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Experimental Investigation to Evaluate Critical Aspects of Denim Quality

Nazmus Sakib[1], Guocheng Zhu[1*]
[1]*School of Materials and Textiles, Zhejiang Sci-Tech University, Hangzhou, 310018, China*
Corresponding Author:Guocheng Zhu

Abstract: *In this study, how the quality changes in terms of denim construction and finish by considering the parameters such as tensile strength, tear strength, dimensional stability and color fastness to wash, water & rubbing. Quality control plays a very crucial part for any kind of business of any company or industry. High quality denim means high performance fabric which must be ensured by quality tests.*
But sometimes it is very difficult to maintain high quality in terms of different constructions of fabric because different constructions have different properties which impacts on the quality of denim fabrics. For which we need to know how the quality changes according todifferent constructions of fabric.
For this study 98% cotton & 2% Lycra with five different constructions of fabric were used for examine tensile strength test, tear strength test, dimensional stability test, and color fastness to wash, water & rubbing test of these different fabric.
Theresult showed that both tensile, tear strength increased if higher count of yarn was used, and it decreased if lower count of yarn was used in both warp and weft directions. But differences happened when the number of ply of the yarn increased or decreased. Tensile and tear strength increased with the number of ply of the yarn and it decreased if number of ply of the yarn was reduced. In the dimensional stability analysis I found because of spandex warp yarn the shrinkage rate was increased and so the G.S.M value. The quality of abrasion and pilling, color fastness to wash, water and rubbing depends on the fiber and yarn quality.
As the demand for denim is increasing day by day so for satisfying consumer we must ensure the quality of denim according to the expectation of consumer.

Keywords: *Denim, Quality Control, Tensile Strength, Tear Strength, Dimensional Stability*

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I. Introduction

Modern consumers are interested in comfort clothing as it has not only aesthetic appearance but also provides great feeling[1].

Clothing is in direct contact with human body and interacts with the skin during use. The interaction between clothing and human body stimulate sensorial properties which lead to perception of either comfort or discomfort. Comfort and convenience are very important for the selection of garments and style of construction is the thing customers try to find which means high quality of garments to the customer[1, 2].

Denim apparel has an important role in fashion industry. The global denim market was valued at $56,178.1 million in 2017 and is forecasted to witness a CAGR of 5.8% during 2018–2023[3].That means the value of using denim is increasing day by day. So in my study I focus on how the quality of denim can be improved for different structure of fabrics. The value of denim products are related to comfort as well as physical, chemical and mechanical properties of the fabrics[4]**.** Every detail and decision regarding the developing process of a denim style are being built into the overall quality of the garment[5]. If the product does not meet the expectations of the users, they will get dissatisfied and some of the customers will return the product with complaint. During all processes of the production chain, several actors are involved; designers, pattern makers, quality department, buyers and suppliers[1, 4].

To produce and maintain high quality jeans, the quality management is an important part of the product developing- and production phase. The quality management can be expressed in many different ways, from quality management systems to quality requirements and tests [1, 2, 4].

Quality tests are important to secure the product's pledged properties, but also to make it possible to evaluate user complaints and claims. By testing the products and put the test results in relation to the reclaims, analyses can be made as to whether the reclaims are valid or not[1, 2, 4].

II. Materials and Methods

Materials:

Fabric content: 98% cotton & 2% Lycra

Fabric Constructions:

For this experimental work five denim samples were used. For sample 1 single ply of yarn was used where 10 counts of yarn used in warp directions and 10 counts with 70 denier lycra used in weft direction considering E.P.I and P.P.I was 80 and 40 respectively. For sample 2 double ply of yarn was used where 10 counts of yarn used in warp directions and 16 counts with 70 denier lycra used in weft direction considering E.P.I and P.P.I was 84 and 40 respectively.For sample 3 single ply of yarn was used where 16 counts of yarn used in warp directions and 16 counts with 70 denier lycra used in weft direction considering E.P.I and P.P.I was 132 and 60 respectively.For sample 4 single ply of yarn was used where 9 counts of yarn used in warp directions and 9 counts used in weft direction considering E.P.I and P.P.I was 71 and 48 respectively.And For sample 5 single ply of yarn was used where 16 counts of yarn used in warp directions and 12 counts used in weft direction considering E.P.I and P.P.I was 112 and 56 respectively.

