STUDY THE PHENOMENA OF WARP YARN CLINGING ON AIR-JET WEAVING MACHINES

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ABSTRACT:
Warp yarn clinging is a technological problem. It affects the rate of weaving machine stoppages, the production and the quality of the produced fabric. On high speed air-jet weaving machine, where the shed dimensions is small, the occurrence of warp yarn clinging is more serious. Analysis of the phenomena of warp yarn clinging is the aim of this work. The effect of shed angle, warp yarn tension, yarn withdrawal speed, yarn count, yarn twist factor and cotton type on the yarn clinging are investigated. Scanning of the weaving machine stoppages due to warp yarn clinging is determined for the same fabric article on high speeds weaving machines in six weaving mills.

It was found that, the opportunity of warp yarn clinging increases as the shed angle being small, at low yarn tension, low withdrawal speed, fine yarn count and low twist factor. Giza 75 is preferable to be processed on high speed air-jet weaving machines. The percentage of weaving machines stoppages due to clinging can reach 45% of the total weaving machine stoppages at high warp density poplin fabric.

Keywords: Warp yarn clinging, shed geometry, clinging index, clinging length, clinging force.

NOMENCLATURE

ε = Strain in warp yarn (%)
$\Delta\varepsilon$ = Increase of strain in warp (%)
β = Back shed angle (°)
α = Front shed angle (°)
θ = Back shed angle due to clinging (°)
φ = Front shed angle due to clinging (°)
L_1 = Front shed free length (mm)
L_2 = Back shed free length (mm)
h = Half shed height (mm)
a,c = Back and front stretched length (mm)
b,d = Back and front stretched length due to clinging (mm)
T_{cb}, T_{cf} = Back and front vertical component (cN)
L_{cb}, L_{cf} = Back and front clinging length (mm)
E = Warp yarn modulus
$T_{b1,2,3}$ = Warp yarn tension
I = Clinging index
L_t = Tested length for 10^5 picks (m)
c = Predicted percentage of warp crimp (%)
v = Withdrawal speed (m/min.)
n = Weft density (picks/cm)
N = Weaving machine speed (p.p.min)

INTRODUCTION

With the aim of increasing productivity, the modern weaving machines run at high speeds. Indeed, significant progress has been made with regard to universality, flexibility, ecology and improved quality, but it was born a processing problem, which is the clinging of warp yarns.

On shuttle weaving machines, the shed geometry is proportional to the shuttle dimensions and the pirn diameter, which may suit the weft yarn count. On shuttleless weaving machines, the shed geometry is independent of the dimensions of the weft insertion element particularly on air-jet and water-jet weaving machines. Therefore, the shed height on shuttle weaving machines is greater than on modern shuttleless high speeds weaving machines.

The smaller shed leads to create the problem of warp yarn clinging which in turn leads to an unclear shed and, consequently to other faults such as loose yarns, pick-off, under-pick or over-pick and also stoppages of the weaving machines. These affect the quality of the products and the efficiency of the weaving machines.

The subject of warp clinging has attracted the attention of some researchers. By reviewing the available literature, the work can be divided into methods of measuring yarn clinging and the effect of some parameters on clinging of warp yarns. Some researchers concerned developing a suitable method for measuring yarn clinging objectively. The earlier works presented either indirect or direct methods for measurement of this problem. The indirect methods depend on the measuring of warp yarn tension during the weaving operation, but the measuring of tension affects the tension itself.

Weinsdörfer and El-Tayeb [1,2] presented a direct method on the principles of a photoelectric detection of clinging of the warp yarn. Another method is developed by Weinsdörfer and Horter [3]. The principle of this method depends on either laser stream or infrared stream, which passes through the width of the loom. The measurement of warp clinging on air-jet weaving machines is not exactly explained. Also the measurement of yarn coefficient of friction does not give any knowledge about the clinging of the yarns [4]. Soliman and Pfäffiken [4] measured the clinging of yarns through the measurement of the movement of the clinging point as a function of increasing the force in the clinged yarns.

