

Factors Influencing The Performance Characteristics of Terry Warp-Knitted Towels

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ABSTRACT: Terry fabrics and particularly – terry towels, are among the most frequently used textile items in the world. A terry towel is described as a textile product which is made with loop pile on one or both sides generally covering the entire surface or forming stripe, checks, or other patterns. Terry fabric can be produced by warp knitting as well as by weaving. This study aims to investigate the availability of warp knitted pile fabric as a durable towel. In this paper the effects of pile yarn material, pile height, fabric structure, fabric weight and thickness on the performance characteristics of warp knitted towels are tested and reported. For this reason, Eighteen knitted towels were manufactured by terry Tricot warp knitting machine using different materials (cotton, polyester microfibers and bamboo fibers) associated with different towels purposes. Water absorption behavior, structural parameters, and mechanical properties are evaluated. The results showed that the performance characteristics related behavior of terry towel fabrics were based on their fabric constructions parameters.

KEYWORDS: Bamboo fibers, Microfibers, Performance characteristics, Terry towel, Tricot warp knitting machine.

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I. INTRODUCTION

A towel is a piece of absorbent fabric or paper used for drying or wiping. It draws moisture through direct contact, often using a blotting or a rubbing motion. Common household textile towels are made from cotton, rayon, bamboo, nonwoven fibers or a few other materials. The name "terry" comes from the word "tirer" which means to pull out, referring to the pulled out by hand to make absorbent traditional. Terry towel is a fabric with loops on the surface either one or two sides of the fabric that can absorb huge amount of water compared to conventional structure. Terry towel is characterized by soft touch, thick texture, excellent water absorption and heat retention. Terry towel or fabric with loop piles can be produced using both weaving and knitting technology. The terry can form pattern effect on the knitting surface distributed according to some certain rules [1, 2].

Terry fabric formation by warp knitting technique is generally more economical than weaving technique due to its higher production rate. Synthetic fibers are generally used in ground yarns in order to add strength and stability to the warp knitted structure[3]. Terry towel fabric is one of the main consumer goods being used by people globally. Market requirements for terry towels include performance, fashion, style, color, pattern and hand [4]. Terry towels are used in various places including bathroom, sports, swimming pool, kitchen, beach, etc. with different water absorption characteristics. The absorptive capacity of terry fabrics predominantly depends upon the material (fiber type, yarn count, etc.) and structural parameters (pile height, structure and stitches density) [5, 6].

Among various natural fibers, cotton fiber is the most widespread material used for the production of terry fabrics due to its characteristics such as high absorbency, hypoallergenic properties, etc. Later, rises the use of linen, man-made cellulose (bamboo, modal, Lyocell, etc.) and other fibers [7].Bamboo may be the next premium fiber other than high quality cotton fibers. Bamboo can be used in towels because of its softness, luster, antibacterial properties and greater absorbency. Bamboo towels are made from either a combination of cotton and bamboo or of just bamboo. These towels are very absorbent and are made from a plant that is anti-bacterial, because of its natural properties. The bamboo plant also grows well in an environment where it does

not attract any bugs or other pests [8]. Microfiber is traditionally defined as a fiber with a denier of less than one denier. Micro-fiber towels are also pushing into the ultra-touch/high absorbency arena with a manmade synthetic product constructed primarily from a blend of polyester and polyamide. The result is a cloth that goes through another process to split its fiber into smaller "micro" fibers, creating tiny channels. As each microfiber strand may be smaller than the bacteria it is attracting, it is able to penetrate microscopic particles of dirt and grease on a surface. Micro fiber towels can absorb 5 to 7 times their weight in water. Microfiber towels are thinner than cotton towels and weigh less, though they are excellent at absorbing water [9].

Warp-knitted pile fabrics can be classified into three categories according to different processes. Plush or fleece fabric is produced on a double-needle bar Raschel machine and gray fabric with connected pile yarns is cut into two pieces of pile fabric by a cutting machine[10]. Cut pile fabric is produced by warp-knitted terry machine [11]. Both of the mentioned pile fabrics have even and protruding piles. Brushed fabric is normally produced on a Tricot warp-knitting machine with three or four guide bars. The long underlaps of knitted fabric are broken up and raised into piles on a raising machine. Different from the other two kinds of pile fabrics, piles on this brushed fabric are uneven and declining. Due to the high speed of the Tricot machine, the production of brushed fabric is highly efficient [12, 13].

