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Analyzing and Improving the Weaving Efficiency by Using Pre-Wetting in Sizing

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***Abstract*: In cotton weaving industry, efficiency of loom shed is highly influenced by the quality of weaving preparatory processes. During sizing, core yarn strength has been improved at significant level along with preserving its elongation property. Whereas higher end breakage rate in warping leads to generation of lappers during sizing and it a reason for weavers beam quality. This paper presents an investigation consisting of several stages of sample treatment and testing. The first stage was warp is prepared in a sectional warping machine on cotton yarns (with nominal counts of 20ne and 30ne). Differences in physical and mechanical properties between yarns of different were then investigated. In the second treatment stage all samples were sized using two processes: the standard sizing process and pre-wetting sizing process, with same size concentrations, with the aim to investigate the influence of the sizing process on warp. Also, the influence of conventional sizing process over pre-wet sizing process will make any impact on sizing cost and energy reduction are studied. Also, the weaving efficiency was studied on the rapier auto loom that both conventional sizing and pre-wet sizing will make any impact. Well as on physical-mechanical properties of sized yarns required for weaving is studied and concluded that will increase the weaving performance, which are of paramount importance for the further process of making a woven fabric.**

***Keywords*: sizing, pre-wetting, performance, weaving efficiency.**

1. Introduction

The purpose of the sizing process is to improve the physical and mechanical parameters of the yarn in order to achieve a minimum number of breakages of warp threads in the weaving process at minimum cost. The goal of sizing is to keep the fibres in the yarn in the position where they were before sizing, with minimal yarn deformations during weaving. Today's achievements in all engineering branches enable the exceptional progress of the sizing processes to achieve a very high quality of sizing that meets the needs of today's modern weaving. However, sizing costs are still very high, despite the complete automation of the regulation and control of the most important sizing process parameters.

Their reduction is possible by reducing the consumption of sizing agents and energy, as well as by the modernization and development of machinery and technology, without any consequences on the quality of the sized yarn. Therefore two sizing processes were applied in this study in order to see possible differences in the properties of sized yarns obtained and consumption of all auxiliaries during sizing:

1. Standard sizing process (S)
2. Pre-wetting sizing process (P)

Here the "S" indicates the standard sizing process and the "P" indicates the pre-wetting sizing process

In order to fulfil all demands placed on the sized yarn, the most important thing is to optimise and maintain the size pickup constant, which can be continuously measured and maintained at constant temperature and size concentration in the size box, automatic regulation of the squeezing force, sizing speed, as well as yarn moisture before and after sizing. The complexity of the problem increases when sizing multi-coloured warp, where significant inequality in terms of size pick-up, yarn extension during the sizing process, and ultimately the mechanical properties of the yarn occur.

2. Material and Methodology

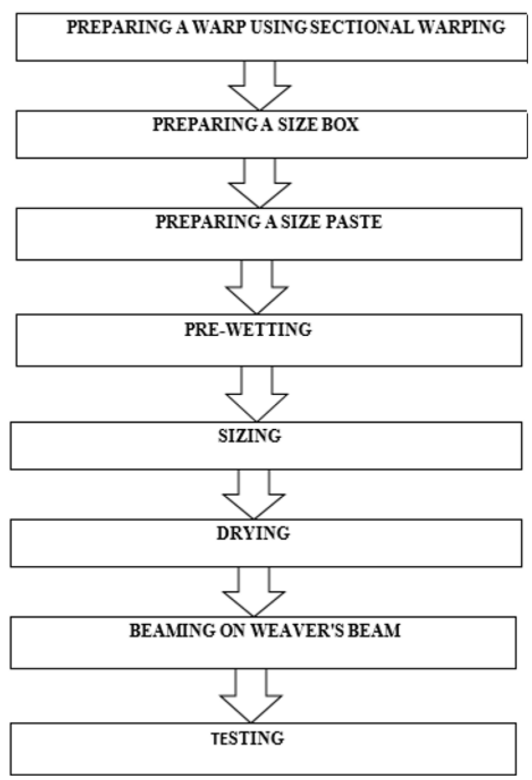

Fig. 1. Methodology

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A. Selection of Materials

In this project 20 ne and 30 ne cotton yarns are used in a multi cylinder sizing machine with double size box and weaving efficiency was calculated on both pre-wetted and non-pre-wetted sizing and compared.

