Proceedings of the
International Conference on Mechanical Engineering 2011
(ICME2011) 18-20 December 2011, Dhaka, Bangladesh

ICME11-AM-013

EFFECT OF WEAVE STRUCTURES ON JUTE-COTTON UNION FABRIC PROPERTIES

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ABSTRACT
A study is performed to observe the effect of weave structures on jute-cotton union fabrics in order to increase the uses of biodegradable jute diversified products and to replace the synthetic polymers and cotton. Two fabric samples; 2/2 twill noted by "A" and 3/1 twill noted by "B" are produced from same EPI and PPI. Here, the jute yarn of 413 tex (6 lbs/spy 2 ply) is used in weft direction and cotton yarn of 177 tex (10^s/3 ply) is used in warp direction. From the experiment, the comparative results of both the samples on average tensile strength, abrasion resistance, drape co-efficient, bending length, flexural rigidity are analyzed to exhibit the effect of twill structures to perform the task for apparel purposes in the near future.

Keywords: Jute Yarn, Cotton Yarn, Twill Structure.

1. INTRODUCTION
Jute is a natural long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus*, family Malvaceae. About 40 species of *Corchorus* are known throughout the world. Corchorus capsularies yields the "White" jute and *Corchorus olitorius* yields the "Tossa" [1]. The present of cellulose percentage in the jute is lower than the cotton fiber. On the other hand hemicelluloses is the another component present in the jute. Due to present of hemicelluloses and lignin jute is more stiff and yellowish in color than cotton [2]. Each fiber is composed of a large number of smaller units known as fibrils and these are arranged in right-handed spirals. The fibrils are again made up of molecular chains, closely held together. These are known as micells. Though lignin and other non-cellulose materials are abundant in the middle lamella, they are also found in other parts of the cell wall [3]. Chemically jute fiber contains alpha cellulose (58-63%), lignin (12-14), hemicelluloses (22-24%), waxes (0.4-0.8%), pectin (0.2-0.5%), protein (0.8-1.5%), mineral matters (0.6-1.2%) and traces of tannin and coloring matters. The hemi-cellulose portion is a mixture of pentosan (xylane 12-14%), polyuronide (4-5%) and contains acetyl groups (3.2-3.5%) etc [4-6]. Jute fiber conventionally is not used for producing textile products as it has some shortcoming in regard to feel, stiffness, drape, coarseness wash ability and abrasion. The stiffness or hardness of fabric has great impact on its bending length or drape coefficient. It is widely being used as a natural choice for plant mulching and rural road pavement construction. As jute is stiff and rough to the feel jute fabrics have poor draping qualities, attempts have been made to produce fabrics of jute in union with cotton for better fall. In these union fabrics the cotton yarns constitute the warp threads while jute yarn is used as filling thread. The weaving pattern is designed so as to give a facing more of the warp threads than the weft ones. Such materials used as furnishing fabrics present a good look and hang well. In the tropical countries like that of ours cotton clothing is extensively used, general demand to replace cotton with jute is due to obvious reasons of meeting shortage of cloths.

The major sources of supply of jute lie within the commonwealth chiefly in India and Bangladesh. Jute is also grown in Burma, Formosa, China, Brazil, Nepal, Taiwan, Thailand, Vietnam, Cambodia etc [1].

2. MATERIALS AND METHODS
2.1 Materials
Two fabric sample of same construction; constructed from handloom are studied and various physical properties of these samples are tested. The 2/2 twill sample is 14 yards and 3/1 twill sample is 23 yards in length. The loom conditions for producing these samples are given in Table 1.

2.2 Methods
2.2.1 Measurement of Count
Yarn count is measured according to ASTM D 1907 which is short length based method. In this method yarn count is measured, yarns taken from packages; or from any textile fabrics in which the yarns are intact and can be removed in measurable lengths.

2.2.2 The Count Strength Product (CSP)
The concept of CSP may be used to derive an index by which the spinning quality of a fiber may be assessed or, the spinning efficiency of a particular system. It was obtained as the product of cotton count and lea strength

of the yarn. A hank of yarn, with its starting and finishing ends knotted, was placed over the hooks of the lea tester, pendulum lever type. As the lower hook descend a load was imposed on the loops of the yarns constituting the hank The maximum load to break all the threads unraveling the hang was indicated on the dial, which was “lea strength” of the hank.