The press-off method has proved particularly suitable for knitting terry fabrics for toweling and fitted bed linen. A compound needle tricot machine has been specially developed for the technique. The guide bars are threaded I • I • with the ground guide bar overlapping only the normal compound needles and the terry guide bar overlapping only the large-head needles. In the latter case, this occurs only at alternate courses so that at the next knitting cycle the large-head needles knock over the terry pile loops without receiving a new overlap, thus pressing-off their loops [14].

Single-sided terry can be knitted with three guide bars. The front bar produces the ground chain stitch, the second bar inlays the ground, and the third bar alternately overlaps and inlays the terry. After the overlaps of the odd courses have been pressed-off, the inlays of the even courses are held in the structure by the ground bars. Double-sided terry requires a fourth guide bar, in front of the chain stitch ground bar. This overlaps at odd courses over the normal needles and overlaps at even courses over the large-head needles, and is pressed-off the latter. The machine has special brushes to draw these pressed-off loops from the centre of the fabric so that they appear on the technical face, whereas the inlaying terry guide bar shows its terry loops on the technical back [15].

The main objective of this study is to understand the factors influencing the performance characteristics related properties of terry warp knitted towels . Initially, different constructions of terry towels were used to study their water absorption behavior, structural parameters, and mechanical properties according to the standard procedures.

II. MATERIAL AND METHODS

The constructions parameters of the terry-knitted structures in accordance with their usage fields have been identified and in consideration of researched literature the knitting constructions have been arranged and the performance properties have been examined.

All towel samples were produced by TM 4 T-EL terry warp knitting machine E 24. The Motion Control system manages the electronically controlled yarn let-off, while the Pattern Control is responsible for controlling the ground guide bars. The fabric take-down is also controlled electronically to give maximum flexibility during patterning. The parameters of the different designs are input via touch screen. The patterning advantages of the TM 4 T-EL are combined with a high level of productivity as it can reach a maximum speed of 1400 rpm. The wide range of options available for designing single or double sided loop pile products are the result of incorporating loop-free areas of any size at any location in both the lengthwise and crosswise directions.

Different materials (cotton, polyester microfibers and bamboo fibers) with various pile height (1.5, 2, 2.5mm) were used to produce towels samples associated with different towels purposes and structures. Table (1) shows the specification of produced terry warp- knitted towels.

Table (1) The Specification of Produced Terry Warp- knitted Towels

Sample No.	Towel Structure The chain notations	Towel Composition	Pile Height mm	Towel Weight Gm/m ²
1	1-0 / 2-1 / 2-3 / 1-2 // for the back ground bar.	100% cotton	1.5	430
2			2	440
3			2.5	460
4	0-0 / 0-1 / 1-1 / 1-0 // for the front guide bar.	100% polyester microfiber	1.5	410
5			2	425

6	0-0 / 1-1 / 2-2 / 1-1 // for the pile sinker bar.	100% bamboo fibers	2.5	440	
7			1.5	420	
8			2	435	
9			2.5	450	
10	1-2/ 1-0 // for the back ground bar.	100% cotton	1.5	420	
11			2	430	
12			2.5	450	
13		100% polyester microfiber	1.5	400	
14	1-0/0-1// for the front guide bar. 1-1 / 0-0 //		2	415	
15			2.5	430	
16	100% bamboo fibers	1.5	410		
17		2	425		
18			2.5	445	

To investigate the effect of towels constructions on its performance functional behavior, different tests were done including:

- Weight test, this test was carried out according to the ASTM D3776 / D3776M - 09a.
- Air Permeability test, this test was carried out according to the ASTM D737 - 04(2012).
- The resistance to abrasion test, this test was carried out according to ASTM D3885 - 07a (2015)
- Static Absorption test, this test was carried out according to the AATCC Test Method 79-2010.
- Bursting Strength test, this test was carried out according to the ASTM D3786 / D3786M – 13.