With respect to the parameters and the problem of warp clinging, Weinsdörfer and El-Tayeb [2,5] measured the clinging of warp yarns on a ribbon loom and on a warp rapier weaving machine. The material was cotton/polyester 33/67% and only one warp yarn count Nm 68. They found that high relative humidity and temperature reduce the problem of clinging, the size add-on and rewaxing are the key factors regarding clinging. The warp density is a major factor, the weft density has a hardly measurable effect on clinging, warp threading and weight of droppers have hardly an influence on clinging. Ramaszéder [6] concluded that the presence of PVA increased weaving efficiency and decreased clinging of warp. Trauter, Vialon and Stegmeier [7] found that the adhesive strength of the size agent affect the hairiness of the warp yarns and the tendency to clinging. Furrer [8] stated that warp clinging affects the machine stoppages. He represented the Uster Topmatic PC with the aim to decrease the warp clinging. Blanchonette [9] found that, the clinging is the cause of increasing the average tension up to 20% for plain weave while by 2/2 twill no clinging is observed.

From reviewing the literature, the clinging of warp threads is a problem from the technological and economical point of view.A test stand [10] is constructed for measuring the clinging index with a simple technique. Shed dimensions such as crossing angle, yarn tension and withdrawal speed are the machine parameters, which are investigated. The effect of cotton type, yarn count and yarn twist factor on the clinging index are evaluated. The ratio of the weaving machine stoppages due to clinging to the total weaving machine stoppages in different weaving mills, which was not studied in the previous work, are measured.

ANALYSIS OF THE PHENOMENA OF WARP YARN CLINGING

If the hairiness of the processed warp yarns are little and the friction between the adjacent warp yarns is very small due to the lower warp density, the shed will be clear without any problem, as shown in Figure1- a and the warp yarns will be extended with a value proportional to the shed geometry.

$$\varepsilon = \frac{h^2}{2 L_1 L_2} \tag{1}$$

When the shed is opened and two adjacent yarns entangled together either in the back or in the front shed as illustrated in Figure 1-b and c this leads to clinging the yarns. Clinging can also occur due to the knot ends, accumulation of fibers, due to sizing agent applied on the warp yarns, or loose long fibers. Cling of warp yarns leads to put the yarns under more strain and consequently high tension (see Figures1-b and 1-c), which in turn creates stripiness in the produced fabric.

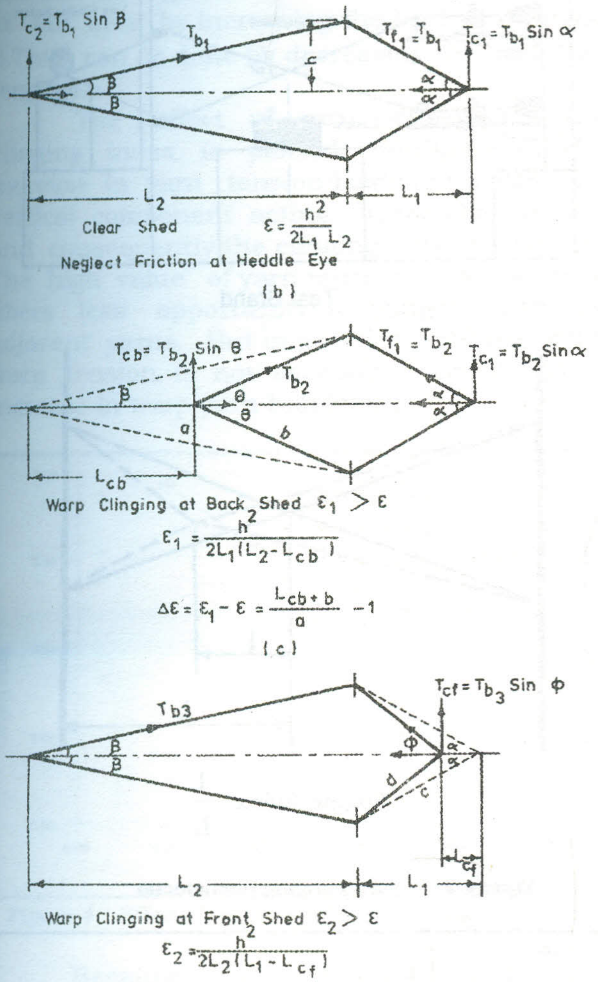


Figure 1 Warp clinging at back or front shed

When the clinging in the back shed Figure1-b disappeared and the entanglement is opened, the respective warp yarns become slack and tend to stop the machine. This slackness is due to an increase in warp yarn strain due to clinging and it is proportional to the new back shed dimensions.

