Journal on Materials and its Characterization
Vol: 3(4), December 2024
REST Publisher; ISBN: 2583-6412
Website: http://restpublisher.com/journals/jmc/
DOI: https://doi.org/10.46632/jmc/3/4/1

Effects Of Test Parameters On Mechanical Properties Of Jute Yarns

*** Anshuman Banerjee, Asis Mukhopadhyay**
Calcutta University, College Square, Kolkata, West Bengal, India.
*Corresponding Author Email: anshumanbanerjee90@gmail.com

Abstract. *Quality of jute yarn is usually judged in terms of tensile property and irregularity. Tensile property is basically the response of the material to tensile force or extension. Tenacity and breaking extension are most important parameters for jute yarn. Filled in jute bags are stacked in storehouse and the height of the stack is more than 20 ft., when the bags are dropped from the stack the bags are subjected to impact loading on the floor of the store house and reasonably good work of rupture is helpful for preventing the failure of the bag. Initial modulus value may have certain role to take proper shape when the material is packed inside the bags. The tenacity of a textile yarn is dependent on the gauge length and test speed during tensile testing. Studies on the effects of gauge length and test speed on tensile properties of jute yarn have been discussed in this paper.*

Keywords*: Yarn, tenacity, initial modulus, gauge length, test speed, k-value*

1. INTRODUCTION

Mechanical properties of yarn: In addition to the contribution of fibre structure and fibre properties, the behaviour of textile materials is significantly influenced by the role played by the yarn structure and yarn properties. Backer [1] has given a list of material properties that fall under each classification. It has been summarized as follows:

1. Bulk Properties, which include uniaxial tension and compression, biaxial tension, compression, shear; bending behaviour (including creasing and crease resistance) tensional characteristics behaviour under stress concentration (such as tear resistance or cutting resistance)

2. Surface properties, such as hand, roughness, wear resistance, friction and resistance to stress concentration (pill resistance).

3. Transfer properties, namely, air and water permeability, filtration efficiency, penetration resistance and heat transfer as such, alternative energy sources have the potential to provide a more sustainable energy system in the long term. However, there are also challenges associated with the use of alternative energy sources. For example, many renewable energy sources are intermittent, meaning they are only available at certain times and may not always be able to meet demand. Solar power, for example, is only available during the daytime, while wind power is only available when there is sufficient wind. As such, alternative energy systems often require the use of energy storage technologies, such as batteries, to ensure a steady supply of electricity. Another challenge associated with alternative energy exploitation is the need for new infrastructure and technologies to support their widespread use. For example, the development of new transmission lines and storage facilities may be required to transport and store the energy generated by alternative sources. Additionally, there may be a need for new technologies to make alternative energy sources more efficient and cost-effective. Despite these challenges, there is growing interest and investment in alternative energy sources around the world. Many countries and companies are working to develop and deploy new renewable energy technologies, and there is growing

recognition of the importance of transitioning to a more sustainable energy system in the face of climate change. Ultimately, the success of alternative energy exploitation.

The weak-link effect: Strength can be determined at every point along the length of a fibre or yarn. Therefore, it is found that it varies from point to point, as shown in Fig. 2.1

If a gradually increasing load is applied to this whole specimen, it will break at its weakest point, giving a strength S1, but if the specimen is tested in two half-lengths, each will break at its own weakest place, one giving the value S1, and the other a value S2, which is necessarily greater than S1. The mean strength S1/2, measured on half-lengths, is the mean of S1 and S2, and must therefore be greater than the strength measured on the whole length. Similarly, going to quarter-lengths, we get the four values, S1, S2, S3, S4, and the mean strength S1/4 is greater still. This increase will continue until at very short lengths the mean strength tends to the value S0, which gives equal areas of the curve above and below the line S = S0, since each small element will break at its own value of strength.

The order of ranking of specimens may alter if the test-length is altered. Figure 2.3 illustrates this. At very short lengths, the fiber shown in (a) appears stronger, but at the length l the more uniform fiber B, appears stronger. As example of such a reverse in ranking, Meredith [3] quotes the values in table for cotton and nylon fibre.