III. RESULTS AND DISCUSSIONS

3.1. Air Permeability

The movement of the air through the fabric thickness considerably influences of the final usage performance parameters such as the wind resistance of the product that will be made out of this fabric, water vapor permeability and filtering property. Air permeability test results of terry towels are shown in Figure (1).

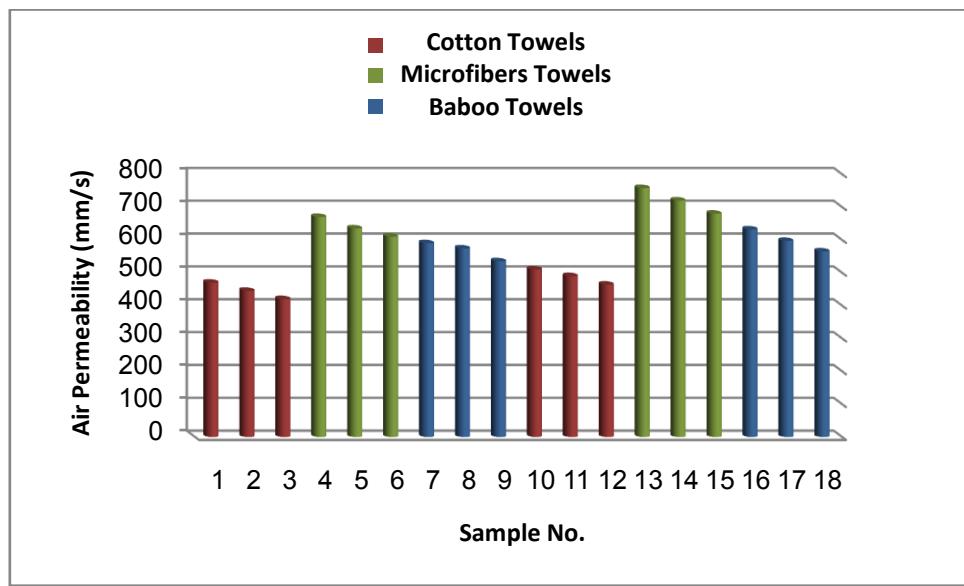


Figure (1) Air Permeability (mm/s) Test Results of Terry Towels

The results in terms of the effect of pile height on air permeability show that an increase in pile height causes a decrease in air permeability rate and this decrease is important statistically. The reason of the decrease of air permeability derives from that the amount of the volume that the air can pass through in the high pile towels is less than low pile towels. Using microfibers lead an increase in air permeability, as seen in Figure (1). The yarns made from micro denier fiber contain many more filaments than regular yarns producing towels with improved breathability. This increase is considered to be important statistically.

3.2. Abrasion Resistance

Abrasion resistance of the textile materials is very complex phenomenon and affected by many factors, mainly classified as follows: fiber, yarn, fabric properties and finishing processes [17]. Weariness or abrasion resistance is expressed as the decrease in weight percent after abrasion (10000 rubs of abrasion). The weight test was carried out according to the ASTM D3776 / D3776M - 09a.

$$\text{Lose in weight (\%)} = [(\text{original weight} - \text{weight after abrasion}) / \text{original weight}] \times 100 \quad (2)$$