$$\Delta\varepsilon = \frac{L_{cb} + b}{a} - 1 \tag{2}$$

If the weaver allows the machine to run again, these strained yarns will be woven in loosely state and produce warp stripes. Also when the vertical component T_{cb} reaches to the warp yarn breaking load, the yarn breaks and the machine stops. At the back shed, the vertical component is:

$$T_{cb} = T_{b2} \sin\theta \tag{3}$$

$$T_{cb} = [T_{b1} + (\frac{L_{cb} + b}{a} - 1)E] \sin\theta \tag{4}$$

$$T_{cb} = [T_{b1} + (\frac{L_{cb} + b}{a} - 1)E] \frac{a}{b} \sin\beta \tag{5}$$

This is the force which counter acts the clinging force and overcomes the warp yarn clinging in the back shed zone.

On the other side, when the clinging occurs at the front shed, in this zone either the shuttle or the projectile or even the rapier can break the clinged warp yarn. This occurs when the vertical component T_{cf} cannot open the clinging before the flight of the weft insertion element across the weaving machine.

The vertical component is also

$$T_{cf} = T_{b3} \sin\varphi \tag{6}$$

$$T_{cf} = [T_{b1} + (\frac{L_{cf} + d}{c} - 1).E] \frac{c}{d} \sin\alpha \tag{7}$$

On air-jet and water-jet weaving machines, the clinging of the warp yarns in the front shed directs the air or water stream from its normal position and the inserted weft yarn fails to complete its way to the other side of the weaving machine. Therefore, the occurrence of warp yarn clinging either at the back shed or/and the front shed affects the productivity of the weaving machine and the economics of the weaving.

EXPERIMENTAL WORK

A theoretical analysis for the phenomena of warp yarn clinging may be explained. The change in the dimensions of the shed geometry due to warp yarn clinging in the back shed and at the front shed may be determined. The value of clinging force as a function in warp yarn tension and shed geometry may be evaluated. The effect of parameters in the theoretical equation on the yarn clinging must be studied.

The first part will be carried out on the test stand, which is shown in Figure 2. The simple technique which is used in this work to measure the clinging index depends on taking photographs for the movement of the crosspoint of two yarns. The two yarns may be put just in contact at the crossing point to simulate the high warp density.

The yarn parameters which are studied are cotton type, i.e. Giza 75, Giza 80 and American cotton. The yarn counts are Ne. 20, 24,30 and 36 which are the average yarn counts used for the warp yarns in the Egyptian weaving mills. Four twist factors are studied 3.3, 3.4, 3.8 and 4.2.

The constructed test stand is also available to simulate some weaving machine parameters such as the shed height, the tension on the warp, the shed angle (crossing angle on the test stand) and the withdrawal speed which is a parameter for the weft density and the weaving machine speed, which are also investigated.

The tested length for 10^5 picks:

$$L_t = \frac{10^5(1+c)}{100n} \text{ [m]} \qquad (8)$$

and the speed of the winding head of the test stand

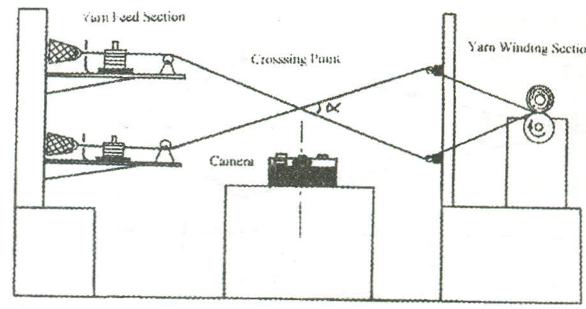
$$V = \frac{N(1+c)}{100n} \text{[m/min]} \qquad (9)$$

where N= speed of the weaving machine in p.p.min

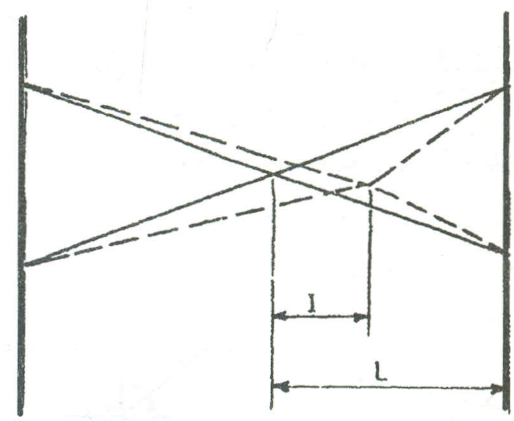
The second part in this work is a scanning for the occurrence of warp yarn clinging in six weaving mills, which produce the most common Egyptian fabrics on air-jet weaving machines. The circumstances of each mill may be recorded, such as the dimension of the mill, the size agent and its percentage on the warp yarns, as well as the climatic conditions.

