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Effect of weft insertion system on physical properties of fabrics

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The effect of different weft insertion systems, viz. shuttle, projectile and water-jet, on fabric properties such as crimp, thickness, tensile strength, elongation at break and crease recovery has been studied. It is observed that the crimp and tensile properties of fabric are significantly influenced by the weft insertion system. Market survey reveals that the consumers, in general, have no particular preference for any of the fabrics woven on looms having different weft insertion systems.

Keywords: Crimp, Projectile weaving machine, Tensile strength. Water-jet weaving machine, Weft insertion

1 Introduction

Although the basic principles of weaving remain same for conventional (shuttle) and unconventional (shuttleless) weaving machines, but owing to the difference in weft insertion systems there are certain inherent differences. Some of these differences are as follows:

(i) In a conventional weaving machine, the weft takes a curved path in the shed[1] and due to this, the reed meets the weft at different portions across the warp at different centres of crank cycle. In an unconventional weaving machine, the path of weft is straight and the reed meets the whole length of weft at the same time.

(ii) During beat up, in a projectile weaving machine, the weft is gripped by the selvedge grippers and in a jet loom, it is gripped by the catch cord, whereas in a conventional weaving machine, one end of the weft is gripped by the selvedge and the other end is free to unwind from the shuttle.

(iii) In a conventional weaving machine, weft insertion takes place from both sides, whereas in an unconventional weaving machine, weft insertion generally takes place from one side.

(iv) Tension on the warp threads for an unconventional weaving machine is kept higher than that for a conventional weaving machine.

(v) The timings of closed shed positions are different in conventional and unconventional weaving machines.

Owing to the above mentioned differences, there is a possibility that warp and weft crimp % may be different for weaving machines with different weft insertion systems and this variation may lead to variation in other properties of fabrics. There is a dearth of literature on the subject. Ishida[2] observed difference in the handle properties of fabrics woven on jet, rapier and shuttle looms. Grasnovskii and Tekstulnay[3] concluded that the tensile and elastic properties do not vary widely.

The present paper reports the effect of different weft insertion systems, viz. shuttle, projectile and water-jet, on certain properties of grey and finished fabrics and the result of a market survey conducted to find out the consumer preference for fabrics woven on different weaving machines.

2 Materials and Methods

A commercial plain weave fabric having the following specifications was used: Ends/dm, 331; picks/dm, 236; warp, 96 dtex crimped filament; weft, 200/2 dtex 48/52 PE/V blend; and reed space, 127 cm.

The fabric samples were woven using the same lot of yarn and weaving preparatory machine, viz. sectional warping. The particulars of the weaving machines used are given in Table 1. The shed timings of the looms and the average tension of the warp during the beat up are given in Table 2. All the fabrics were dyed and finished in the same batch.

3 Results and Discussion

Table 3 shows the properties of fabrics, at grey and finished state, woven on three different types of weaving machine. Analysis of variance with one way classification was used to test the statistical significance.

Table 1—Particulars of weaving machines

	Tsudakoma Water-jet	Ruti Sulzer Projectile Weaving Machine	Lakshmi Ruti Automatic Loom
Model	ZW 302	PU_1 VSDKR D1	Ruti C
Reed space, cm	150	388	150
Shedding	Dobby 16 Shafts	Dobby 16 Shafts	Dobby 16 Shafts
Weft insertion rate, m/min	750	1000	400
Selvedge	Leno	Tucking	Conventional

Table 2—Shed timings and average warp tension

Type of weaving machine	Shed		Beat up deg	Warp tension g
	Fully opened deg	Closed deg		
Shuttle	55	330	0	45
Projectile	140	10	50	55
Water-jet	180	355	0	40

3.1 Crimp

Table 3 indicates a significant difference in the values of warp crimp for both grey and finished fabrics; the highest value is obtained with water-jet followed by shuttle and projectile weaving machines. This may be because of the following reasons:

(i) There are differences in warp tension levels at beat up with the weft insertion systems (Table 2). According to Morton and Williamson[4], increase in the level of warp tension results in decrease in warp crimp and increase in weft crimp values.

(ii) Closed shed positions for the three weaving machines are different; change in shed timing from normal to late or very late gives an increase in weft crimp and a decrease in warp crimp[5]. Since the timing on a projectile weaving machine is very late in comparison to water-jet and shuttle looms, the warp crimp % on the former machine is higher. The reasons for these observations are as follows:

The higher crimp in one set of threads is compensated by the lower crimp in the other set and the total crimp is maintained approximately the same in similar fabric structures[6]. Thus, higher warp tension prevalent during weaving on a projectile weaving