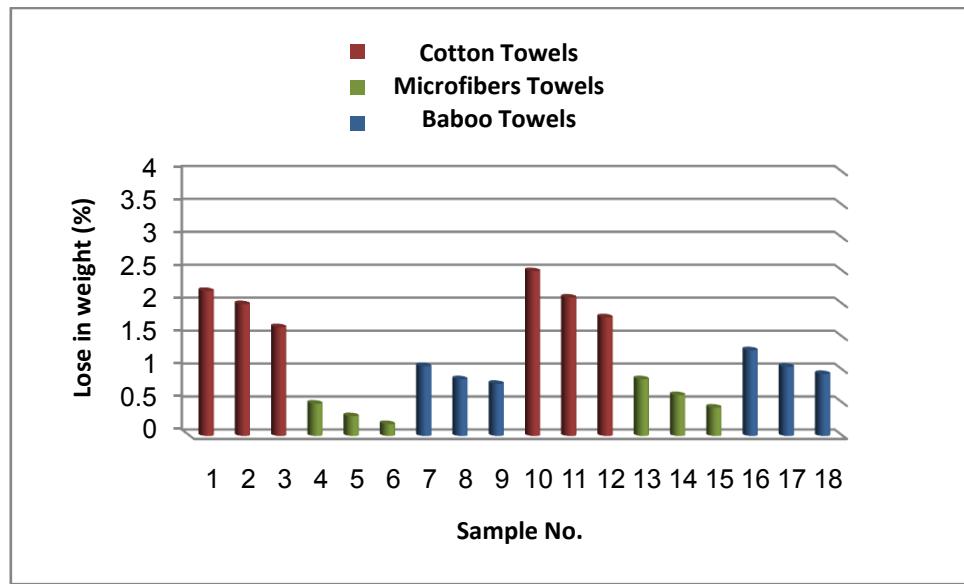


Figure (2) Lose in weight (%) after Abrasion Test Results of Terry Towels

The results show that, the towel construction, thickness, weight and the pile height are the main towel properties that affecting abrasion as seen in Figure (2). knitting structure has also an important effect on abrasion characteristics of knitted towels. The abrasion resistance values of tight structure are higher, as in the first structure, than loose opened in the second structure because the structure is more stable, thicker and voluminous structure. As shown in Figure (2),the towel mass per square meter and fabric thickness are the main structural properties that have an effect on abrasion resistance. Higher values of these factors give higher abrasion resistance. Microfibers towels give higher abrasion resistance than cotton and bamboo towels due to microfibers are so fine, many fibers can be packed together very tightly. With many more fine fibers required to form a yarn, greater fiber surface area results making more abrasion resistance properties possible.

3.3. Static Absorption

Static water absorption of terry towel defines the amount of water that can be absorbed and it is a principal requirement of any terry towel [16]. The measurement of static water absorption of terry towels were carried out using Bureau Veritas Consumer Product services BV S1008 internal testing method. The amount of water absorbed by terry towels were calculated by taking the difference between the wet and dry mass. The percentage of water absorption was calculated by the following formula:

$$S_w = (m_w - m_d) / m_d \times 100 \quad (1)$$

Where:

- S_w – water absorbed.
- m_w – fabric wet mass.
- m_d – fabric dry mass.