Cotton yarn specifications

- 20s ne
- 30s ne

B. Sample Preparation

The warp prepared by using a sectional warping machine and both warp are tested with and without pre-wetting sizing. A double squeeze size box with twin rolls is also used for slashing light and heavy warp sett spun yarns. The twin immersion rolls allow both sides of the yarns to be exposed to the size mixture, thus ensuring uniform coating and penetration of the size liquor. Both squeeze rolls are equipped with independent loading and lifting controls. This provides flexibility to the slashing operator in using either one or both rolls depending upon the requirement. A size box having double roller, double immersion with high pressure squeezing, as shown in Fig. 19, is also used. In such a size box, one set of immersion and squeeze rolls is followed by another set of immersion and squeeze rolls. A recent development is the Equi-Squeeze Size Box, shown in Fig. 20. In this system the top squeeze roll position is adjustable. A unique bracket and loading system allows the positioning of the roll to the rear 15 or 30 degrees off the top centre position, as shown in Fig. 20. By moving the roll to the rear, the adherence of yarns to the roll as they leave the squeezing nip is minimized. Schematic of double squeeze rollers, double immersion with high high pressure squeezing.

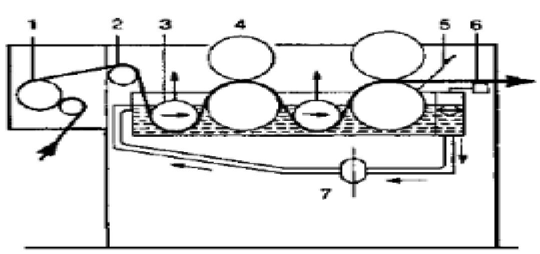


Fig. 2. Size box

Parts:

1. Feed Roller
2. Guide Roller
3. Dipping Roller
4. Nipping Rubber Coated Roller
5. Squeezing Roller Bottom
6. Sensor
7. Pump

The multi cylinder double size box machine is chosen for this project. The size box 1 is used for pre-wetting and size box 2 is used for sizing. In size box 1 we use water for per-wetting and size box 2 we use a sizing paste for sizing. After that both warps were weaved and weaving efficiency was compared. The water in the pre-wetting box is set at a temperature at 65-degree C. The RO treated water is used for size paste preparation and pre-wetting.

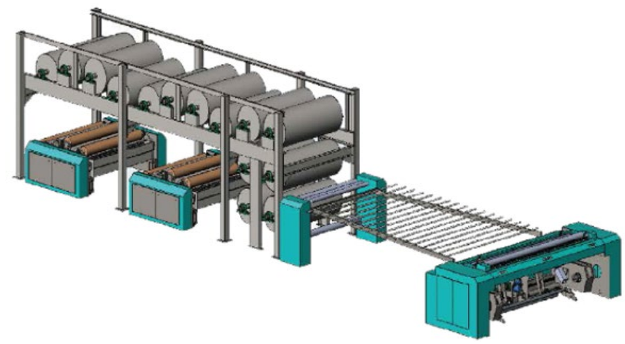


Fig. 3. Multi cylinder double size box sizing machine

Table 1
Sizing recipe table

Name	PVA Single Shot
Character	Sizing agent
Chemical nature	Polyvinyl alcohol
Appearance	White granulates
pH- value	5-7
Application	4-10%
Temperature of application	75-85 C
Chemical used	35 kgs
Price per kg	180
Water used	250 L
Chemical price	6300 rs

3. Results and Discussion

Table 2
Parameters

Parameters		Values	
Tt_n, tex		20.00	30.00
Tt_s, tex		18.55	29.57
U, t.p.m	$\bar{x}$	913.04	707.44
	CV, %	5.20	5.93
	δ, %	47.51	41.92
H (number of protruding fibres)	$\bar{x}$	20428	19055
	CV, %	2.30	2.09
	δ, %	470.12	397.91
A (number of cycle)	$\bar{x}$	80.76	144.80
	CV, %	11.63	14.92
	δ, %	9.39	21.60
F, cN	$\bar{x}$	281.69	375.04
	CV, %	6.78	12.63
	δ, %	20.76	44.60
ε, %	$\bar{x}$	3.83	5.42
	CV, %	7.26	9.53
	δ, %	0.29	0.56

Where: Ttn - nominal yarn count in tex, Tts - actual yarn count in tex, U - yarn twist ni t.p.m, H - yarn hairiness in number of fibres longer than 1 mm protruding from the yarn surface, A - abrasion resistance in number of cycles, F - breaking force in cn, ε - elongation at break in %, x - mean, CV - coefficient of variation in %, δ – standard deviation in %.

