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Tensile behaviour of woven velour printed terry fabrics

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The present research work is focused to design terry fabrics in such a way that their overall performance can be improved. Three important constructional variables, such as pile height, pick density and pile count (one ply and two ply both), have been optimised for maximum tensile strength of woven velour printed terry fabric. Thirty samples have been prepared as per Box – Behnken design of experiments. Results obtained clearly state that the pile height has negative interaction effect on pick density and yarn count both. Hence, if one wants to increase the fabric strength by increasing pick density and coarseness of warp, the pile height should be kept constant or should be reduced. The results mentioned above are found true for both the fabrics having single ply and double ply pile yarns. The tensile strength of the fabrics having double ply pile yarn is always higher as compared to fabric having single ply pile yarn.

Keywords: Pile height, Pick density, Printed fabric, Tensile strength, Terry fabric, Velour fabric

1 Introduction

Terry fabrics are the most popular in textile, especially in home furnishing. Cotton terry fabrics are made from pile warp, ground warp and weft yarn by 3-pick terry weave. Terry is produced by pile warp ends on both side of fabric, generally covering the entire surface which is the cause of uneven surface of woven terry fabric. So, the pile loops of one side of the fabric are sheared to make the surface even for printing the finest design. These terry fabrics are known as woven velour printed terry fabrics which are one of the most exclusive and demanding class of terry fabrics. Printing enhances the appearance, and increases the aesthetics of these fabrics and hence its demand is increasing day by day. It is accepted by consumer due to aesthetic exposure and properties like strength, wash ability and performance. Systematic research work of design, development, performance enhancement and structure-property relationship of these fabrics have not been reported yet.

Terry fabrics are printed by using continuous flat screen printing, which is a new technology introduced by Zimmer Austria Inc. Company. It is most versatile flat screen printing for woven velour printing terry fabric for finest printing quality especially for centre printing and geometric designs. Serviceability, quality and manufacturing cost play important role to customer acceptability but aesthetic properties is more important. Durability of any product depends on it tensile strength which is mainly dependent on yarn count, pick density, etc. There is inverse relationship between number of pile tufts per unit area and tensile strength[1]. Strength of non-terry fabrics increases with the increase in pick density[2]. The yarn tensile strength and diameter are dependent on the structural parameters of the yarn such as count and twist multiplier. Researchers proved that tensile, tear and bursting strength of plain fabrics are dependent on the yarn count, twist multiplier and picks density[3,4]. Tensile behaviour of a fabric especially depends on yarn strength and crimp of the fabrics[5]. Picks/weft density is an important factor that governs the fabric elongation[6]. Strength of fabric may be increased by optimizing the different weft count and pick densities[7]. The aim of this research is to investigate the effects of pick density, pile warp count and pile height on the tensile behaviour of woven velour printed terry fabrics. It is normally believed that pile warp count and pile height do not contribute much towards fabric's tensile strength but in some cases they do. These two variables are very important for absorbency and aesthetic properties of woven velour printed terry fabrics. So, it is very crucial to observe their effect on tensile behaviour also and this is the main motivating force for this research work.

2 Materials and Methods

The woven velour printed terry fabric were produced on Toyata loom (Model: JA4T-2800DE-

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EHT7100) using 100% cotton single and double ply yarns in pile. Terry construction was produced using the 3-pick weave (Fig. 1). Thirty samples of woven velour printed terry fabric were prepared as per Box – Behnken design of experiments. The details of the variables and their levels are given in Tables 1 and 2. The samples were tested for tensile strength (warp way) by following the test method ASTM D5035.

3 Results and Discussion

Prepared velour printed terry fabrics (both one ply and two ply pile yarns) are tested for tensile strength. The results have been analysed and discussed hereunder.

3.1 Effect of Fabric Variables on Tensile Strength

3.1.1 One Ply Pile Yarn

The Model F-value of 153.28 (Table 3) implies that the model is significant. There is only a 0.01% chance that the large F-value could occur due to noise. Values of "Prob> F" less than 0.0500 indicate that the model terms are significant. In this case, A, B, C, AB, AC, BC, A^2, B^2, C^2 are significant model terms. Values greater than 0.1000 indicate that the model terms are not significant.