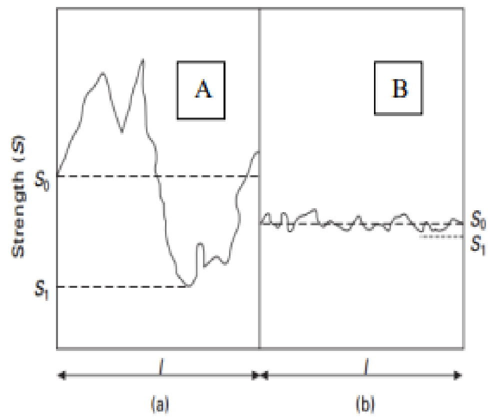

Figure 2.3- Change in order of ranking of materials.

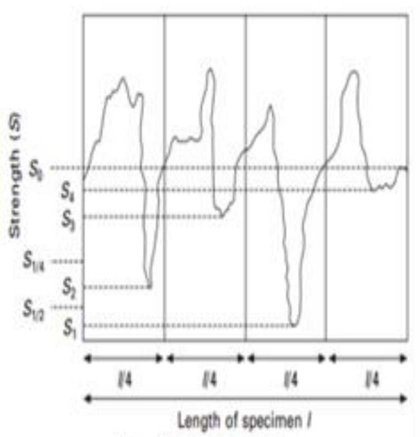

Figure 2.1: Weak Link Effect

FIGURE 1.

TABLE 1.

Type of fibre	Tenacity (N/ tex)		
	1 cm test length	1 mm test length	0.1 mm test length
Cotton	0.31	0.43	0.59
Nylon	0.47	0.5	0.54

Peirce obtained the following equations-

$$S_l - S_{nl} = 4.2(1 - n^{-\frac{1}{5}})\sigma_l \qquad (1) \text{ and}$$

$$\frac{\sigma_{nl}}{\sigma_l} = n^{-\frac{1}{5}} \qquad (2)$$

The distribution of strength S_l and knowing σ_l and n. Peirce obtained equation (1) giving the mean strength S_{nl} and standard deviation σ_{nl} for specimens of length *nl*,

S_l =mean value of S_l ,

S_{nl} = mean strength of S_{nl}

Influence of rate of loading on breakage: Meredith [3; JTI, 1953] tested yarns over a million-fold range of rates of extension and found that the relation between tenacity and rate of extension was approximately linear (actually slightly concave to the tenacity-axis) for most fibers. For breaking times ranging between a second and an hour, the following formula may be used without much error:

$F_1 - F_2 = kF_1 \log_{10}(t_2/t_1)$ …………… **(3)**

F_1 is breaking load in a time t_1, F_2 is breaking load in a time t_2, and k is the **strength-time coefficient**. Values of the strength-time coefficient are given in Table Meredith stated that the same formula applies to constant-rate-of-loading and constant-rate-of extension tests.

As the literature suggests, the '**k- value** for jute yarn has not been determined yet. Therefore, an attempt has been made to measure the respective value for jute yarn in this work.

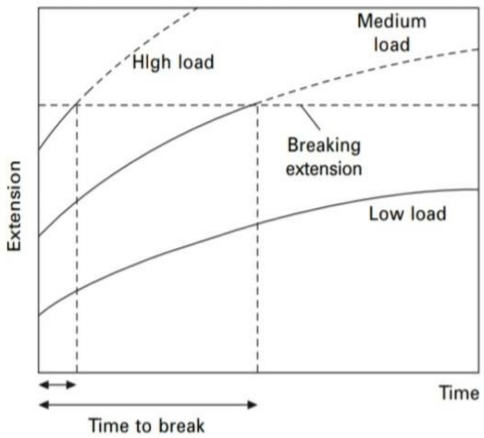

FIGURE 2.