2.2.3 Quality Ratio

The quality ratio is calculated using the following relationship.

$$\text{Quality ratio (\%)} = \frac{\text{Tensile Strength in lbs}}{\text{Count of yarn lbs per spy}} \times 100$$

2.2.4 Measurement of Tensile Strength

The most commonly used mode is the CRE mode and is often required by the test standards. The main factors that need to be considered are the size and accuracy of the load cell (0.5–25 kN), the distance of cross-head travel (0.1–2 m) and the rate of cross-head travel (0.1–500 mm/min) [7].

BS 2576 Method is used for determination of breaking strength and elongation (strip method) of woven fabrics. Five fabric samples are extended in a direction parallel to the warp and five parallel to the weft, no two samples to contain the same longitudinal threads [8].

2.2.5 Measurement of Abrasion Resistance

ASTM D4966 by Martindale Method of Abrasion Resistance is used to measure the abrasion resistance and weight loss percentage is recorded on 3000 revolution [8].

2.2.6 Measurement of Drape Co-Efficient

Drape is a critical textile characteristic in determining how clothing conforms to the shape of the human silhouette [9]. The quality of ‘drape’ is important to a designer as it influences a garment’s appearance.

The drape was measured as the drape co-efficient F which is the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk. Drape of the produced fabric is measured by using the CUSICK Drape meter according to IS 8357/1977.

Thus, $$F = \frac{A_s - A_d}{A_D - A_d}$$

Where, A_D= the area of the specimen

A_d= the area of the supporting disk, and

A_s= the actual projected area of the specimen.

In the actual test, the light beam casts a shadow of the draped fabric onto a ring of highly uniform translucent paper supported on a glass screen. The surface drape pattern area on the paper ring is directly proportional to the mass of that area. So the drape coefficient (F) can be calculated in a simple way [7].

$$F = \frac{\text{Mass of shaded area}}{\text{Total mass of paper ring}} \times 100\%$$

2.2.7 Bending length

The bending length is a measure of the interaction between fabric weight and fabric stiffness in which a fabric bends under its own weight. It reflects the stiffness of a fabric when bent in one plane under the force of gravity, and is one component of drape. Thus bending length is also called drape stiffness [7]. The bending length of the fabric is measured by cantilever test according to ASTM D1388-2007.

2.2.8 Measurement of Flexural Rigidity

The flexural rigidity (or stiffness) of a fiber is defined as the couple required to bend the fiber to unit curvature. Curvature is the reciprocal of radius of curvature. By this definition, the direct effect of the length of the specimen is eliminated. The flexural rigidity may be calculated in terms of other fiber properties [10-11].

$$G = WC^3 \times 10^3 \text{ mg/cm} = \text{mN/mm}$$

Where,

C = Bending length

W = Cloth weight (gm) per square cm

N = Newton

3. RESULTS AND DISCUSSION

All the tests are performed in the standard testing atmosphere i.e. 65±2 % R.H and 20±2º C. Two woven fabric samples 2/2 twill sample is noted by “A” and 3/1 twill sample is noted by “B”.

Table 1: Loom Condition for Producing Jute-Cotton Union Fabric

Fabric Sample	A	B
Nature Of Weave	Twill 2/2	Twill 3/1
Warp Yarn	Cotton	Cotton
Weft Yarn	Jute	Jute
Count Of Warp Yarn	177 Tex (10^s/3 Ply)	177 Tex (10^s/3 Ply)
Count Of Weft Yarn	413 Tex 6 Lbs/Spy(2 Ply)	413 Tex 6 Lbs/Spy(2 Ply)
Reed Count	20	20
No Of Heald Eye	680	680
No Of Heald Frame	4	4
Name Of The Loom	Hand Loom	Hand Loom

Table 1 shows the specification of loom in which the woven fabric samples are produced. Reed count of the loom is 20 and no of heald eye used is 680. Total no of heald frame used to produce twill fabric is 4.