Figure 2 (a) shows that the tensile strength has increased from 20 kg to 25 kg, when pick density increases from 14.5 picks/cm to 18.5 picks/cm at pile height 5 mm. The increase in tensile strength is found from 25 kg to 40 kg, when pick density increases from 14.5 picks/cm to 18.5 picks/cm at pile height of 3.5 mm. The rate of increase in tensile strength is higher at low pile height as compared to that at high pile height. So for tensile strength, this shows a negative interaction effect between pick density and pile height. Figure 2 (b) shows that the tensile strength has increased from 15 kg to 26 kg, when pick density increases from 14.5 picks/cm to 18.5 picks/cm at pile count 16 Ne. The increase in tensile strength is found 26 kg to 41 kg at pile count 12 Ne. The rate of increase in tensile strength is higher at coarse pile count as compared to that at fine pile count. So, for tensile strength, this shows a positive interaction effect between pick density and pile count. High pick

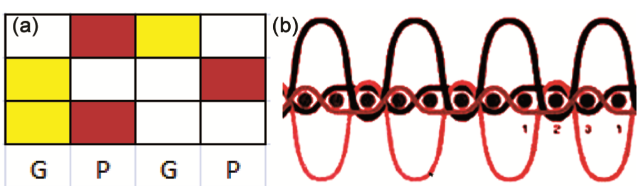

Fig. 1 — (a) 3-pick terry weave and (b) 3-pick terry structure

Table 1 — Sample variables and their levels

Variables	Level		
	+1	0	-1
	One ply pile yarn		
Pick density, picks/cm	14.5	16.5	18.5
Pile height, mm	3.5	4.25	5
Pile count, Ne	12	14	16
	Two ply pile yarn		
Pick density, picks/cm	14.5	16.5	18.5
Pile height, mm	3.5	4.25	5
Pile count, Ne	2/16	2/20	2/24

Table 2 — Yarn variable with measured response

Run	Factor 1 Pick density Picks/cm	Factor 2 Pile height mm	Factor 3 Pile count Ne	Response 1 Tensile strength kg
		One ply pile yarn		
1	14.5	4.25	12	27
2	16.5	3.50	16	26
3	14.5	3.50	14	25
4	14.5	5.00	14	21
5	16.5	4.25	14	34
6	16.5	5.00	12	28
7	18.5	5.00	14	24
8	16.5	4.25	14	33.5
9	16.5	4.25	14	34
10	16.5	5.00	16	19
11	14.5	4.25	16	20
12	18.5	4.25	16	27
13	18.5	4.25	12	41
14	18.5	3.50	14	39
15	16.5	3.50	12	40
		Two ply pile yarn		
1	14.5	5.00	10	38
2	18.5	4.25	12	38
3	14.5	3.50	10	41
4	18.5	4.25	8	52
5	18.5	5.00	10	40
6	16.5	4.25	10	44
7	16.5	5.00	8	46
8	16.5	3.50	12	37
9	16.5	5.00	12	32
10	18.5	3.50	10	52
11	14.5	4.25	12	28
12	16.5	4.25	10	44
13	16.5	4.25	10	44
14	14.5	4.25	8	48
15	16.5	3.50	8	55

Table 3 — Analysis of variance for tensile strength

Source	Sum of squares	df	Mean square	F-value	p-value
One ply pile yarn					
Model	735.77	9	81.75	153.28	< 0.0001
Pick density (A)	180.50	1	180.50	338.44	< 0.0001
Pile height (B)	180.50	1	180.50	338.44	< 0.0001
Pile count (C)	242.00	1	242.00	453.75	< 0.0001
AB	30.25	1	30.25	56.72	0.0007
AC	12.25	1	12.25	22.97	0.0049
BC	6.25	1	6.25	11.72	0.0188
A^2	34.16	1	34.16	64.05	0.0005
B^2	46.31	1	46.31	86.84	0.0002
C^2	15.39	1	15.39	28.86	0.0030
Residual	2.67	5	0.53		
Pure error	0.17	2	0.083		
Cor total	738.43	14			
One ply pile yarn					
Model	784.85	9	87.21	581.37	< 0.0001
Pick density (A)	91.13	1	91.13	607.50	< 0.0001
Pile height (B)	105.13	1	105.13	700.83	< 0.0001
Pile count (C)	544.50	1	544.50	3630.00	< 0.0001
AB	20.25	1	20.25	135.00	< 0.0001
AC	9.00	1	9.00	60.00	0.0006
BC	4.00	1	4.00	26.67	0.0036
A^2	4.67	1	4.67	31.15	0.0025
B^2	0.058	1	0.058	0.38	0.5623
C^2	6.98	1	6.98	46.54	0.0010
Residual	0.75	5	0.15		
Pure error	0.000	2	0.000		
Cor total	785.60	14			

density and coarse yarn increase the number of fibres sharing the load along with the fabric assistance.