Yarn Count:

The yarn count was tested in a laboratory by using a warp reel and weighing scale.

Table 3
Yarn count

S.No.	Material	Count in NE
1	Cotton	20s
2	Cotton	30s

Size Pick-Up:

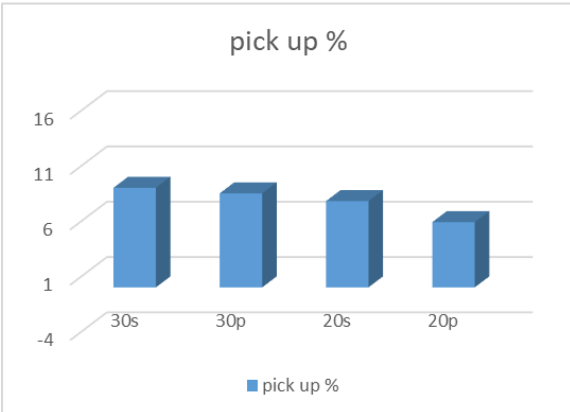


Fig. 4.

It can be determined that for yarns of the same count sized with different sizing treatments with and without pre-wetting (20s,20p,30s,30p), there is a very similar relation between the size pick-up. In this test the 20s has size more pick% up then the 20p and 30s have more size pick% up then the 30p respectively. one of the main advantages of the pre-wetting sizing process is great size saving, proven in this way.

Yarn Elongation:

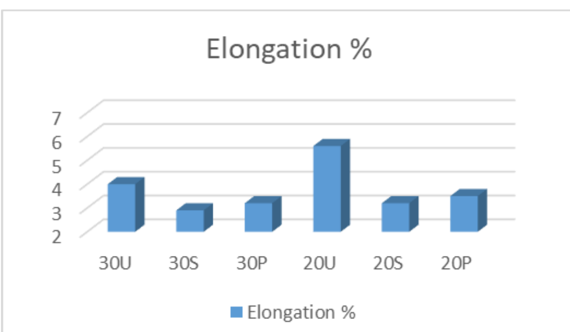


Fig. 5.

Yarn tension is very important during the sizing process and it affects yarn extension, thus causing deformations seen as a change in tensile properties of the sized yarns. Laboratory analysis showed that these changes are visible even in the case of minimal tension. In the wet state, yarns are even more sensitive to tension, and therefore a greater deformation occurs during the pre-wetting sizing process.

Tests conducted during the sizing confirmed this, the results of which are shown in Figure 8. Yarn extension of all yarns is higher when they are sized with the pre-wetting sizing process (with both yarn counts - 30 s and 20 s), the reason for which is the sizing procedure, where warp threads between the pre-wetting box and size box are wet, which makes them extremely sensitive to tension. In the standard sizing process the yarn enters the size box dry, and extension is reduced.

Breaking Force and Elongation:

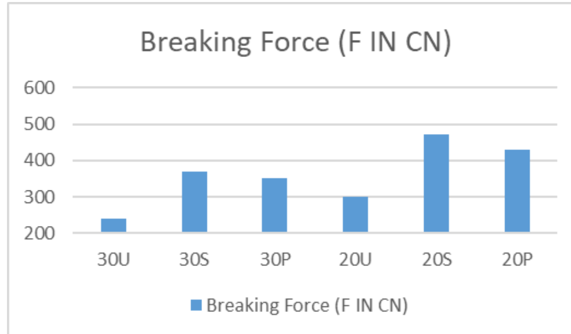


Fig. 6.