Samples	Fabric Constructions	Plies	Yarn In warp direction	Yarn in weft direction	Ends per inch (E.P.I)	Picks per inch (P.P.I)
1	10 × 10+70D / 80 × 40	1	10 counts	10counts+70Denier lycra	80	40
2	10+10S × 16+70D / 84 × 40	2	10 counts	16counts+70Denier lycra	84	40
3	16 × 16 + 70D / 132 × 60	1	16 counts	16counts+70Denier lycra	132	60
4	9 × 9 / 71 × 48	1	9 counts	9 counts	71	48
5	16 × 12 / 112 × 56	1	16 counts	12 counts	112	56

III. Methods

Tensile Strength Test

For measuring tensile strength ISO 13934-2 Testing Method is followed. OTS Tensile Strength Tester machine is used for measuring tensile strength. This type of test is used to find out the tensile or breaking strength of fabric. This test is applicable for woven fabric.

Tear Strength Test

For measuring tear strength ISO 13937-2 Testing Method is followed. OTS Tear Strength Tester machine is used for measuring tear strength. This type of test is used to assess the tear strength of fabric. This test is applicable for woven fabric.

Abrasion & Pilling Test

For measuring abrasion & pilling ISO12945-2 Testing Method is followed. OTS Abrasion & Pilling Tester machine is used for measuring abrasion and pilling. This type of test is used to assess the abrasion & pilling resistance of fabric.

Color Fastness to Rubbing Test

For measuring color fastness to rubbingISO105-X-12 testing method is followed. OTS Crocking Tester machine is used for measuringcolor fastness to rubbing. This type of test is used to assess rubbing fastness of dyed fabrics (color transferred to crocking cloth).

Dimension Stability Test

For measuring Dimension Stability ISO 6330 testing method is followed. This type of test indicates required Dimension of fabric. Here, different test is performed including with measurement EPI & PPI count, GSM Measurement, Shrinkage Test, and Twisting Test.

- **GSM Test**

For measuring weight GSM Test is required. James H. Heal GSM Cutter is used for GSM Test.

Color Fastness to Wash Test

For measuring Color Fastness to Wash Test ISO C06 testing method is followed.

The Recipe which used for measuring color fastness to wash test is given below:

- Sodium Perborate – 1 gm/liter.
- ECE Phosphate – 4 gm/liter.
- Sample Preparation:
- Sample fabric – 10 cm × 4 cm.

- Multi fiber fabric – 10 × 4 cm.

Color Fastness to Water Test

For measuring Color Fastness to Water Test ISO E01 testing method is followed.
The Recipe which used for measuring color fastness to water test is given below:

- Distilled Water.
- Sample Preparation:
- Sample fabric – 10 cm × 4 cm.
- Multi fiber fabric – 10 × 4 cm.

IV. Result and Discussions

Tensile Strength Analysis

From the figure 1 we can see that the tensile strength of all denim samples in warp direction was higher than that of tensile strength in weft direction. And among them the sample two had highest tensile strength.

In warp direction, tensile strength values of sample 1,2,3,4 & 5 are 466N, 599N, 460N, 560N, and 425N respectively. Here percentage of tensile strength varies 55.6%, 99%, 53.3%, 86.67% and 41.67% respectively. So we found that in warp direction sample 2 had highest tensile strength value because two ply of yarn is used in warp direction. But tensile strength value of sample 1, 3, 4 & 5 varies because of count of warp yarn. From the figure 1we can found that the more count of warp yarn the more tensile strength value.

In weft direction, Tensilestrength values of sample 1,2,3,4 & 5 are 296N, 381N, 375N, 365N and 295N respectively. Here, percentage of tensile strength varies 49.5%, 90.5%, 87.5%, 82.5% and 47.5% respectively. So we found that in weft direction Tensile strength value of sample 2 and 3 is almost close because they are of 16+70D weft yarn but tensile strength value of sample 1 is so less because of 10+70D of weft yarn. Between sample 4and 5 we found that sample 4 has more tensile strength it used 9Ne weft yarn.