Table 2: Physical Properties of Cotton Yarn

No. Of The Experiment	Yarn Count	Tensile Strength (Lea Strength In lbs)	Extension (%)	CSP (Mean)
1	10.2	164	9.8	1658.50
2	10.6	160	9.6	
3	10.5	162	9.6	
4	9.7	169	9.2	
5	10.5	161	9.9	
6	9.4	171	9.0	
7	10.0	166	9.5	
8	9.6	168	9.1	
9	9.8	169	9.8	
10	9.7	170	9.8	
Mean SD CV%	10 0.4268 4.268	166	9.53	

Table 3: Physical Properties of Jute Yarn

No. of the Experiment	Yarn Count	Tensile Strength (Single Yarn Strength in lbs)	Extension %	QR% (Mean)
1	5.9	5.2	3.3	91.67
2	6.4	5.9	3.2	
3	6.6	6	3.0	
4	5.3	5.4	3.6	
5	6.2	5.7	3.4	
6	6.5	5.8	3.2	
7	6.0	5.3	3.1	
8	5.6	5.0	3.3	
9	5.5	5.1	3.2	
10	6.0	5.6	3.1	
Mean SD CV%	6 0.437 7.28	5.5	3.24	

Table 4: Different Physical Properties of Sample A

Name of Fabric	No. of Exp.	Construction of The Fabric		Tensile Strength (Kg)		Abrasion Resistance		Drape Co-Efficient (%)	Bending Length In (cm)		Flexural Rigidity (mg/cm)	
		Warp	Weft	Warp	Weft	Revs	Wt. Loss%		Warp	Weft	Warp	Weft
A	1	33	20	83.24	153.34	3000	2.216	52.48	3.071	7.232	3475.53	41727.06
	2			84.50	158.21	3000	2.217	52.49	3.177	7.636	3461.60	43539.90
	3			87.21	152.96	3000	2.218	52.47	3.375	7.438	3343.75	40090.88
	4			81.67	157.24	3000	2.213	52.49	3.578	7.933	3936.76	46962.97
	5			80.34	158.23	3000	2.216	52.48	3.275	7.237	3198.36	38331.45
	6			83.67	151.11	3000	2.215	52.47	3.477	7.631	3787.26	45185.03
	7			87.32	161.28	3000	2.219	52.48	3.173	7.336	3337.23	40056.71
	8			82.89	154.54	3000	2.211	52.48	3.575	7.532	3489.13	41727.06
	9			85.13	149.68	3000	2.214	52.47	3.274	7.735	3340.48	40039.64
	10			83.16	153.25	3000	2.217	52.48	3.776	7.438	3201.48	38347.90

Table 5: Different Physical Properties of Sample B

Name of Fabric	No. of Exp.	Construction of The Fabric		Tensile Strength (Kg)		Abrasion Resistance		Drape Co-Efficient (%)	Bending Length (cm)		Flexural Rigidity (mg/cm)	
		Warp	Weft	Warp	Weft	Revs	Wt. Loss%		Warp	Weft	Warp	Weft
B	1	33	20	78.26	147.21	3000	2.112	68.72	2.43	5.224	1014.68	13314.91
	2			79.13	146.90	3000	2.117	68.73	2.53	5.927	1111.31	14609.13
	3			78.80	147.23	3000	2.201	68.20	2.92	5.621	1191.01	15822.70
	4			77.90	147.68	3000	2.213	68.74	2.24	5.326	1029.04	13330.82
	5			78.50	148.10	3000	2.135	68.73	2.72	5.422	1095.73	14565.58
	6			78.64	147.42	3000	2.216	68.72	2.43	5.827	1014.68	13338.77
	7			78.72	147.63	3000	2.152	68.74	2.23	5.128	1111.31	14617.85
	8			78.15	148.24	3000	2.170	68.73	2.52	5.324	1191.02	15851.08
	9			78.41	147.36	3000	2.164	68.72	2.22	5.626	1000.45	13330.82
	10			79.12	146.80	3000	2.129	68.72	2.63	5.425	1111.31	14591.70