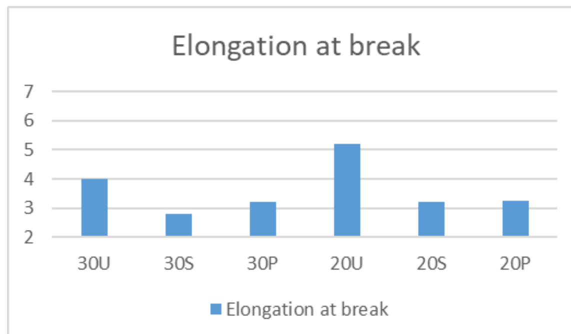


Fig. 7.

According to the results obtained, it can be tentatively stated that by sizing, the elongation at break decreased, which represents a negative side of the sizing process. The pre-wetting sizing process shows certain advantages, where generally the elongation at break is somewhat higher, especially in dyed yarns, where the elongation at break increases compared to undyed yarns, while the elongation decreases in the standard sizing process. These indicators are of great importance for the subsequent weaving process, and can be associated with a lower size pick-up on yarns sized with the pre-wetting process, where the yarns did not become stiff as those sized with the standard process.

Hairiness:

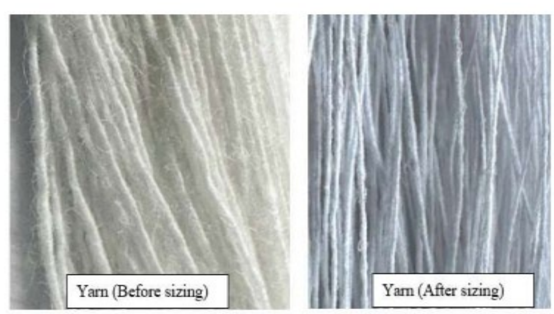


Fig. 8.

Hairiness is a very important feature in the weaving process, where due to high frictions (caused by the yarn passage through metal parts of the weaving machine), yarn breakage and, thus, faults in the fabric occur, resulting in a decrease in the quality of finished fabrics. Higher yarn hairiness also resulted in a greater friction between the yarns, caused by bonding the yarns with the size. The necessary separation of yarns after drying causes more damage and uneven removal of the size pick-up from the yarn surface, which can also adversely affect the weaving process and finished fabric quality. Due to sizing, the reduction is much more pronounced, where the dyed yarns (due to the fact that the dyeing process itself smoothies protruding fibres) become increasingly smoother, with a very small number of protruding fibres, making them suitable for weaving. Less hairiness is present in all yarns sized with the pre-wetting process (an average of 80%) due to previous immersion in hot water and having been passed through rollers for water squeezing, as well as to the size distribution on the yarn, making it smoother and thus less susceptible to rubbing i.e. friction.

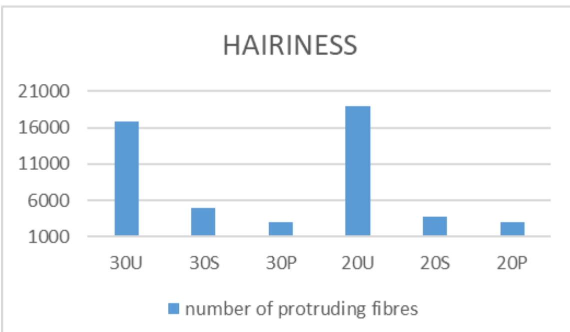


Fig. 9.

Abrasion Resistance:

