

The Research on Properties of High Count Doubling Fabrics in Home Textiles

Lei Zhang ^{1,2}, Kehui Deng ^{3*} and Ziqi Wang ³

¹ College of Textiles, Donghua University, Shanghai 201620, China

² College of Electronic and Electrical Engineering, Wuhan Textile University, Wuhan 430200, China

³ College of Humanities, Donghua University, Shanghai 201620, China

Email: dengkh@dhu.edu.cn

ABSTRACT

An innovative experiment was carried out on one kind fabric of home textiles in this paper to study the relationship between the plying structure of yarns and properties of the fabric. With the same warp yarn, we compare these fabrics weaved by different weft yarns, such as high count multiply yarns without twisting, the same plied yarns with twisting and the same single yarns, then explore the pros and cons of the plied yarns with twisting or without twisting and their impacts on home textiles.

Keywords: Doubling Yarn, Plied Yarn, Breaking Strength, Abrasion Resistance, Pilling Resistance, Air Permeability, Friction.

1. INTRODUCTION

The textile industry in China pays much attention to the self-independent innovation and accelerates the speed of the structural adjustment. As for the increasing demand of innovative home textile products, we need to change the quantitative mode of relying on raw material resources and low-cost human resources over the years, promoting technological progresses and optimizing industrial structures to turn to the mode of increasing quality and efficiency. The content of this article is about an innovative experiment and research of a kind fabric in home textiles, to study properties of the high count doubling fabric in home textiles.

1.1 The significance of application of high-count doubling fabric in home textiles

Textiles are a necessity to human life. From leaves, animal skins in ancient times to various textile products in modern times, they all reflect the process of human civilization's constant improvement, innovation and progress [1]. The development of textile industry in the 21st century brings about demands about newer and more humanized designs in home textiles. Meanwhile, the application of high-tech processing technology and the detrusion of new fiber materials also contribute to the development of textiles towards the direction of diversification. As people's living standards continue to improve and demands continue to deepen, there are more and more textile fabrics of high count plied yarns with twisting in the market, while fabrics of plied

yarns without twisting are in its infancy, so it has important theoretical values and practical significances the research for this application.

1.2 Research methods of properties of high count doubling fabrics in home textiles

This article is a research about comparing data and testing properties of fabrics of high count doubling yarns and fabrics of the same plied yarns. Exterior characteristics and interior properties of fabrics are decided by the structure of fabrics, such as the arrangement, status and interaction of yarns and fibers in the fabric [2]. Woven fabrics are sheet aggregation made by warp yarn, which are parallel to the selvage of the fabric or has a certain angle with the selvage, and weft yarn, which are arranged perpendicular to the selvage of fabric according to the law of interweaving. Besides, the crossed arrangements and the undulating pressing contact form a stable pilotaxitic structure [3]. First, determined the desired counts of yarns; second, spooled yarns with doubling and plying respectively; then, weaved it on a small model loom; finally, make a research about doubling fabrics through a series of tests of anti-bending, brute force, friction, pilling and draping.

2. THE PLYING STRUCTURE OF YARNS AND THE SELECTION AND PERFORMANCE INDEX OF FABRICS

2.1 The plying structure of yarns

The fabric's properties have close relationship with the structure of the yarn, and by changing the structure of yarns, properties of the fabric can be improved. The new type of yarns made by a different pattern of plying is one of the important approaches to develop new products. This paper is about the plying structure of yarns, using a plurality of high count doubling yarns without twisting as the weft yarns to reflect its advantages of wearability.

Twist the plied yarn to two or more single yarns on the steel wire ring. While the steel wire ring rotates in a circle, the plied yarns adds one twisting [4]. The conventional plied yarns generally have the same Tex of the single yarns, while the direction of twisting is contrary to the single yarn, and these two single yarns bear the same stress during the production process, so the arrangement of the yarn's structure is balanced [5]. If the Tex of single yarns in the plied yarn differs a lot, each single yarn will bear different stresses when twisting and the twining structure will be in an unequal proportion.

This study makes comparison between the doubling yarns which use a plurality of yarns without twisting and the conventional plied yarns (two single yarns with the same Tex plied together with a specific twisting; the direction of twisting is opposite to the single yarn) to reflect its differences in wearability.

2.2 Determining the varieties and counts of yarns

In this experiment, we choose 50S/2 polyester with the higher strength and better abrasion resistance as the warp yarn, avoiding problems of unclear openings and frequent breakages. As for the weft yarn, we choose two kinds of cotton yarns with the same count, and one kind is doubling yarns without twisting which has a plurality of yarns with the same count together; the other is common plied yarns.