Figure 2 (c) shows that tensile strength has increased from 20 kg to 26 kg when pile height is reduced from 5 mm to 3.5 mm at pile count 16 Ne. The tensile strength has increased from 26 kg to 40 kg when pile height is reduced from 5 mm to 3.5 mm at pile count 12 Ne. The rate of increase in tensile strength is higher for coarse pile count as compared to that for fine pile count. So, for tensile strength, this shows a negative interaction effect between pile count and pile height. Finer pile has less number of fibres in the yarn cross-section and smaller diameter than the coarser pile yarn. Pile yarn breaks after the breakage of ground warp yarn. This causes an increase in the length of the specimen. Therefore, negative interaction effect between pile count and pile height to tensile strength is observed. Pick density, pile height and pile yarn count have been optimised for maximum tensile strength. Pertubation plot (Fig. 3) shows the combined effect of all the variables on tensile strength at the same time and it is observed that the maximum tensile strength can be achieved at 18.4 picks/cm, 3.5 mm pile height, and 12 Ne pile yarn count.

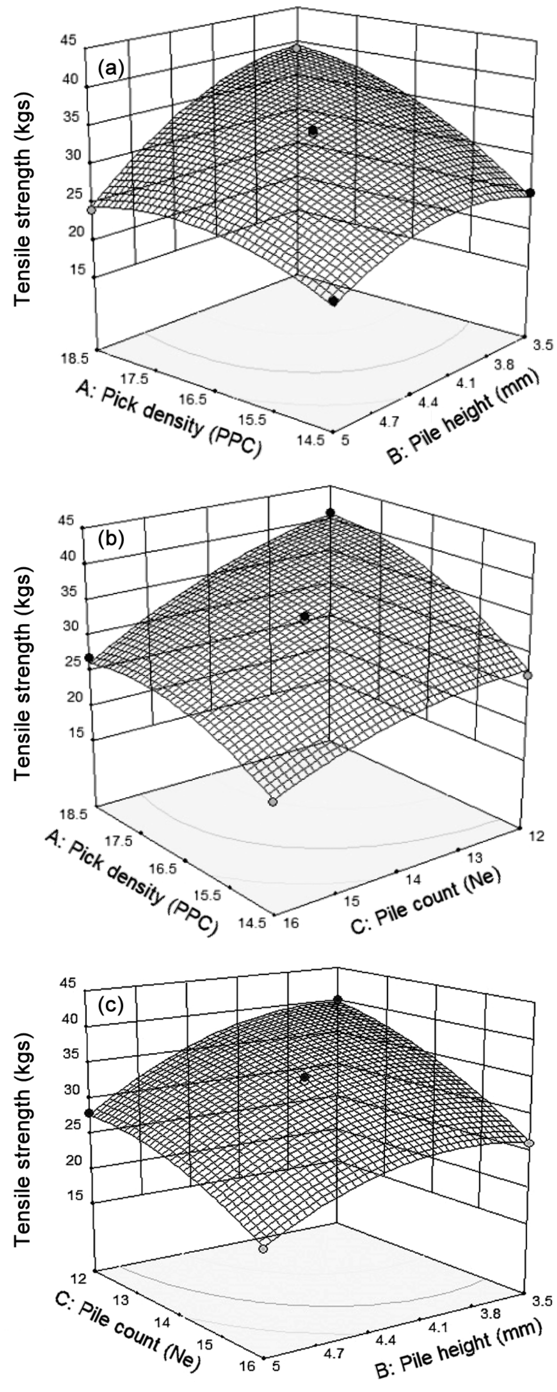

Fig. 2 — Effect of (a) pile height and pick density, (b) pile count and pick density (c) pile height and pile count on tensile strength of fabric having one ply pile yarn

