Influence of Twist Loss of the Staple Weft Yarn on the Air-jet Loom

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Abstract

In this paper, we focus on the impact of the weft yarn twist loss on the properties of the fabric woven by air-jet loom. The weft yarns insertion time is adjusted by changing the loom speed; the twist loss degree and the difference of the properties on two sides of the fabrics are tested separately. The testing result shows that, the decrease of the weft injection time will significantly reduce the twist loss of the weft yarn: the difference in the tensile property of the two sides of fabric is not significant under any insertion time, while the difference in the dyeing properties of the two sides of fabrics is sensitive to the change of the weft injection time, especially when the dyeing process is carried out in a short time.

Keywords

Influence, Staple Weft Yarn, Air-jet Loom.

1. Introduction

The air-jet loom is widely used in the textile industry with its high productivity, convenient controllability, high filling insertion rate, low noise and low vibration levels, and it has become one of the shuttles looms with the fastest development. During the weft injection of the air-jet loom, compressed air is injected through a nozzle (main) for carrying the weft yarn from one side of the loom to the other. To eliminate the dispersion of the air and increase the dragging force, the profiled reed and the relay nozzles are carried on the air-jet looms. As the weft yarn is pulled by the dragging force of air, spun yarns with higher coefficient of friction is preferred. During the flying time of the weft yarn in the profiled reed, the weft staple yarns cannot be effectively held, and the staple yarn will rotate in an opposite direction of the twist due to its inner twisting torque [1]. The twist is expected to differ along the direction of the weft staple yarn's insertion.

Staple yarns should be twisted to obtain certain strength, and twist has a great impact on almost all the mechanical properties of staple yarns: the tensile properties, the bending properties, the friction properties, and the dyeing properties etc. For the dyeing properties, increasing the twist will increase the compactness of the staple fibers, and decrease the color depths accordingly [2].

Twist distribution of the weft staple yarns is greatly influenced by the yarn motion status as well as the weft yarn tension. Nosratya et al. [3] provided a theoretical simulation model to analyze the weft yarn motion under different conditions of weaving procedure; they also [4] investigated the relationship between the weft tension and the yarn motions; Tesaˇr [5] provided a sensor based on the principle of fluidic amplification to test the weft insertion tension; the influence of the twist on the dragging force of the compressed air is discussed in the research by S Adanur[6-7] , which showed that with the increase of the twist, the staple yarns will reduce the diameter and make the yarn surface smoother, and dragging force will be reduced as well.

The problem of twist loss of weft yarn in the air-jet loom is an obvious defect when the dragging media is the air, and the twist changing can affect many properties of the fabrics. Green wood and Makki[8] studied the twist loss under controlled conditions of twist loss. Mohamed et.al [9] discussed the extent of twist loss according to the width of fabrics. Measurement of extent of twist loss on various air-jet looms was provided by Qin Yaoqi[1]. The factors that would influence the twist loss action on the air-jet looms were analyzed by Talavasek and Svaty[10]. A special vortex nozzle is designed at the exit of the weft yarn to retwist the weft yarn[11],and the twist loss can be compensated slightly. The influence of the twist loss on the strength of the fabric was studied by Ray et.al [12], and the result shows that the impact of the twist loss is not significant; Abdulkader[13] focused on the skewness of the fabrics, and the warp crimp ratio along the weft insertion are compared to estimate the skewness.

In the literature mentioned above, the differences in the dyeing properties of the air-jet loom fabrics have not been discussed in detail, and what's more, the dyeing difference between the two sides of the fabrics is a common defect of the air-jet loom. In addition, the weaving speed of the air-jet loom increased significantly in the recent 10 years, and the weft insertion time decreased accordingly. The extent of the twist loss as well as the effects on the properties of the fabrics need to be studied based on the higher speed air-jet loom.

In this study, the twist loss of the weft yarn is tested based on different weaving speeds; some mechanical properties difference between two sides of the fabrics are obtained with the contrast experiment. The dyeing property difference of the fabrics is compared separately under different weaving speed and dyeing time.

2. Materials and Methods

2.1 Sample Preparation

The model of the air-jet loom used for making fabric samples is the ZAX9100 of Tsudakoma Corporation in Japan. Three fabric samples are woven on the air-jet loom with the same parameter setting except the weaving speed (500 r/min, 600 r/min, and 700r/min, the weaving speed in the daily manufacture). The specification of the sample fabrics are shown in the Table 1.

Tab .1 Specification of the samples

Parameters	Values
Yarn type	Combed cotton Ring spun yarn
Yarn counts tex	14.5 (both warp and weft yarn)
Weft yarn designing twist turns/m	1080
Width cm	166(let 0ff)
Density (/10cm)	354*276(let off)
Structure	Plain

Tested yarns and fabric blocks are selected from 15 cm away from the two sides of the fabrics. The left side marked as A is the beginning of the weft insertion, and the right side marked as B is the end of it. Weft yarns are drawn out from the fabric elaborately in the following experiments.