Strength-time coefficients	
MATERIAL	**k**
Cotton	0.088
Viscose rayon	0.083
Acetate	0.060
Flax	0.079
Silk	0.079
Nylon	0.080
Wool	0.073

FIGURE 3.

2. MATERIALS & METHODS

TABLE 2. Yarn specifications

Sample code	Linear density (tex)	Grist (lb/spyndle)	Turns per inch (tpi)	Twist factor
Y_1	250	7.21	4.38 (11.57)	12.88
Y_2	320	9.25	4.04 (15.88)	12.28
Y_3	480	13.39	4.00 (18.24)	14.96

In this research, a series of tensile tests were conducted on jute yarn samples with different gauge lengths and test speeds. The gauge lengths chosen were 100 mm, 200 mm, 250 mm, 300 mm, 350 mm, 400 mm, 450 mm and 500 mm while the test speeds tested were 1 mm/min, 10 mm/min, 100 mm/min and 300 mm/min. The tensile properties, including tensile strength, elongation at break, work of rupture and Young9's modulus were measured and analysed.

The tensile properties were measured using the Zwick- Roell Z010 tensile tester. It is an electronic type tensile tester with a loadcell capacity of 500 N.

3. RESULT AND DISCUSSION

The following tables (5.3 to 5.5) determines the variation of tensile strength with gauge length for different yarn counts. (*figure in the bracket is representing strength CV%).

TABLE 3. Tensile strength of Jute yarn. Yarn Count: 250 tex (7.21 lb/spy) Test Speed:300mm/min

Sl. No.	Gauge length (mm)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Work of rupture (mJ)	Initial modulus (N/tex)	
						0.5%	1%
1.	100	31.0(14.88)	12.40	2.1	32.87	5.52	5.60
2.	200	33.2(18.48)	13.28	1.9	61.27	5.52	6.04
3.	250	26.9(24.58)	10.76	1.5	50.77	6.48	6.96
4..	300	29.1(22.44)	11.64	1.6	72.64	6.48	6.68
5.	350	24.0(25.01)	9.60	1.3	55.68	7.72	7.20
6.	400	27.5(21.65)	11.00	1.5	79.03	6.48	7.08
7.	450	25.1(21.15)	10.05	1.3	74.38	6.72	7.40
8.	500	30.2(18.01)	12.08	1.4	95.86	6.88	7.04

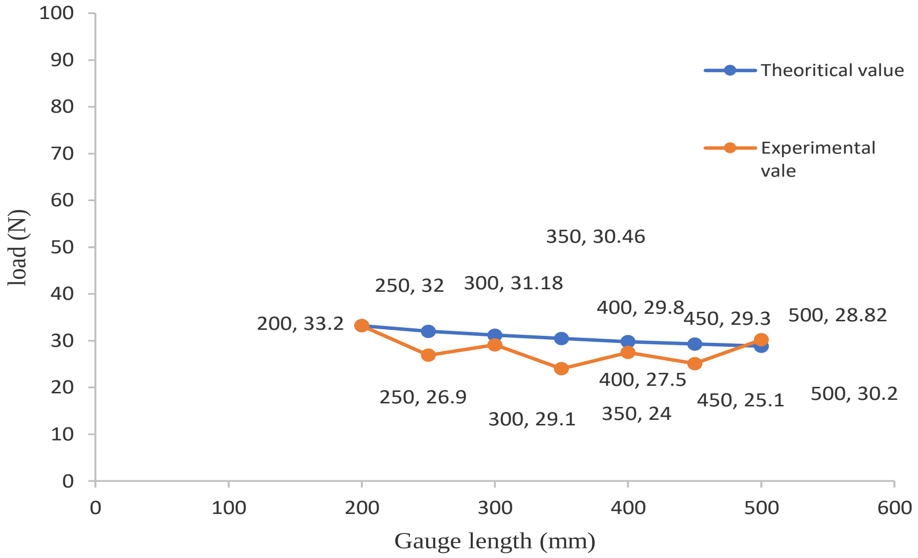

FIGURE 4. Variation of Load of 250 tex (7.21 lb/spy) for different gauge lengths

TABLE 4. Tensile strength for Jute yarn. Yarn Count: 320 tex (9.25 lb/spy) Test Speed:300mm/min