2.3 The performance index of yarns

2.3.1 The degree of yarns' fineness

Yarns' fineness can be represented with direct index (diameter, cross-sectional area) and indirect index (the relationship between length and quality). Using hinging weighing method to measure the fineness of the selected single yarn, and the result of the experiment is as followed: the single yarn is 60S, the plied yarn is 10S.

2.3.2 The degree of twist

Testing with the Y331N twist tester, and taking the sample with the length of 25cm. The plied yarn uses the method of direct untwisting with pre-tension 14CN, while the single yarn uses the method of untwisting and twisting once with pre-tension 4CN. Testing for 5 times and the results are as follows:

Table 2-1. Twisting data sheet
Unit: /10 cm

Project	The single yarn	The plied yarn
1	112. 30	49. 72
2	110. 12	52. 00
3	113. 96	50. 52
4	116. 16	49. 08
5	131. 24	51. 80
average	116. 756	50. 624

2. 3. 3 The strength of tensile failure

One of the important assessments of yarns' quality is the tensile mechanical properties. The mechanical properties of yarns not only relate to the shape of the fibers themselves, but also relate to the structure of yarns and the interaction between fibers. Using the CRE (constant rate of elongation) strength tester to get the results which are as followed:

Table 2-2. Data sheet of plied yarns' strength

Projects	Breaking strength CN	Intensity CN/tex	Elongation mm	Elongation rate %	Breaking time S
1	790	14. 23	37. 0	7. 40	8. 00
2	754	13. 59	36. 0	7. 20	7. 90
3	802	14. 45	41. 0	8. 20	9. 00
4	715	12. 88	37. 0	7. 40	8. 10
5	700	12. 61	38. 0	7. 60	8. 30
6	752	13. 55	38. 0	7. 60	8. 30
Average	752. 1	13. 55	37. 8	7. 56	8. 27

Table 2-3. Data sheet of doubling yarns' strength

Projects	Breaking strength CN	Intensity CN/tex	Elongation mm	Elongation rate %
1	1595	27. 35	35. 0	7. 00
2	1292	22. 15	28. 0	5. 60
3	1100	18. 86	27. 0	5. 40
4	1169	20. 05	30. 0	6. 00
5	1162	19. 93	30. 0	6. 00
6	1305	22. 38	29. 0	5. 80
Average	1270. 5	21. 79	29. 8	5. 96

We can see from the data in the table that the breaking strength of doubling yarns is about 68. 87% higher than the breaking strength of plied yarns; the intensity is about 60. 81% higher than that of plied yarns; the elongation is about 29. 18% higher than that of plied yarns. The physical properties of doubling yarns are better than that of plied yarns, while physical index is much more useful in fabrics' wear and stretch.

3. THE TEST OF FABRICS' PROPERTIES

In the experiment, we choose polyesters as the warp yarn, cotton plied yarns and cotton doubling yarns which is a plurality of yarns together without twisting as the weft yarn; we choose five with satin weave of three fly and the selvedge with plain weave of two on and two under. According to the assumed color effect, select the appropriate colors of yarns and determine the arrangement of colored yarns in the direction of warp or weft.

Fabrics' specifications are as followed:

Yarns material: Polyesters Reed number: 2 Counts of the warp yarn: 25Ne

Number of ground warp yarns: 480 Number of side warp yarns: 24 Width of the fabric: 20 ~ 21 (cm)

Different fabrics have different uses, so their required properties are different, and projects and methods of testing are also various. We can compare them from their properties

of tensile failure, fatigue resistance, draping, anti-pilling, air permeability, antistatic and fabric styles and so on.

3. 1 Appearances and parameters of fabrics

Table 3-1. Data sheet of density
Unit: root/ 5cm

Fabrics' types	Fabrics of doubling yarns		Fabrics of plied yarns	
	Pj/5cm	w/5cm	Pj/5cm	Pw/5cm
Direction				
1	120	128	118	128
2	115	132	119	134
3	117	127	117	132
4	115	125	119	136
Average	116. 75	128	118. 25	132. 50

The density test method of Fabrics' warp yarns and weft yarns: under the same condition of weaving, taking two pieces of cloth woven separately, using the cloth counting glass to measure by the direct reading method. The distance is 5cm. Each group was measured for 4 times and calculated the average result. As shown in Table 3-1.

From the data in Table 3-1 we can see that the yellow sample's density (fabrics of plied yarns) is slightly larger than the red sample's (fabrics of doubling yarns). But from the hand feeling of these two samples, the yellow one is relatively softer.

3. 2 The test of fabrics' thickness

Test with the YG141L fabrics' thickness gauge, and set the area of presser foot as 12. 56cm² and the diameter as 4cm. The test time is 5 seconds, and the test mode is continuous.