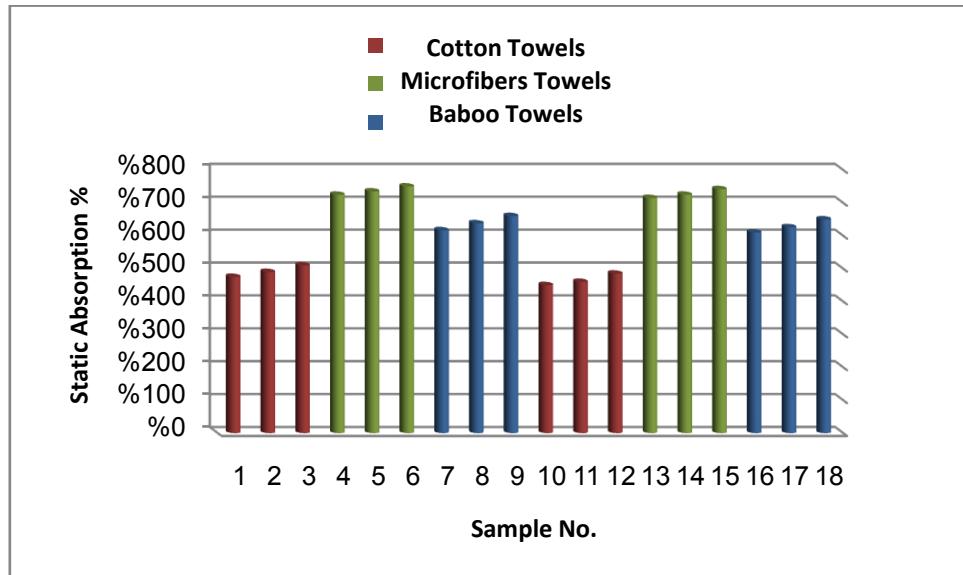


Figure (3) Static Water Absorption Test Results of Terry Towels

Static water absorption test results of terry towels are shown in Figure (3). The absorbency depends on type of fiber, yarn properties, towel characteristics, the results show that the terry towels which is produced using microfibers exhibited greater static water absorption capacity. This is due to microfibers are engineered in such a way as to make them very sensitive to the capillary effect. The action of splitting microfibers is a clincher as it releases the polyester wedges shaped, which is rather hydrophilic, while multiplying the number of strands available on a same volume. It thus proportionally increases the total added surface of all the fibers available and hence enabling to absorb higher amount of water when compared to other samples produced using cotton or bamboo yarns. In addition, towels samples consists of higher piles length (2.5mm) help to absorb more water compared to lower piles length (1.5 & 2 mm). However, the lower absorption was noticed for towels samples using second structure.

3.4. Bursting Strength

The bursting strength of knitted towel is extremely important in many ways. As illustrated in Figure (4), the results for bursting strength revealed that the effect of yarn material, knit structure and pile height are highly significant in produced towels.

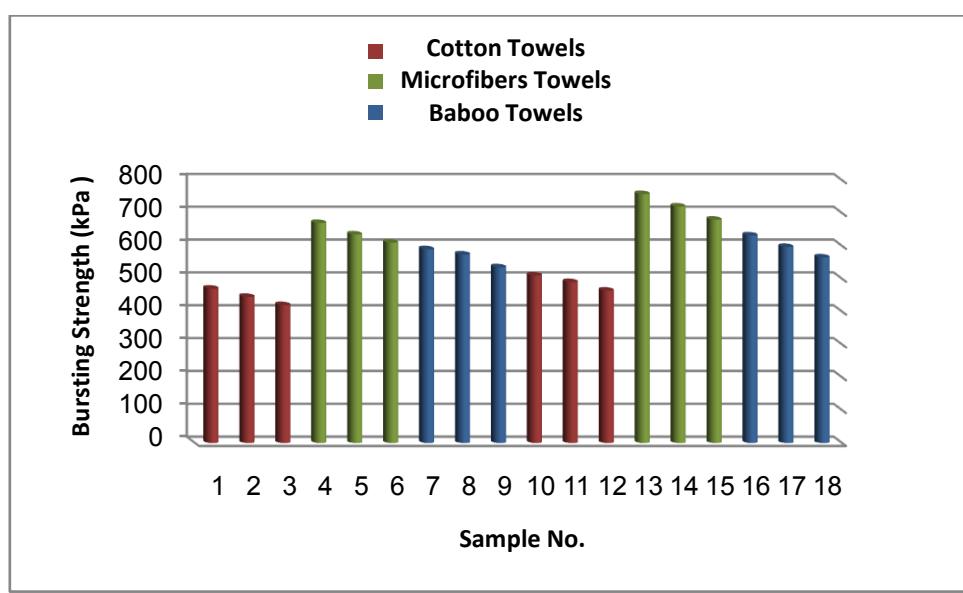


Figure (4) Bursting Strength (kPa)Test Results of Terry Towels

The results show that, higher weight and pile height provided higher bursting strength and tension strengths. Microfibers towels have comparatively higher bursting strength than cotton and bamboo towels using the same other parameter construction factors. This result due to the fact that more number of fibers can be accommodated in the yarn cross section which increasing the basic tenacity of yarn and also partly due to higher stitch density and tightness factor values in micro denier towels.

IV. CONCLUSIONS

The demand of terry towel is increasing day by day. It is seen that the terry towel market is a rapidly growing and innovative market with the new technologies of spinning, which is special for towel end use, new fibers -both natural and manmade-, new knitting features. These process influence the performance functional properties of towels. The results show that, the towel construction, thickness, weight, the pile height are the towel properties affecting abrasion. High absorbency can be achieved in a towel by increasing the surface area with pile yarns and using microfiber yarns. The absorbency depends on type of fiber, yarn properties, fabric characteristics. When the air permeability values are studied; low piled, high microfibers ratio; loose structure provided better air permeability values. Microfibers provided that high air permeability values due to their low density. The results for bursting strength revealed that the effect of yarn material, knit structure and pile height are highly significant in produced towels. All the performance characteristics related behavior of terry towel fabrics based on their fabric constructions parameters.

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