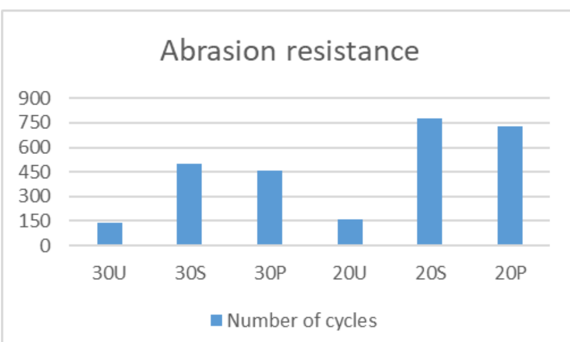


Fig. 10. Abrasion resistance

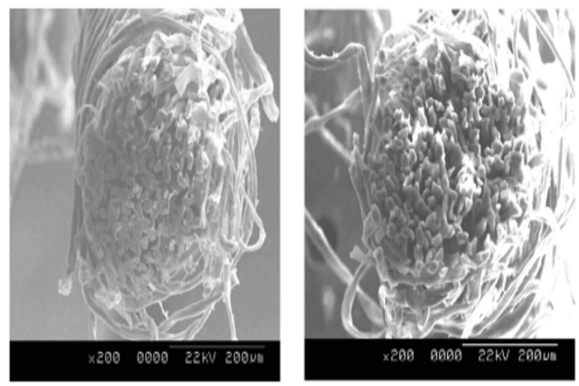
By sizing with the pre-wetting process, yarn abrasion resistance is not as high as for yarns sized with the standard process. Here the average increase is 205% (S) for 30S yarns and 210% (S) for 20S yarns. From these results it can be concluded that in general the standard sizing process "protects" yarns from abrasion better than the pre-wetting sizing process, in which case, the size is mostly retained on the yarn surface, forming a strong film that is harder to destroy and tear off, while on yarn sized with the pre-wetting process, the size is evenly distributed over the cross section of the yarn, providing a little less resistance to abrasion. It is also very significant that higher size concentrations do not guarantee a much higher abrasion resistance.

Effect of Various Sizing Formulations on Weaving Efficiency:

The data presented in Table 4 explains the incidence of warp cuts and machine stops while weaving running in a rapier loom with 210 rpm speed. A lower number of occurrences indicates better yarn performance. The data from the graph demonstrates that the pre-wet sizing yields the fewest machine stops and warp cuts, resulting in the highest efficiency (85.82%). In comparison, the other type display lower efficiencies, with values of 82.33% respectively, underscoring the superior performance of the pre-wet sizing.

Table 4

Production shift	**Sizing**	**Pre-wetting sizing**
Shift A	83.60 %	88.10 %
Shift B	79.30 %	82.60 %
Shift C	84.10 %	86.90 %
Average Weaving Efficiency	82.33 %	85.87 %
Shift A	13	6
Shift B	11	6
Shift C	16	9
Average warp cut	13	7



(a) (b)

Fig. 11. a) Without pre-wetting, b) With pre-wetting

Examination of the cross-sections of the two yarns (Fig. 11) showed that these bridges between fibers made it possible to obtain better sized yarns. In fact, the size seemed to be better distributed on the surface of the sized yarn with pre-wetting. The fibers were quite tight on the surface and formed a crown. With pre-wetting, the bridges between fibers were to be found near the external surface of the yarn. On the other hand, in the case of the sized yarns without pre-wetting, it could be observed that the fibers were greatly compacted in the core and outside. This difference in structure could be attributed to the pre-wetting operation with the hot water which "washed" and was used to "clean" waxes off the fiber surface. This had a consequence i.e. an increase in the surface energy and explained the improvement of the physical wetting.

4. Conclusion

The new sizing devices having two padders and the yarns are padded with water before their padding with size solution. This treatment reduces the size consumption by 15–16%. This reduction of 15-16% of size consumption without losing the weaving performance will give a better savings on a sizing filed. However, in spite of this reduction the yarn hairiness is reduced. These results are due to a better adhesion of the bridges between fibers of the yarns. Consequently, a yarn pre-wetted before sizing would yield less breakage during weaving so the weaving performance in affected but its improved. The changes in mechanical and physical properties [Yarn strength, elongation, hairiness, abrasion resistance etc.,.] is also not having much difference, there is some difference on the testing result value but it won't affect the weaving process. The pre-wetting sizing have achieved the properties required for weaving.

There are generally no excessive variations in the values of certain properties found between the two processes, while some properties (which are of paramount importance for the subsequent weaving process - elongation and hairiness) show better results for yarns sized with the pre-wetting process (this is very important for the weaving process, where during shed formation yarns are subjected to large dynamic loads, which cause permanent yarn deformation), even with a lower size concentration. This is a very important indicator because in spite of a lower amount of size pick-up, the yarn achieves exceptional performance due to the size distribution, which is also very significant because the pre-wetting sizing process achieves great savings of sizing agents, water, and energy to do the sizing process (when sizing and desizing) and energy, which contributes to environmental protection.

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