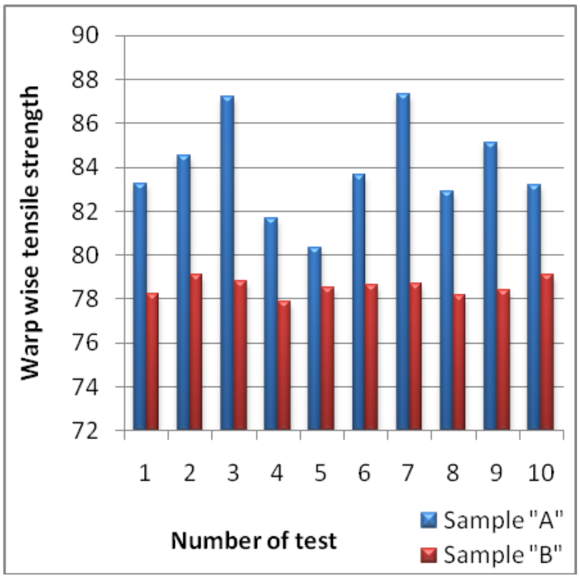

Fig 1. Comparison of warp wise tensile strength

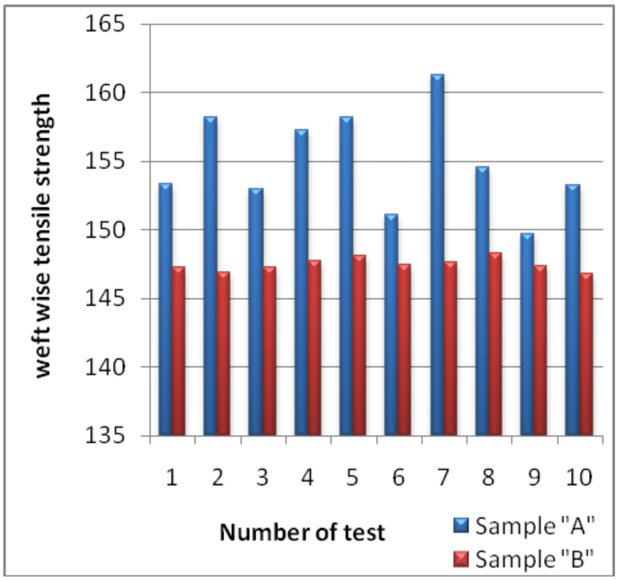

Fig 2. Comparison of weft wise tensile strength

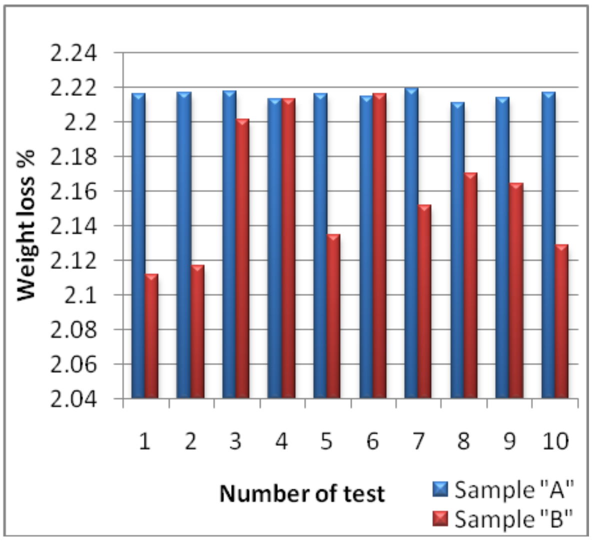

Fig 3. Comparison of abrasion resistance

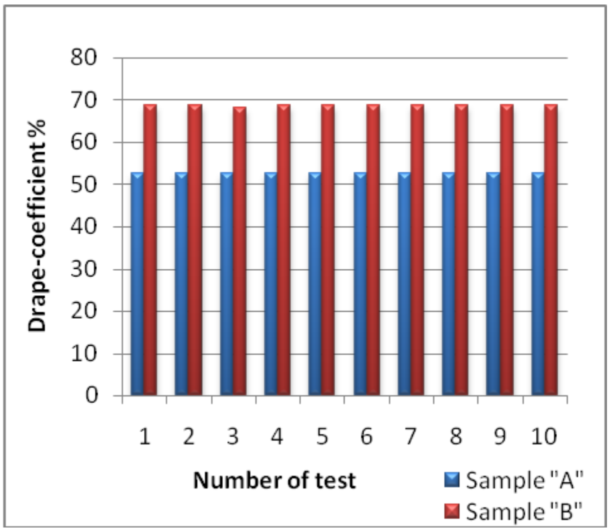

Fig 4. Comparison of drape co-efficient%

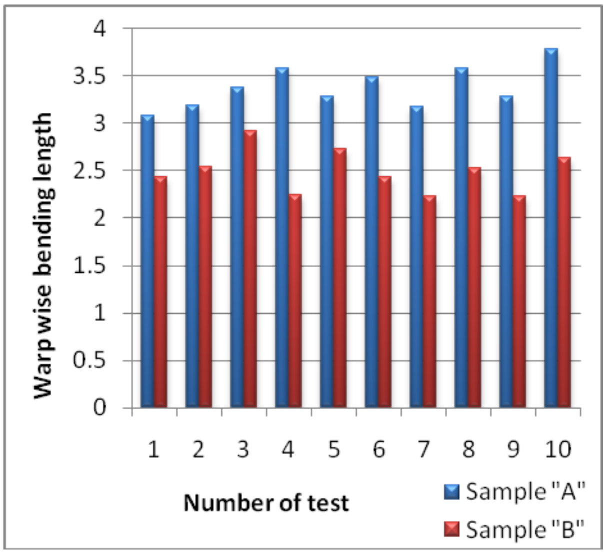

Fig 5. Comparison of warp wise bending length

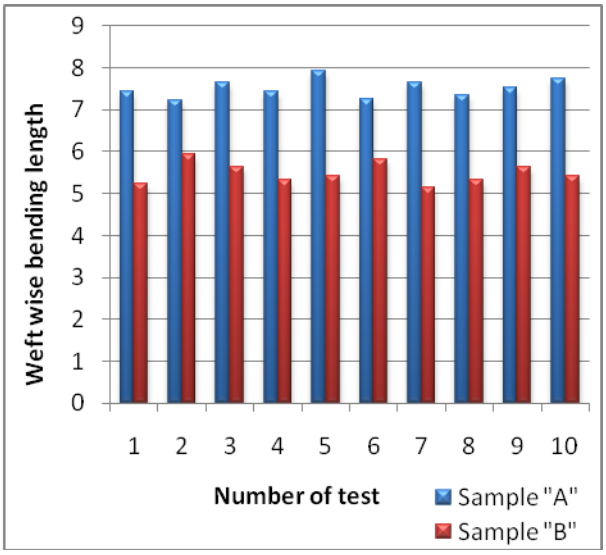