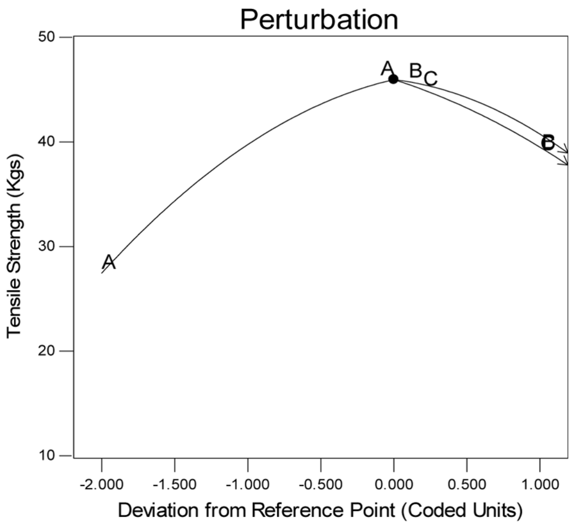

Fig. 3 — Pertubation plot for tensile strength of fabric having one ply pile yarn

3.1.2 Two Ply Pile Yarn

The Model F-value of 581.37 (Table 3) implies that the model is significant. As mentioned in section 3.1.1, there is only a 0.01% chance that the large F-value could occur due to noise. Values of "Prob> F" less than 0.0500 indicate that the model termsare significant. In this case A, B, C, AB, AC, BC, A^2, C^2 are significant model terms. Values greater than 0.1000 indicate that the model terms are not significant.

Figure 4(a) shows that the tensile strength has increased from 37 kg to 40 kg, when pick density increases from 14.5 picks/cm to 18.5 picks/cm at pile height 5 mm. The increase in tensile strength is found from 40 kg to 51 kg, when pick density increases from 14.5 picks/cm to 18.5 picks/cm at pile height of 3.5 mm. The rate of increase in tensile strength is higher at low pile height as compared to that at high pile height. So, for tensile strength, this shows a negative interaction effect between pick density and pile height. The reason may be attributed to the more fibre orientation in two ply yarn as compared to one ply yarn. Figure 4 (b) shows that the tensile strength has increased from 25 kg to 38 kg, when pick density is increased from 14.5 picks/cm to 18.5 picks/cm at pile count 2/24 Ne. The increase in tensile strength is found to be from 47 kg to 48 kg at pile count 2/16 Ne. The rate of increase in tensile strength is higher at coarse pile count as compared to that at fine pile count. Figure 4 (c) shows that tensile strength has increased from 35 kg to 46 kg when pile count is reduced from 2/24 Ne to 2/16 Ne at pile height 3.5 mm. The tensile strength has increased from 31 kg to 44 kg