Table 3-2. Data sheet of fabrics' thickness
Unit: mm

Samples	Fabrics of doubling yarns	Fabrics of plied yarns
1	0. 45	0. 54
2	0. 63	0. 51
3	0. 46	0. 53
4	0. 45	0. 45
5	0. 33	0. 43
6	0. 46	0. 46
7	0. 44	0. 47
8	0. 44	0. 50
9	0. 47	0. 54
Average	0. 459	0. 492

As can be seen from Table 3-2, the sample of plied yarns is a little thicker than the sample of doubling yarns, which might be relevant to the density of samples' warp yarns and weft yarns. By observing the original data of the fabric, we can find that making six yarns together doubling into the fabric, the data of the thickness is fluctuating.

3.3 The comparative test of fabrics' tensile breaking

The tensile breaking strength of the fabric is used to indicate the ability to resist tensile forces, and also used to

assess changes before and after wear and tear, in order to evaluate the effects of sunshine, washing and various finishing on the intrinsic quality of the fabric [6]. The property of fabrics' tensile breaking property also affects the hand feeling of the fabric. The test of fabrics' tensile breaking property at present is mainly one-way stretching which is testing the strength of the warp direction, the strength of the weft force, or the strength of a certain angle to the warp direction and the weft direction.

Test with the YG (B) 026-250 electronic tester of fabric strength, use the method of splitting selvage of fabrics, and set the clamping distance as 100 mm. Stretch the samples of a certain size to break them according to a constant elongation. Each sample cloth is tested for two times (the weft direction), and the data in Table 3-3 is the average of the two samples and it can be a good reflection of the nature described.

Table 3-3. Data sheet of fabrics' tensile failure

Types Direction	Fabrics of doubling yarns	Fabrics of plied yarns
Breaking Force	Weft 1251. 8	Weft 622. 75
Breaking F (N)		
Elongation Braking	14. 005	16. 9
L (mm)		
Time T (S)	7. 975	6. 795
Elongation %	14. 01	16. 90

As can be seen from Table 3-3, the breaking force in the weft direction of fabrics of plied yarns is about 50. 25% smaller than that of fabrics of doubling yarns, breaking elongation of which is about 20. 67% higher than that of fabrics of doubling yarns. Although the density of fabrics of plied yarns is slightly larger than that of doubling yarns, the breaking strength of which is smaller; this may have a close relationship with its single yarn's strength. The experimental result is as followed: the breaking force in the weft direction of fabrics of doubling yarns is better than that of fabrics of plied yarns. It shows that the fabric of doubling yarns is more stretch-proof in the direction of its weaving.

3.4 The test of fabrics' abrasion resistance

Fabrics would rub people's skins or clothes during wearing. Studies have shown that 7% of clothes' damage is due to wear and tear. The slippage of fabrics' yarns, especially at the place of interweaving, is connected to the property of fabrics' abrasion resistance [7]. If the sample has a good elasticity, the kinetic energy accumulated where the fabric frays can spread rapidly and can have a better ability to recover, it will reduce wear and tear to give the sample a good property of abrasion resistance, namely a better elasticity, a better abrasion resistance [8] [9]. The property of wear and tear directly affects the durability of the fabric, so it is an important indicator of measuring the durability.

Testing with the Y522 type disc grinding apparatus, and the sample is divided into two groups, one group is fabrics of doubling yarns, and another is fabrics of plied yarns. Abrasive is the A-150 charring wheel, the pre-tension of the pressurized hammer is 250g, while the number of turns is 200 times.

Table 3-4. Testing data of abrasio

Types	Weighing Time	Sample Weight (g)	Wearing Weight (g)	Weight Loss/Unit Areage/(cm ²)
Fabrics of doubling yarns	Pre-wearing	3. 2968	0. 0267	0. 000218
	Post-wearing	3. 2701		
Fabrics of plied yarns	Pre-wearing	2. 6448	0. 0354	0. 000289
	Post-wearing	2. 6094		

As can be seen from the testing data, under the same wearing condition, the weight loss per unit area of fabrics of plying is about 32.57% higher than that of fabrics of doubling yarns. This experiment shows that the abrasion resistance of fabrics of doubling yarns is better than that of fabrics of plied yarns.

3.5 The comparison test of fabrics' pilling resistance

Fabrics will suffer various external forces in the process of wearing and using which makes fluff or monofilament on the surface of fabrics gradually pulled out. When the height and density of fluff reaches a certain value, the continuous effect of external friction makes the fluff tangled into a ball and emboss on the surface of the fabric. The pilling of the fabric will deteriorate the appearance of the fabric and reduce its wear ability.

Testing with YG502 fabrics' pilling tester, and dividing the sample into two groups, one group is the fabric of doubling yarns, and another is the fabric of plied yarns. Cutting a sample with the diameter of (113 ± 0.5) for each group, with nylon brushing abrasive and the standard fabric's abrasive, using the testing method of circular locus. The pre-pressure is 300CN; nylon abrasive grinds for 150 times, and the fabric's abrasive grinds for 150 times.