EFFECT OF MACHINE PARAMETERS:

From the above equations, it is obvious that there are some parameters having a great effect on clinging of the yarn. These parameters are crossing angle, value of yarn tension and the withdrawal speed of warp yarn. Figure 3 shows the effect of the crossing angle on the clinging index. The decrease in clinging index is due to the increase in the vertical component T_{cb} or T_{cf} as the angle of crossing increases, and consequently the opportunity of the continuity of the yarn clinging decreases.



Test Stand



Clinging Index $\frac{l}{L}$

Figure 2 Yarn clinging phenomena

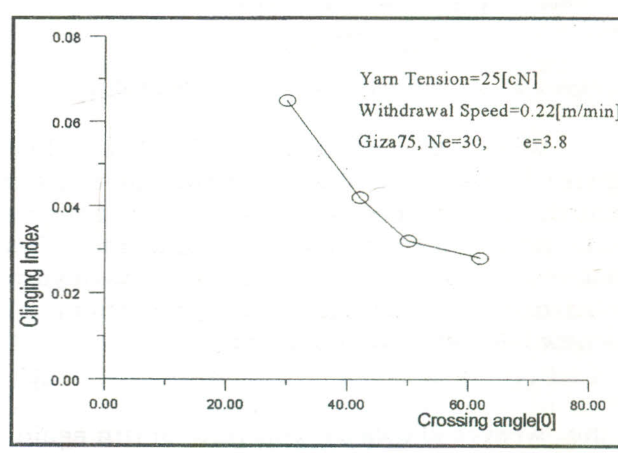


Figure 3 Effect of crossing angle on clinging

In practice and particularly on air-jet weaving machines, the shed angle is small and the occurrence of warp yarn clinging cannot be avoided through the increase of the shed angle α but only by increasing the back shed angle β. This can be done by decreasing the back free length L_2.

The effect of yarn tension on the clinging index is plotted in Figure 4. The increase in yarn tension leads to increase the vertical component acting on the clinged yarn and consequently the clinging index decreases. The high value of yarn tension gives the loose fibers less opportunity to clinging with the adjacent yarns. But in practice, increasing the warp tension is not acceptable and leads to increase in warp yarn breakages.

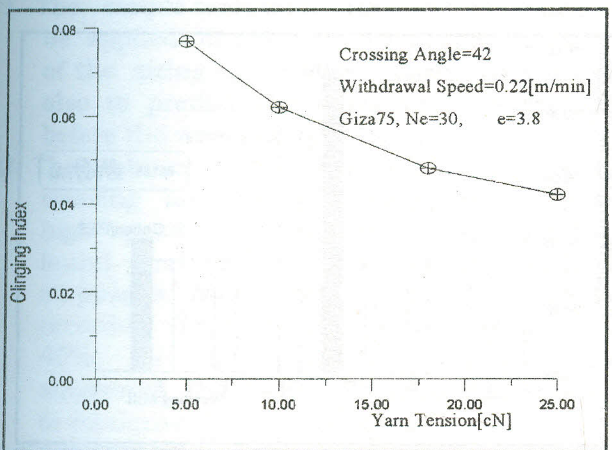


Figure 4 Effect of yarn tension on clinging

Because the withdrawal speed is a simulated parameter for the weft density, four yarn speeds are studied. Figure 5 shows the effect of the yarn withdrawal speed on the clinging index. At low withdrawal speed, the clinging index is high, while the clinging index decreases with the increase in the withdrawal speed due to the increase in yarn tension and consequently the increase of the force which counter-acts the continuity of yarn clinging. In practice, as the weft density increases, the take-up of the produced fabric decreases and the warp yarns are rubbed more with the heddle eye and the reed dent. This excess rubbing leads to the increase in the hairiness in the warp yarns and the probability of warp yarn clinging occurrence increases. Therefore, waxing or an increase in the softener during sizing can minimize the friction and rubbing of the warp yarns.