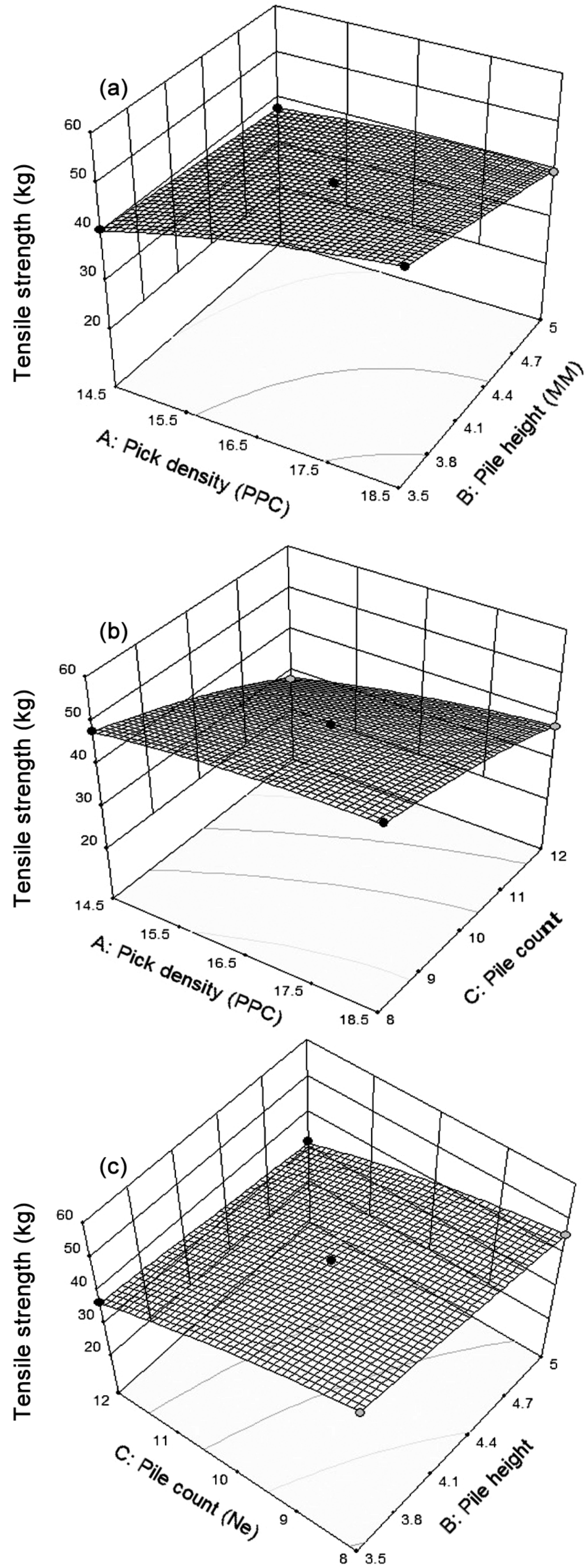

Fig. 4 — Effect of (a) pile height and pick density, (b) pile count and pick density and (c) pile height and pile count on tensile strength of fabric having two ply pile yarn

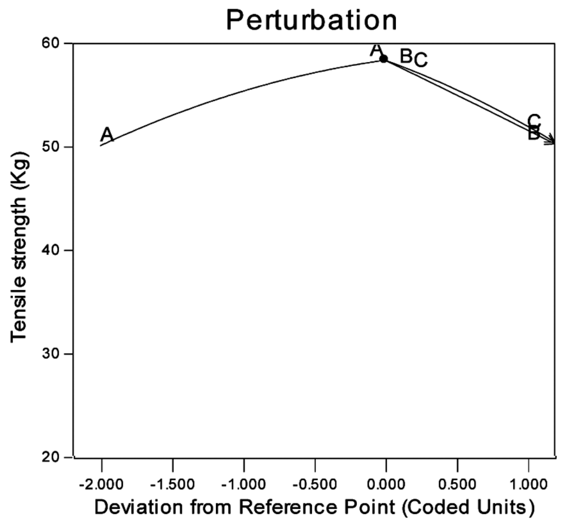

Fig. 5 — Pertubation plot for tensile strength of fabric having two ply pile yarn

when pile count is reduced from 2/24 Ne to 2/16 Ne at pile height 5 mm. The rate of increase in tensile strength is higher at coarse pile count as compared to that at fine pile count. So for tensile strength, this shows a negative interaction effect between pile count and pile height. Finer pile yarn has less number of fibres in the yarn cross-section and smaller diameter as compared to coarse yarn. Pile breaks after the breakage of ground warp, which is the cause of length increases in specimen. These factors seem sufficient enough to explain the negative interaction effect between pile count and pile height to tensile strength. Pick density, pile height and pile yarn count have been optimised for maximum tensile strength. Pertubation plot (Fig. 5) shows the combined effect of all the variables on tensile strength at same time, and it is observed that the maximum tensile strength can be achieved at 18.4 picks/cm, 3.5 mm pile height, and 2/16 Ne pile yarn count.

4 Conclusion

This research work investigated the effect of pile height, pick density and pile count on the tensile strength behaviour of woven velour printed terry fabrics. Results conclude that the tensile strength of woven velour printed terry fabrics increases with the increase in pick density and coarseness of the pile count. The tensile strength of the fabric decreases with increase in pile height. Results also suggest that the tensile strength of woven velour printed terry fabrics having double ply pile yarn is always higher as compared to the fabric having single ply pile yarn. Those fabrics having two ply and coarse pile yarn show higher strength. Pile height has negative interaction effect on pick density and yarn count both. So if one wants to increase the fabric strength by increasing pick density and coarseness of pile warp, the pile height should be kept constant or should be reduced.

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