Sl. no.	Gauge length (mm)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Work of rupture (mJ)	Initial modulus (N/tex)	
						0.5%	1%
1.	100	39.3(14.11)	12.30	2.3	44.26	4.33	4.68
2.	200	39.0(21.61)	12.18	2.0	69.95	4.37	4.96
3.	250	35.8(21.60)	11.18	1.7	72.70	5.06	5.71
4..	300	33.0(23.11)	10.30	1.5	73.21	6.18	6.59
5.	350	32.3(20.60)	10.09	1.6	84.83	5.31	6.00
6.	400	33.9(25.15)	10.60	1.7	104.81	4.80	5.50
7.	450	31.9(23.77)	9.96	1.5	100.59	5.50	6.15
8.	500	34.5(14.28)	10.78	1.5	120..66	6.18	6.68

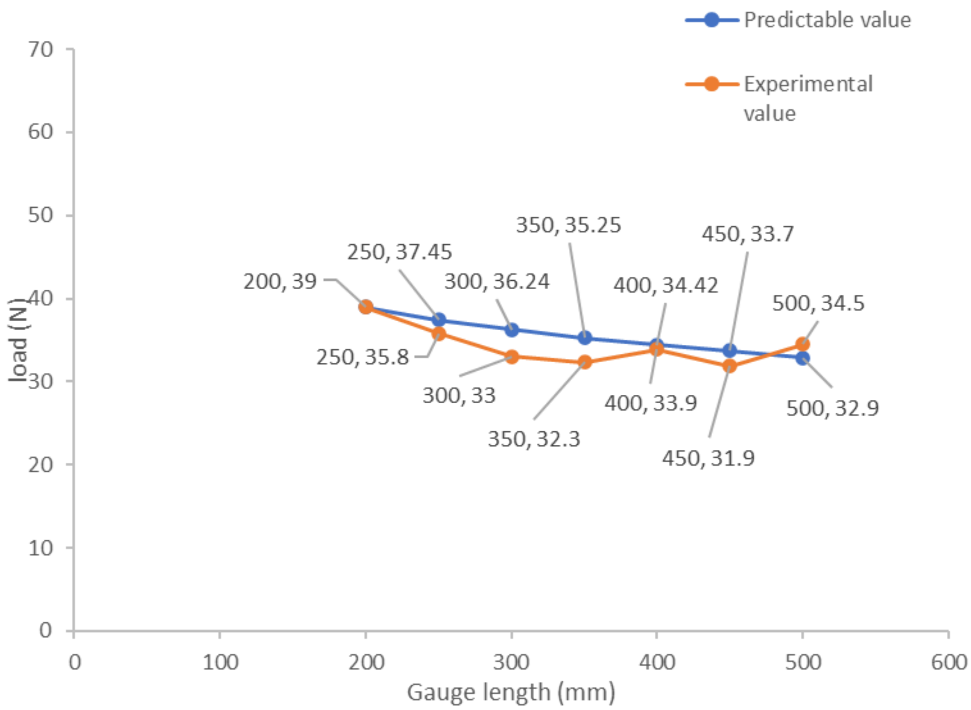

FIGURE 5. Variation of Load of 320 tex (9.25 lb/spy) for different gauge lengths

TABLE 5. Tensile strength for Jute yarn. Yarn Count: 480 tex (14 lb/spy) Test Speed: 300mm/min

Sl. lo.	Gauge length (mm)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Work of rupture (mJ)	Initial modulus (N/tex)	
						0.5%	1%
1.	100	60.8(14.80)	12.60	3.2	89.66	2.60	2.90
2.	200	53.0(17.82)	11.00	2.8	129.55	2.29	2.68
3.	250	50.8(17.43)	10.50	2.4	139.96	3.25	3.70
4..	300	51.9(18.16)	10.80	2.3	168.48	3.80	4.16
5.	350	49.8(17.01)	10.30	2.2	124.73	3.80	3.70
6.	400	47.8(16.20)	9.95	2.1	184.91	3.50	4.04
7.	450	46.3(15.87)	9.64	2.4	214.65	2.45	2.97
8.	500	45(10.28)	9.37	2.0	224.80	4.00	4.50