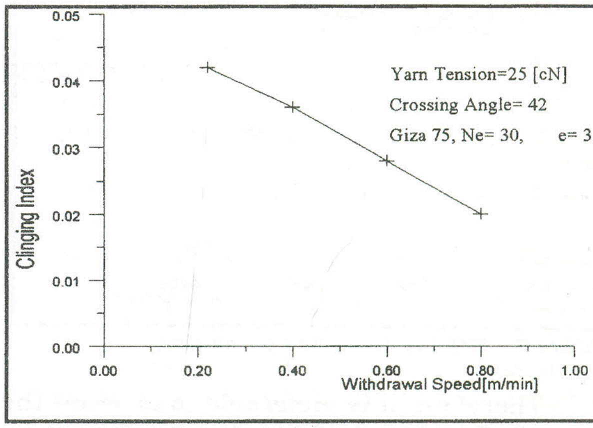


Figure 5 Effect of withdrawal speed on clinging

EFFECT OF YARN PARAMETERS ON CLINGING

The initial modulus of the cotton yarn E is mainly a function in cotton type, yarn count and yarn twist factor. The effect of these three parameters on the clinging index are studied.

Figure 6 shows that Giza 75 is better than Giza 80 and American cotton to overcome yarn clinging. i.e. yarn made from Giza 75 has lessopportunity of yarn clinging in spite of the lower hairiness and protruding fibers on the surface of the yarn than the coarser yarn count. This can be also shown from the results as shown in Figure7. Fine yarn count has higher clinging index than the coarser one. This is due to the smaller value of the vertical component which counter acts the presence of yarn clinging.

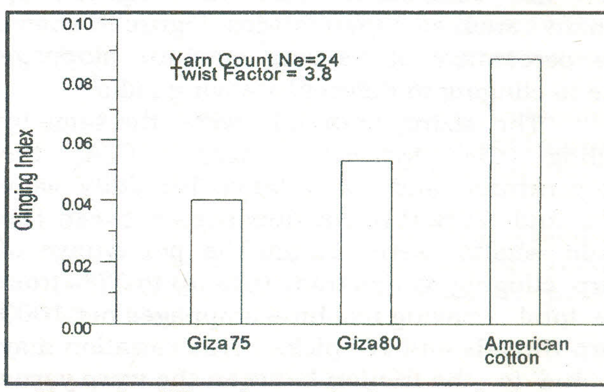


Figure 6 Effect of yarn twist factor on clinging.

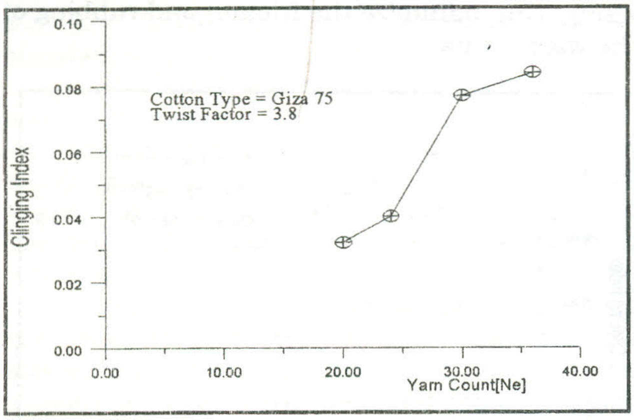


Figure 7 Effect of yarn count on clinging

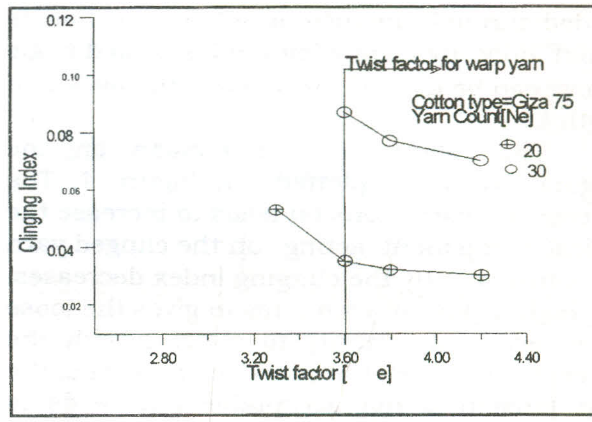


Figure 8 Effect of yarn twist factor on clinging

Therefore, it is preferable to increase the percentage of size on fine yarns to increase its thickness and to increase the value of warp yarn tension without an increase in warp yarn breakage.