2.2 Testing Methods

2.2.1 Yarn twist and tensile property testing

The twist and the tensile property of the drawn-out weft yarn were tested based on ASTM standards. 15 weft yarns with 35cm length on both sides of the fabrics are drawn out to test the twist value; and 20 weft yarns with 60cm length are provided to evaluate the tensile property.

2.2.2 Fabric weft tensile property testing

The twist loss appears only on the weft yarn, so the tensile property of the weft should be more significantly affected than that of the warp. Besides, the weft tensile properties are tested based on the ASTM standards. 5 fabrics from both sides are prepared for the tensile property testing, with the length of 200mm.

2.2.3 Dyeing property testing

The testing for differences of the dyeing property between the two sides of the fabrics is the key procedure of this paper. The color depth is chosen as the main feature to assess the dyeing property. The K/S (Kubelka-Munk) values of the both sides of the fabric are calculated based on the 10 times testing with Datacolor 650, and the heavier K/s value is referred to the deeper color [14]. Two fabrics are prepared for each dyeing experiment, and all the samples are processed by desizing, scouring, bleaching procedure before dyeing. The reactive dye YMHL are provided for the dyeing process, and the samples are immersed in the dye path with different time.

3. Results and discussion

3.1 Weft yarn twist loss

Table 2 shows the twist loss of the weft yarn under different weaving speeds, and the result shows that with the increase of the weaving speed, the twist loss decreased accordingly. The twist loss ratio is calculated as in the following equation:

Tab. 2 Twist loss of the weft yarns

No.	Weaving speed r/min	Twist of A T/m	Twist of B T/m	Twist loss ratio %
I	500	1108	1036	8.4%
II	600	1120	1065	4.8%
III	700	1088	1039	4.5%

The twist loss ratio of the weft yarn was up to 8.4% when the weaving speed was about 500 r/min, and this value was very close to the result of the research in 2005[12], when the weaving speed was about 350r/min. The twist loss ration decreased significantly when the weaving speed increased from 500 r/min to 600r/min, while the difference between 600r/min and 700r/min was not remarkable.

The twist loss difference among the three fabrics can be analyzed through the weft free flying time, which can be calculated based on the weaving speed and the insertion parameters setting. In the manufacture of air-jet looms, the time of each process can be marked by the degree of principle axis [15]. For these three fabrics, the weft yarn insertion began at 90 degree (insertion beginning time), and the weft yarn was grasped by the warp yarn at 300 degree (the heald level time). The free flying time of the weft yarn was about 210/360 of the work cycle of the weaving, and they were about 0.070 s (500r/min), 0.058s (600r/min) and 0.050s (700r/min). The free flying time difference between I and II was more remarkable than that between II and III, so the twist loss decrease between I and II was more significant.

3.2 Weft yarn tensile property

The drawn-out weft yarn was prepared for the tensile property testing, and the difference between the two sides of the wefts was mainly caused by the twist loss of the yarn. The weft yarn breaking strength and the breaking elongation rate are shown in Table 3.

Tab. 3 Tensile property of the weft yarns

No.	Breaking strength cN		Breaking elongation rate %	
	A	B	A	B
I	218.8	203.7	4.09	4.02
II	232.7	225.8	3.50	3.39
III	226.0	225.1	4.06	4.03

There is no evident difference between the breaking elongation rate characteristics of the two side weft yarns, which means the twist loss extent cannot efficiently affect that property.

The effect of twist loss on the strength is also not very distinct. The biggest strength loss appears on Sample I (only 15 cN), with the ratio of 6.9%. The twist loss leads to the decrease of the cohesive force between fibers, and so to the yarn strength. The strength loss ratio of Sample III is the smallest (only 0.40%), which can be regarded as no influence on the strength loss.

3.3 Weft tensile property of the fabrics

The weft breaking strength and the breaking elongation rate of the fabrics are shown in Table 4.

Tab. 4 Weft tensile property of the fabrics

No.	Breaking strength N		Breaking elongation rate %	
	A	B	A	B
I	359.7	341.5	11.5	10.9
II	361.1	355.6	10.8	10.7
III	355.5	351.7	12.0	11.9

There is no evident difference in the weft tensile property between the two sides of the fabrics; the breaking strength and the breaking elongation rate of the two sides of the fabrics are on the same level. The influence of the twist loss of the three samples can be regarded as a minor factor to the tensile property. The maximal breaking strength reduction on Sample I was about 5.1%. With the improvement of the weaving speed, the reduction ratio of the tensile decreased significantly compared with the result of Qin[1](8-17%).