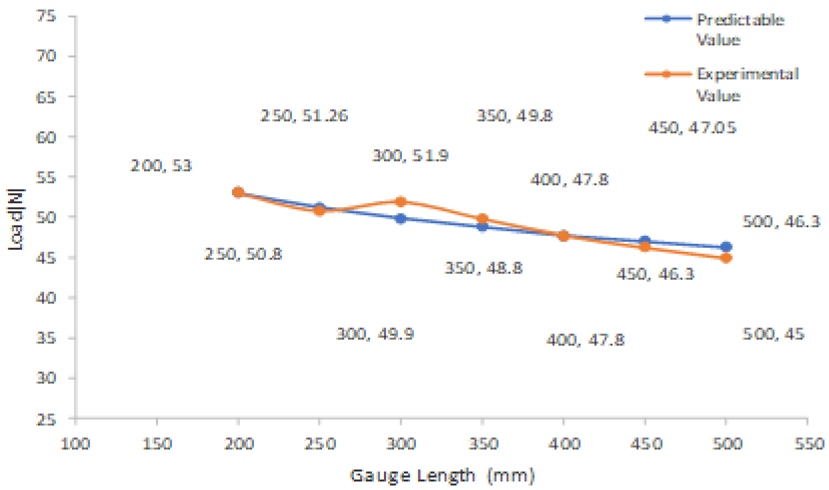

FIGURE 6. Variation of Load of 480 tex (14 lb/spy) for different gauge length

The following tables (5.6 to 5.8) determines the variation of tensile strength with test speed for different yarn counts.

TABLE 6. Tensile strength for Jute yarn. Yarn Count: 250 tex (7.21 lb/spy) gauge length:500mm

Sl. no.	Test speed (mm/min)	Test time (sec)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Initial modulus (N/tex)	
						0.5%	1%
1.	1	437.84	23.0 (16.89)	9.2	1.4	5.36	5.96
2.	10	47.33	28.7 (16.73)	11.4	1.5	6.16	6.88
3.	100	5.51	29.7 (13.41)	11.9	1.6	5.84	6.6
4..	300	2.23	30.2 (13.81)	11.2	1.5	5.92	6.8