Figure 8. shows the effect of warp yarn twist factor on the clinging index. It is clear that, a slight decrease in clinging index can be obtained by increasing the twist factor from 3.6 up to 4.2, which is the range for warp yarns. The slight decrease in clinging index is due to the decrease in yarn hairiness as the twist factor increases.

WEAVING MACHINE STOPPAGES DUE TO CLINGING

The most popular fabric which is produced in most Egyptian weaving mills has the specification of 65 inches or 63 inches wide, plain weave and $\frac{68 * 68}{30/1 * 30/1(N_e)}$,while there are some fabrics which have higher warp density such as poplin fabrics. Figure 9. shows the percentage of weaving machine stoppage due to clinging in different weaving mills.

The sizing materials were the same by adding the synthetic agent PVA, the temperature and the relative humidity were 27°c and 75% R.H. the distances between The heald shafts were 12mm.The percentage of warp clinging varies from 16% up to 37% from the total weaving machine stoppages per 1000 warp threads and 10^5 picks . This variation may be due to the friction between the warp yarns and different machine parts particularly at drop

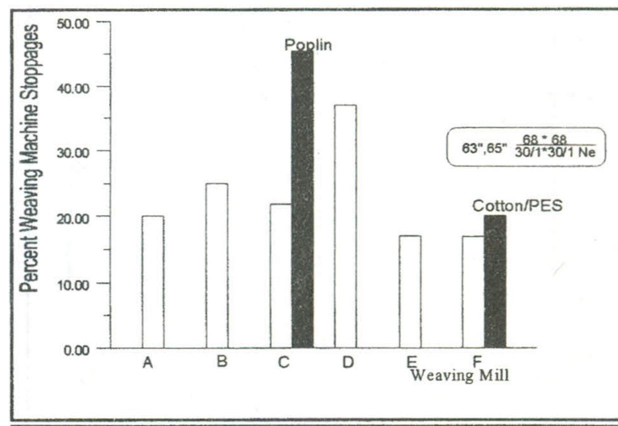


Figure 9 Percentage of weaving machine stoppages due to warp clinging on air jet weaving machines.

wires, lease rods and heddles, and the tension and its variation across the weaving machine width from weaving mill to another one. The ventilation system and its maintenance has also an influence on the presence of the fly in the surrounding places and over the weaving machine, which is remarked in weaving mill D.

An increase in warp density from 68 to 116 ends per inch in weaving mill C leads to increase the percentage of weaving machine stoppages due to clinging from 22% to 45% . This increase is due to the increase in warp yarn friction between the adjacent yarns during the movement of heald shafts up and down. Therefore, it is preferable to staggering the heald shafts to minimize the occurrence of yarn clinging.

In spite of cotton yarns are more hairy than cotton/PES yarns, the tendency of increasing the hairiness; on cotton/PES than cotton yarns after sizing and during weaving, is possible. This is due to the convolution of cotton fibers which are sticked on the yarn surface after the sizing and needs higher friction force to split it from the yarn surface than the polyester fibers which are cylindrical. This can be also observed in Figure 9. in weaving mill F.

CONCLUSION

From the analysis, results and discussions it can be concluded that:

1. The simple technique used in this work can be applied in practice to evaluate the effect of the sizing operation on yarn clinging and also to predict the behavior of warp yarn before the weaving operation.
2. The problem of warp yarn clinging affects the weaving machine stoppages particularly on high speed air-jet weaving machines. It is found that an increase in weaving machine stoppages from 16% up to 37% can be recorded. This value can be increased to 45% for high warp density. Therefore staggering the heald shafts is the solution to minimize the yarn clinging.
3. The type of cotton gives a significant change in the value of loom stoppage while Giza 75 gives less values. Warp yarns made from Giza 75 are better than Giza 80 and American cotton. Therefore, it is preferable to process Giza 75 for 100% cotton warp yarns on air-jet weaving machines. Blended yarn from cotton and polyester shows high percentage of stoppage than pure cotton due to warp yarn clinging.
4. The opportunity of occurrence of warp yarn clinging is high in case of fine yarn counts and lower yarn twist factor.
5. An increase in the back shed angle β or a decrease in the back free length L_2 diminishes the opportunity of warp yarn clinging, while a suitable high warp yarn tension is recommended.
6. Setting of the looms shows that for high weft density fabrics, it is preferable to increase the percentage of softener in size mix or waxing the yarn to minimize the friction between the adjacent yarns and between the yarn and the heddle eye and also reed dents.

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