Fig 6. Comparison of weft wise bending length

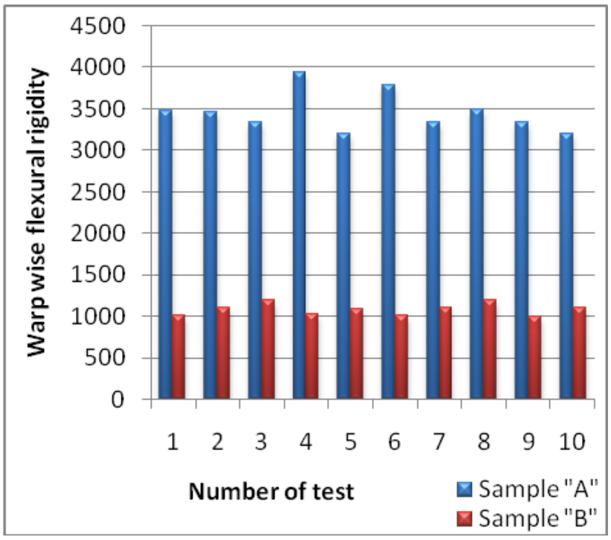

Fig 7. Comparison of warp wise flexural rigidity

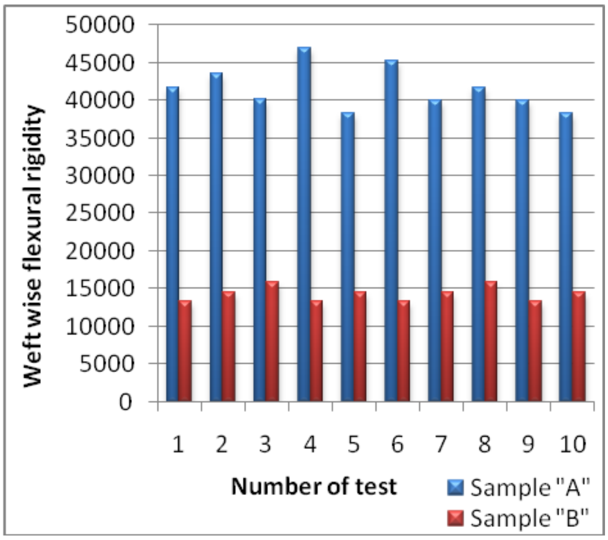

Fig 8. Comparison of weft wise flexural rigidity

Table 2 and Table 3 shows the different physical properties of cotton and jute yarn respectively. The CV% and SD of cotton yarn count is found 4.268 and 0.4268. The CV% and SD of jute yarn count is found 7.28 and 0.437.