Table 3-5. The comparison sheet of pilling of fabrics of doubling yarns and fabrics of plied yarns

Fabrics' types	Fabrics' directions	Levels of samples
Fabrics of doubling yarns	Opposite	Second
Fabrics of plied yarns	Negative	First

As can be seen from Table 3-5, fabrics of doubling yarns is the second level comparing to the standard level of samples, and fabrics of plied yarns is the first level comparing to the standard level of samples. It shows that the pilling resistance of fabrics of doubling yarns is better than that of fabrics of plied yarns.

3.6 The comparative test of fabrics' air permeability

Fabrics' ability to penetrate the air is important to garments. Outerwear in winter should be windproof and warm, namely it should have less air permeability; garments in summer should have a better air permeability for a cool feeling.

Testing with YG (B) 461D type-II digital instrument of fabrics' air permeability, with the 3rd nozzle, and the range of dynamic pressure is 600 ~ 3000Pa, the sample's pressure is

100Pa, the sample area is 20cm². With 12 data tested in total, results are as follows:

Table 3-6. Data sheet of fabrics' air permeability
Unit: L/m²s

Samples	Fabrics of doubling yarns	Fabrics of Plied yarns
1	211. 2	216. 8
2	214. 7	111. 3
3	147. 6	233. 0
4	172. 1	213. 4
5	162. 1	140. 3
6	222. 3	149. 4
Average	188. 3	177. 4

Under the circumstance of the same intensity of pressure, the property of fabrics' air permeability is mainly related to the internal structure of fabrics. The pore size of the fabric is apparently negatively related to the tightness of the fabric and the length of the tissue's float, but it also has some relevance with the thickness of the fabric [10]. As shown in Table 3-6, the air permeability of fabrics of doubling yarns is about 6. 1% higher than that of fabrics of plied yarns and the air permeability of fabrics of doubling yarns is apparently better than that of fabrics of plied yarns.

4. CONCLUSION

This paper makes a research about the property of the high count doubling fabric, through referring to books, searching for the selection of high-count yarns, deciding counts of yarns, doing experiments, weaving on the machine, testing its properties and analyzing the data, we find that the physical property of high count doubling fabrics is better than that of fabrics of plied yarns, such as properties of air permeability, pilling resistance, abrasion resistance and strength against breaking and so on; although the outlook and hand feeling of which is not as good as that of fabrics of plied-yarns, while the practical value of the former is much higher. If this kind of fabric is used in bedding and home textiles, it will be more satisfied with the need of consumers no matter in respect of its appearance or its properties; what's more, this kind of fabric will be easier to have a wider prospect in the field of home textiles.

REFERENCES

- [1] Liu N., "A brief talking on the future trend of home textiles' designs," *Foreign Silk*, vol. 60, no. 2, pp. 269-287, 2005. DOI: [1063/1.4886855](#).
- [2] Yu W. D., *Textile Materials Science*. Beijing: China Textile Publishing, 2006, pp. 12-18.
- [3] Yu X. F., *The Technology of Textile Materials' Experiments*, Beijing: China Textile Publishing, 2004, pp. 122-128.
- [4] Li Y., "The study on hemp fabrics' air permeability," *Hunan Institute of Engineering*, vol. 12, no. 6, pp. 88-90, 2005. DOI: [9.18280/ijht.330428](#).
- [5] Zheng. C. X., Hu X. B., Dong X., et al., "Research on air permeability of the cotton/polypropylene fabric in the dry and wet environment," *Qingdao University*, vol. 10, no. 12, pp. 31-34, 2004. DOI: [1006/1037](#).

- [6] Li J., Zheng T. Y., Yang J. X., et al., "Research on impacts of fabrics' structures to the air permeability of fabrics," *Tianjin Textile Institute of Technology*, vol. 2, no. 4, pp. 269-287, 1998. DOI: [10634/1234.48855](#).
- [7] Cai B. X., *The Structures and Designs of Fabrics*. Beijing: China Textile Publishing, 2008, pp. 122-154.
- [8] Chen D. H. and Zheng E. W., "The pre-test of fabrics' wearing resistance," *Jilin Institute of Technology*, vol. 14, no. 3, pp. 60-63, 1993. DOI: [1671/1548](#).
- [9] Jiang N. and Liu Z. L., "Research on wear mechanism and testing methods of coated fabric," *Textile Standards and Quality*, vol. 12, no. 4, pp. 39-42, 1991. DOI: [1634/1234.4867](#).
- [10] Qiu M. W. and Wang. F. M., "The predictive study on the air permeability of woven fabric," *Textile Technology*, vol. 2, no. 8, pp. 73-75, 2005. DOI: [10.2495/1022-1077-1189](#).