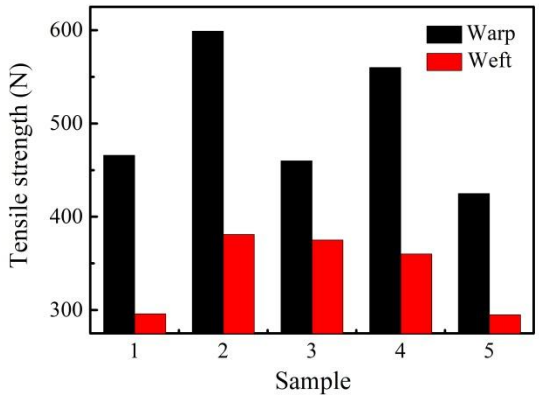

Figure 1. comparison of tensile strength of denim fabric in warp and weft directions

Tear Strength Analysis

In warp direction, tear strength values of report 1, 2, 3, 4 & 5 are 38.44N, 36.60N, 23.22N 35.80N & 20.97N respectively. This difference happens because of their warp yarn count. Here, percentage of tear strength varies 92.2%, 83%, 16.1%, 79% & 3.95% more respectively. From the figure 2 we can see that tear strength percentage value of sample 1 and 2 are almost close but tear strength percentage value of sample 3 is remarkably low because here 16 Ne count warp yarn is used. Between sample 4 & 5 tear strength percentage value of sample 5 is remarkably low because here finer warp yarn is used.

In weft direction, tear strength values of report 1, 2, 3, 4 & 5 are 47.54N, 30.18N, 35.81N, 30N & 22.21N respectively. This difference happens because of their weft yarn count. Here, percentage of tear strength varies 216.93%, 101%, 138% 100% & 48.06% more respectively. From the figure 2 we can see that tear strength percentage value of report 1 is remarkably high because here 10+70D count weft yarn is used but tear strength percentage value of report 2 and 3 are almost close cause of same 16+70D count of weft yarn. As sample 4 & 5 used 9 count &12-count weft yarn so it is clear from figure 2 that sample 4 has higher tear strength value because of higher count weft yarn is used.

By considering both warp & weft direction, from figure 2 we can say that sample 1 has higher tear strength value among these 5 samples.

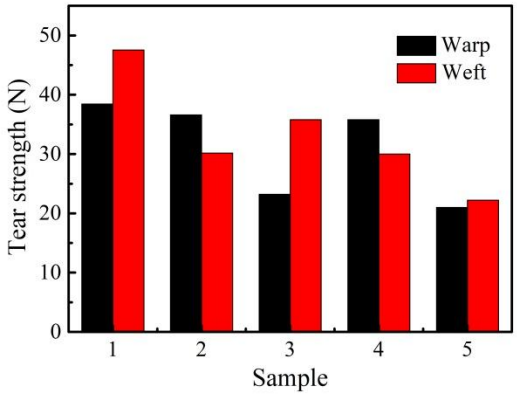

Figure 2. comparison of tear strength of denim fabric in warp and weft directions

Dimension Stability Analysis:

Dimensional Stability is one of the most important test to be analyzed. The dimensional stability depends on the shrinkage percentage rate. For sample 1, 2, 3, 4 and 5 we got that the required width value was 52.7",50.9", 49.3", 50.5", and 57" respectively whereas after wash we got the width 51.5", 49.5", 48.1", 49.8" and 56.2" respectively. This happened because of shrinkage percentage and the yarn contented.

From the figure 3 we got the shrinkage percentage of sample 1, 2, 3, 4 and 5 are 2.27%, 2.75%, 2.43%, 1.38%, and 1.40% respectively. So, from the figure 3 we can say that sample 4 has the least shrinkage percentage value and sample 2 has the highest shrinkage percentage value among these five samples. As we know the more shrinkage of the fabric the less dimensional stability of the fabric. That means for a good dimensional stable fabric we need less shrinkage value fabric. So, from figure 3 we can say that sample 4 has the highest dimensional stability and sample 2 has the lowest dimensional stability.