3.4 Dyeing property

The K/S values of the samples were tested to compare the difference in the color depth of the two sides of the fabrics [14]. In order to examine the dyeing time influence, each fabric was prepared in five groups, and the dyeing time ranged from 5min to 40 min. The K/s values are shown in Table 5 to Table 7.

Tab. 5 K/s value of Sample I

Dyeing time	K/s of side A	K/s of side B	Difference ratio
5min	0.6002	0.6653	10.85%
10min	0.6657	0.7339	10.24%
20min	0.8213	0.9025	9.89%
30min	1.0909	1.1947	9.52%
40min	1.1658	1.2714	9.06%

Tab. 6 K/s value of Sample II

Dyeing time	K/s of side A	K/s of side B	Difference ratio
5min	0.5997	0.6572	9.59%
10min	0.6621	0.7264	9.71%
20min	0.8539	0.9112	6.71%
30min	1.1444	1.2099	5.72%
40min	1.1548	1.1764	1.87%

Tab.7 K/s value of Sample III

Dyeing time	K/s of side A	K/s of side B	Difference ratio
5min	0.5903	0.6308	6.86%
10min	0.6549	0.6722	2.64%
20min	0.8949	0.9209	2.91%
30min	1.1532	1.1685	1.33%
40min	1.2461	1.2525	0.64%

The K/s of the right side B is larger than that of the side A on all the samples at any dyeing time, which is mainly caused by the twist difference. The weft yarn twist of the right side B is smaller than that of the left side A, which makes the weft yarn slacker and easier to absorb the dyeing pigments during the dyeing process. The maximal dyeing difference ratio showed in Sample I with the dyeing time of 5 min (about 10%), and the maximal twist difference also appeared in Sample I. The decrease of the twist difference can weaken the dyeing diversity.

There is another factor affecting the dyeing diversity distribution, which is the dyeing time. With the extension of the dyeing time, all the K/s differences declined, and the dyeing difference ratio dropped up to 0.64% for Sample III when the dyeing time extended to 40 min. The extension of the dyeing time is the right time for the pigments to distribute on the yarns. The difference in the twist between the two sides of the yarns can affect the dyeing liquid absorption efficiently at the early time of the dyeing process, but the effect will be weakened after the yarns has adequate time to react with the dyeing liquid. The minimal dyeing difference between the two sides is the Sample III with 40 mins dyeing time. The smallest twist loss as well as the longest dyeing time has led to the minimal dyeing diversity.

The dyeing difference on Sample I was preserved on 10% with the extension of dyeing time. The twist difference influence was still dominant for Sample I even though the dyeing time was extended to 40 min. The twist loss of Sample I had great impact on the pigments absorptions, and the fabrics made on the low speed of air-jet loom should be paid more attention to for that influence.

On the other hand, the dyeing time for the fabric is a key factor for the whole dyeing process, which will influence the appearance color significantly. The dyeing time extension is not an efficient way to solve the dyeing diversity problems, and the best way to reduce the diversity is to shorten the weft yarn free flying time by increasing the weaving speed. The weaving speed is limited by the equipment and yarn conditions, and cannot be raised to a higher level.

The dyeing difference in the two sides of fabrics made by air-jet loom cannot be well compensated only through the adjustment of the weaving parameters; the increasing of the weaving speed or the extension of the dyeing time can only weaken that diversity while cannot solve that problem. The fabrics with higher dyeing requirements and shorter dyeing time should be planned to produce on the rapier looms to avoid the dyeing diversity.

4. Conclusion

The twist loss of the fabric woven by air-jet loom is discussed in this paper. With the increase of the weaving speed, the weft insertion time decreases, and so does the twist loss of the fabrics. The twist loss can be reduced to about 4.8% when the weaving speed is increased to 700r/min.

The tensile property of the yarn and fabrics is not significantly influenced by the twist loss. Most of the fabrics preserved the similar breaking strength and breaking elongation rate on both sides of the fabrics even the weaving speed is only 500 r/min. The influence of the twist loss to the tensile property of the fabrics can be ignored in the modern weaving process.

The dyeing diversity is a critical defect for the air-jet loom fabrics. The experimental result revealed that, even the weaving speed increases to 700 r/min, the K/s value is still in an obvious scale. Extension of the dyeing time is an efficient way to overcome that defect, but it will affect the color appearance distinctly and cannot be adjusted for this defect. The best way for the fabrics with higher dyeing requirements is to change the weaving loom with the weft yarn efficiently held.

In conclusion, the two sides of the weft yarn of the fabric woven by air-jet loom are compared in this study. The twist loss of the weft yarn decreases with the increase of the weaving speed; and the tensile property of the fabrics and the yarn are preserved at the same level. The critical problem is about the dyeing diversity, and the twist loss will provide different pigment absorption between the two sides of the fabrics, which is not acceptable for the fabric with high requirements of the dyeing effect.

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