Table 3—Properties of fabric

Property	Testing instrument	Fabric state	Weaving machine			Test of significance
			Water-jet	Projectile	Shuttle	
Crimp, %	Shirley crimp tester	Grey	9.6	8.62	9.12	Significant
Warp-way		Finished	4.04	2.58	3.52	Significant
Weft-way	-do-	Grey	1.98	2.83	2.19	Significant
		Finished	4.13	5.21	4.31	Significant
Thickness, mm (Body)	Thickness tester	Grey	0.223	0.224	0.218	Not Significant
		Finished	0.254	0.251	0.248	Not Significant
Tensile strength, kg						
Warp-way	Instron	Grey	52.88	54.25	51.75	Not significant
		Finished	34.96	34.67	31.13	Significant
Weft-way	-do-	Grey	53.25	51.50	51.50	Not Significant
		Finished	25.72	30.29	27.57	Significant
Elongation at break, %						
Warp-way	-do-	Grey	32.67	29.75	32.15	Significant
		Finished	6.05	6.27	7.10	Significant
Weft-way	-do-	Grey	14.13	11.4	12.8	Significant
		Finished	7.43	7.29	6.41	Not Significant
Crease recovery, deg						
Warp-way	Crease recovery tester	Grey	128.4	143.4	134.5	Not Significant
		Finished	142.6	134.5	141.7	Not Significant
Weft-way	-do-	Grey	92.8	110.0	87.4	Not Significant
		Finished	119.8	121.2	107.4	Not Significant

machine results in lower warp crimp and higher weft crimp. Similarly, the opposite trend takes place for a water-jet weaving machine.

3.2 Thickness

Table 3 shows no significant difference in the thickness of the fabrics woven on these looms, both at grey and finishing stage. According to Sardeshpande[7], for a particular cloth sett and weave, thickness depends upon the total crimp (i.e. sum of warp and weft crimp values). Since the values of total crimp for these fabrics remain almost same, there is no significant difference in the thickness of these fabrics.

3.3 Tensile Strength

In the grey state, no significant difference is observed in both warp- and weft-way tensile strength of fabrics woven on different types of loom (Table 3). Also, the effect of difference in crimp is not significant. However, in the finished state, the differences in the tensile strength of the fabrics are significant. Though this phenomenon is not clear, it is felt this may be because of considerable crimp interchange that takes place during the dyeing and finishing processes. Results also indicate considerable reduction in tensile strength after these processes. This may be because of the stretching action imposed on the fabric during the finishing process. Table 3 shows that after finishing the warp-way tensile strength loss is lowest at 34% whereas the weft-way tensile strength loss is highest at 52% for fabrics woven on water-jet loom. This behaviour of fabrics woven on water-jet loom may be because of the minimum reduction in warp crimp (58%) and maximum increase in weft crimp (108%) during dyeing and finishing.

3.4 Elongation at Break

The elongation at break is maximum in both warp and weft directions for fabrics woven on water-jet weaving machine except in the warp direction in finished fabric. The difference in warp-way elongation at break is significant for both grey and finished fabrics whereas weft-way elongation at break is significant only for grey fabrics.

3.5 Crease Recovery

The crease recovery angle provides a measure of the recovery from deformation. The following factors affect the crease recovery angle of fabrics:

(i) Fibre characteristics—diameter, tensile strength and elastic recovery

(ii) Yarn characteristics—thread density, thickness and bending recovery

(iii) Fabric characteristics

Table 4—Market survey results (no. of people who ranked the sample as best)

Type of weaving machine	Quality	Feel	Selvedge	Other reason	Purchase preference
Projectile	94	24	46	4	78
Shuttle	16	14	126	22	14
Water-jet	20	78	2	170	24
	70[a]	84[a]	26[a]	4[a]	84[a]
	200	200	200	200	200

[a]No preference.

From the above it is evident that in the present study only the crimp value was different. However, Table 3 indicates that the difference in crimp values has not resulted in a significant difference in the fabrics woven with different weft insertion systems.

4 Market Survey

A market survey was conducted to know the consumer's preference for any of the fabrics woven on different weaving machines. Two hundred people including 100 cloth traders and 100 users were asked to rank the finished samples in group on the basis of quality, feel, selvedge, any other reason and purchase preference, keeping in mind that the price of the fabrics is the same.

Table 4 shows that a large number of consumers had no preference for any of the fabric samples, indicating that the fabric woven on different types of loom are equally good; nevertheless, there was distinctive preference for the quality of fabrics woven on projectile weaving machine. The feel of the fabric woven on water-jet was considered good and the selvedge of the shuttle loom was most preferred.

5 Conclusion

Although there is no basic difference among the looms with different weft insertion systems as regards shedding, beating up and other motions, the warp and weft crimp values of the fabrics woven on these looms are different because of inherent difference in warp tension, loom timing and contact length of weft with reed at a time during beat up. In the finished state, the differences in the tensile strength of fabrics are significant. This may be because of considerable crimp interchange which takes place during dyeing and finishing. However, the variation in crimp has no significant effect on properties such as thickness and crease recovery. Market survey reveals that consumers, in general, do not have any particular preference for any of the three fabrics considered in the study.

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