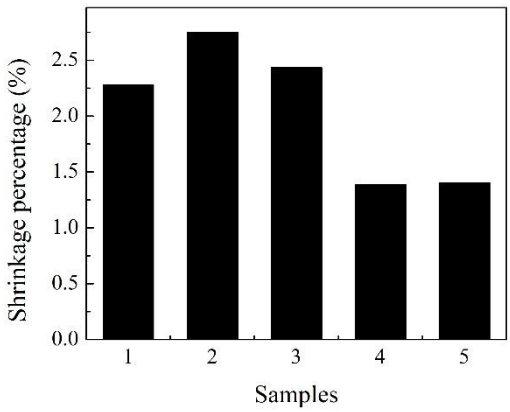

Figure 3. Shrinkage percentage of denim fabrics in weft direction

Abrasion & Pilling test analysis:

Table 1: Abrasion and pilling test results

Sample	Min. Requirements	Value
1	(3/5)	(4/5)
2	(3/5)	(4/5)
3	(3/5)	(4/5)
4	(3/5)	(4/5)
5	(3/5)	(3/5)

From the table 1 we can see that the abrasion & pilling test value for sample 1,2, 3, 4is marked 4 out of 5 where 3 out of 5 is the tolerance. So, we can say that the fiber and yarn quality is good in these four denim fabric sample.

The abrasion & pilling test value for sample 5 is marked 3 out of 5 in the table 1 so that means quality of fiber and yarn of no. 5 sample is not good and it needs to be well finished.

Color fastness to rubbing test analysis:

Table 2: Color fastness to rubbing test results

Samples	Dry Min. Requirements	Dry Value	Wet Min. Requirements	Wet Value
1	(3/5)	(4/5)	(2/5)	(3/5)
2	(3/5)	(4/5)	(2/5)	(3/5)
3	(3/5)	(4/5)	(2/5)	(3/5)
4	(3/5)	(4/5)	(2/5)	(3/5)
5	(3/5)	(4/5)	(2/5)	(2/5)

Color fastness to rubbing is done both in dry and wet positions. The tolerance value, marked for dry condition is 3 out of 5 and wet condition is 2 out of 5. From the table 2 we can see that the value for sample 1, 2, 3, 4 dry condition is 4 out of 5 and wet condition is 3 out of 5. So, it is accepted and we can say that color fixation on the fabric is much better and they will sustain a long time.

But From the table 2 we can see that the value for sample 5 in dry condition is 4 out of 5 and wet condition is 2 out of 5 so that means dyeing quality was not much and the finishing procedure should be improved.

Color fastness to wash test analysis:

Table 3: Color Fastness to wash test results

Multifiber DW			Dark Blue Black	Dark Blue Black	Dark Blue Black	Dark Blue Black	Dark Blue Black
		Min. Requirements	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Color Staining	Acetate	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Cotton	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Nylon	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Polyester	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Acrylic	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Wool	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)

Color fastness to wash refers color staining on fabric. The tolerance value is marked 4 out of 5. From the Table 3 we can see that after test we found 4 out of 5 for all these five sample denim fabrics. So, we can say the finishing process was good on those fabric and they will not fade after washing.

Color fastness to water test analysis:

Table 4: Color Fastness to water test results

Multifiber DW			Dark Blue Black	Dark Blue Black	Dark Blue Black	Dark Blue Black	Dark Blue Black
		Min. Requirements	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Color Staining	Acetate	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Cotton	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Nylon	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Polyester	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Acrylic	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)
	Wool	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)	(4/5)

Color fastness to water refers color staining on fabric after water wash. The tolerance value is marked 4 out of 5. From the table 4 we can see that after test we found 4 out of 5 from all sample denim fabrics. So, we can say the finishing process was good on those fabric and their resistance to water is good.

V. Conclusion

The object of this study was to investigate the changes of physical properties of denim fabrics in order to ensure good quality. For this purpose, five experimental study was conducted. How will fabric perform in

response to tensile strength, tear strength, abrasion and pilling resistance, dimensional stability changes after wash was the first priority to measure of this work. For further studies about denim fabric it should be investigate how appearance and color fastness changes to water, wash and rubbing. The finishing process also plays a role for these kinds of test results.

Finishes that give denim a worn and torn look not only affect their durability, but also the denim's ability to preserve its properties. By being careful and choose fabric such as higher quality fiber and yarn and ensure a skillful manufacturing process, denim production company can produce and sell high quality denim. However, finished denim with a worn look will probably have as good durability, and possess the same ability to preserve physical properties. To some extent the finishing can be controlled and before weaving denim lots of factors can also be controlled. But the fact that jeans' durability is deteriorated when processed makes the finishing a critical aspect. In the end this study it needs to put the aspects and decisions which one is the most important. The worn look is a different type of quality aspect and mainly determines if the customer will choose to buy a pair of denim jeans or not.

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