Figure 1 and figure 2 shows the comparison of tensile strength between sample A and sample B both in warp and weft directions. The average tensile strength of sample A is higher than the sample B.

It is evident from Fig 3 that there is a little difference between the abrasion resistance of sample A and B. The weight loss percentage (on 3000 rev) of sample A is 2.2156 which is 2.469% higher than the sample B.

The sample B draped very elegantly over a circular support. Fig 4 shows that the drape co-efficient of sample B is 69.675 which is 17.196 higher than that of sample A. Fig 5 and Fig 6 represents the comparison of bending length both warp and weft direction between sample A and sample B. Bending length of sample A is higher than the sample B. In the same way figure 7 and figure 8 shows the comparison of flexural rigidity between the two samples A and B. From the result of sample B which exhibits lower flexural rigidity when compared to other sample, it is because of less binding point (not so balanced structure) due to warp facing structure.

4. CONCLUSION

In this experiment it is found that the 2/2 twill structure has greater tensile strength and abrasion resistance than the 3/1 twill structure. So in case of strength and stiffness i.e. in carpets, rugs, floor covering, etc 2/2 twill structure can be used and where drape ability and bending is a considerable factor i.e. bags 3/1 structure can be successfully used. By using interlining in the inner side of the fabric it can be used as winter jacket. Furthermore by the chemical modification or other process jute cotton union fabrics can be successfully used as shirting's suitings and other apparel purposes in near future.

Due to biodegradable and environment friendly characteristics of jute fabrics have considerable demand in home and abroad. At the same time, price of the 100% cotton fabric is higher than the jute-cotton union fabric. That's why union fabric may be the replacement of 100% cotton fabric. The findings will have a direct impact on the jute industry and may be able to produce better quality of union fabric by adopting the method suggested. The output of this experiment would be the rebirth of jute industry of Bangladesh and jute sector will get back its glory.

5. REFERENCES

1. Atkinson, R.R., 1964, Jute Fiber to Yarn, Heywood Books, London, UK.
2. Azad, A.K. and Jafrin, S., 2009, "Effect of Size Material on Jute Cotton Union Fabric", Daffodil International University Journal of Science and Technology, 4 (2): 36-37.
3. Kar, S.N., 1954, The Jute Fiber, Sri Gouranga Press, Calcatta, India.
4. Doree, C., 1947, The Methods of Cellulose Chemistry, Chapman and Hall Ltd., London, UK.
5. Das, N.N., Das, S.C. and Mukherjee, A.K., 1948, "Origin of Acidity in Jute Fiber", Textile Research Journal, Marack: 166-191.
6. MacMillan, W.G., 1957, Jute the Golden Fiber, Pakistan Today Press, Dacca, Bangladesh.
7. Jinlian, HU., 2008, Fabric Testing, Woodhead Publishing Limited, Cambridge, UK.
8. Saville, B.P., 1999, Physical Testing of Textiles, Woodhead Publishing Limited, Cambridge, UK.
9. Kenkare, N. and May-Plumlee, T., Spring 2005, "Fabric Drape Measurement: A Modified Method Using Digital Image Processing", Journal of Textile and Apparel, Technology and Management,4 (3): 1-8
10. Hearle, J.W.S. and Morton, W.E., 2008, Physical Properties of Textile Fibers (4th edition), Woodhead Publishing Limited, Cambridge, UK.

11. Kaswell, E.R., 1953. Fabric Hand; Textile Fibers, Yarns and Fabrics, Reinhold, New York, USA.

6. NOMENCLATURE

Symbols	Meanings
lbs/spyndle	Pounds per spyndle indicates the fineness or coarseness of yarn and it is determined by the weight of 14400 yards (= 1 spyndle) length of yarn in pounds (lb).
10^s	10 count
CV%	Co-efficient of Variation %
SD	Standard Deviation
mg/cN	Milligram per Centi-Newton
kN	Kilo-Newton
kg	Kilogram
cm	Centimeter
mN/mm	Milli-Newton/Millimeter
CSP	Count Strength Product
QR%	Quality Ratio Percentage
revs	Revolutions

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