50% + Polyester 50% blended rotor yarn
S/P/C- Mulberry silk noil 70% + Polyester 20% + Cotton 10% blended rotor yarn
Figure 10 Absorption of plain, honey comb and terry bath towels

Figure 10 shows that Absorption of plain, honey comb and terry bath towels. Take a circular fabric of 10cm diameter and place on a beaker conditioning water for 10 seconds. An area exact pick of water is weighted. The results recorded and reported in table 10.The terry structure have more piles and also more GSM.The pickup water is high for terry towel when compared to plain and honey comb bath towels and the amount of mulberry noil % is higher. Weft yarn terry towel has great wet pickup.

E. Drying Time

After wetting the fabric samples completely, they are hydro extracted and weighted exactly, vertically hung and weights are calculated every 5 minutes until a constant weight is reached. Drying time for thin bath towel-Fast, Drying time for Honey comb bath towel-Medium, Drying time for Terry Towel-Slow.

F. Evaporation

Initially a circular fabric in weighted by placing in the bottom of per try dish before adding 1ml of water and then it is reweighted after 30minutes and % of water evaporated is recorded. The results are reported in table 11.

Table 11 Evaporation rating for plain, honey comb and terry bath towels for three blend ratio weft yarns

Towel Type	50% mulberry silk noil/50% cotton rotor weft yarn	50% mulberry silknoil/50 % cotton rotor weft yarn	70% mulberry silk noil/20% polyester/10% cotton rotor weft yarn
Plain bath towel	Medium	Fast	Medium
Honey comb towel	Medium	Fast	Medium
Terry towel	Slow	medium	Slow

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VI. CONCLUSION

In this work, the silk noil, cotton, polyester blended yarn was successfully manufactured in rotor spinning and the yarn is used to manufacture home textile towel products. Mulberry silk noil rotor yarns were tested and analyzed and reported. In addition the yarn was used to weft yarn for plain, honey comb and terry towel. These towels were checked for water absorption selected properties according to certain standard norms. Highest absorption rate was observed in terry towels. Thus it is concluded that an increasing mulberry noil % of the fabric is responsible for the moisture absorption properties. So the mulberry silk noil, polyester and cotton blended rotor yarns are more suitable for weft yarn in terry towel manufacturing.

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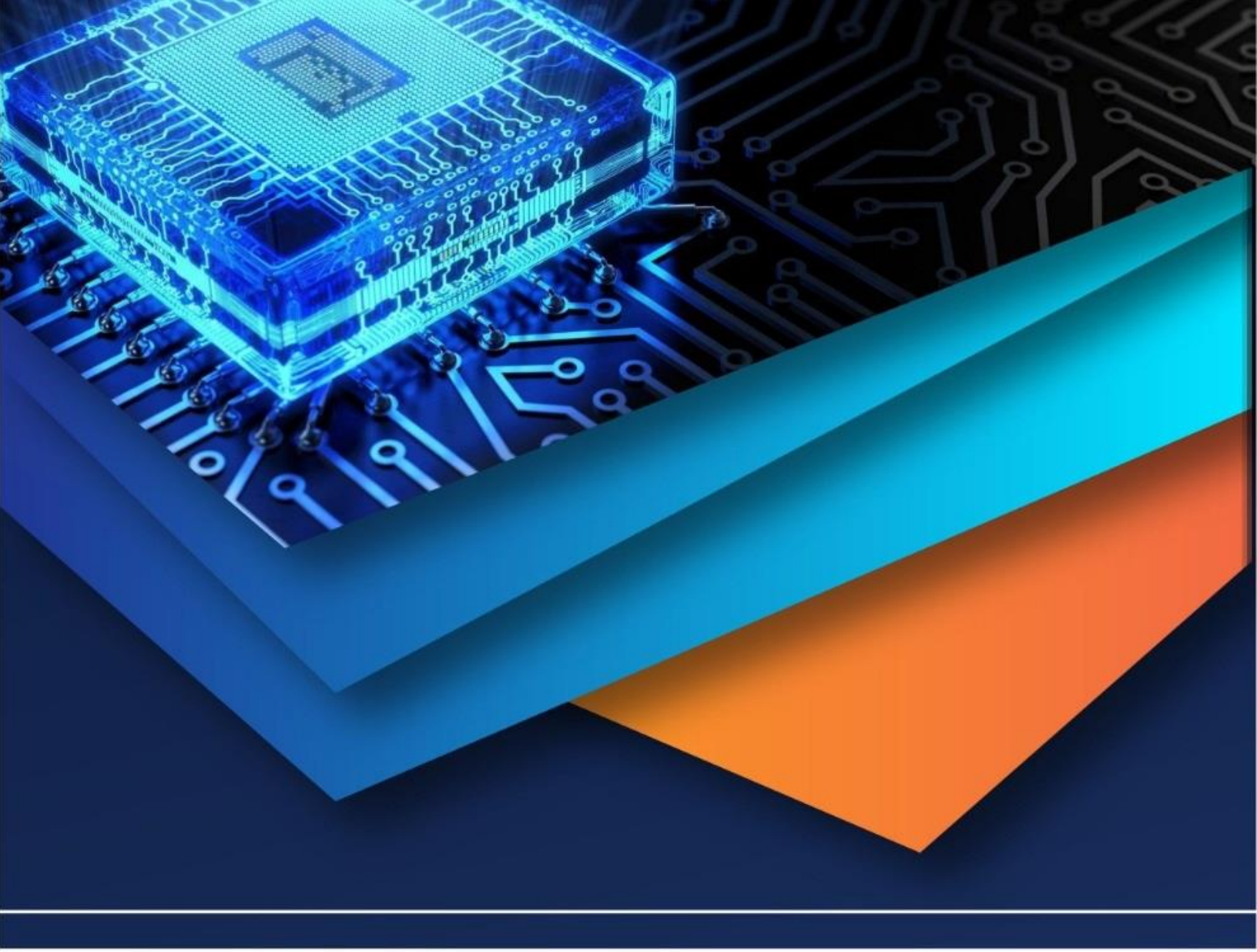

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