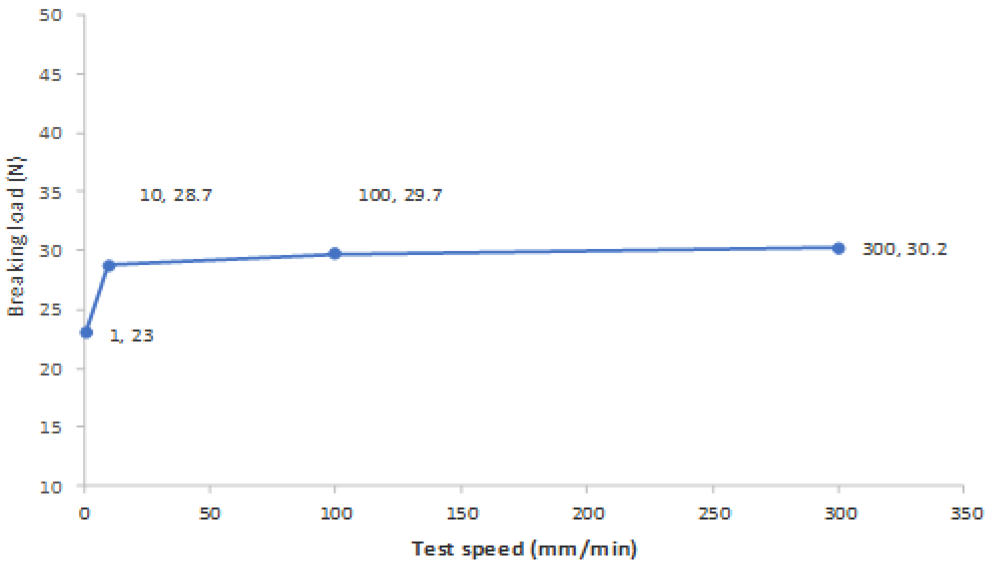

FIGURE 7. Variation of load in different test speed for 250 tex yar

TABLE 7. Tensile strength for Jute yarn.Yarn Count: 320 tex (9.25 lb/spy) gauge length:500mm

Sl. no.	Test speed (mm/min)	Test time (sec)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Initial modulus (N/tex)	
						0.5%	1%
1.	1	483.22	29.6(1.70)	9.25	1.6	4.1	5.00
2.	10	50.50	33.2(19.97)	10.38	1.7	4.50	5.30
3.	100	5.30	33.8(24.8)	10.56	1.6	4.56	5.53
4..	300	2.29	34.5(14.28)	9.84	1.7	4.6	5.6

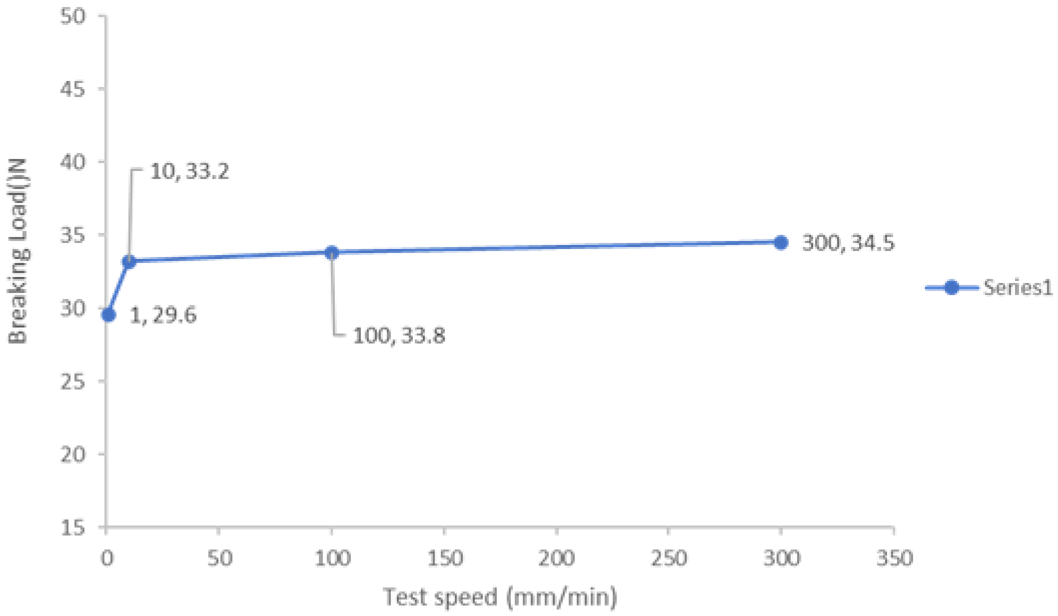

FIGURE 8. Variation of load in different test speed for 320 tex yarn

TABLE 8. Tensile strength for Jute yarn.Yarn Count: 480 tex (14 lb/spy) gauge length: 500mm

Sl. no.	Test speed (mm/min)	Test time (sec)	Breaking load (N)	Tenacity (cN/tex)	Extension (%)	Initial modulus (N/tex)	
						0.5%	1%
1.	1	628.03	36.7(15.54)	7.64	2.1	2.5	2.9
2.	10	62.34	41.2(18.63)	8.58	2.0	2.8	3.3
3.	100	7.44	43.5(11.36)	9.06	2.3	2.5	3.1
4..	300	2.93	45.0(10.28)	9.37	2.3	2.5	3.0

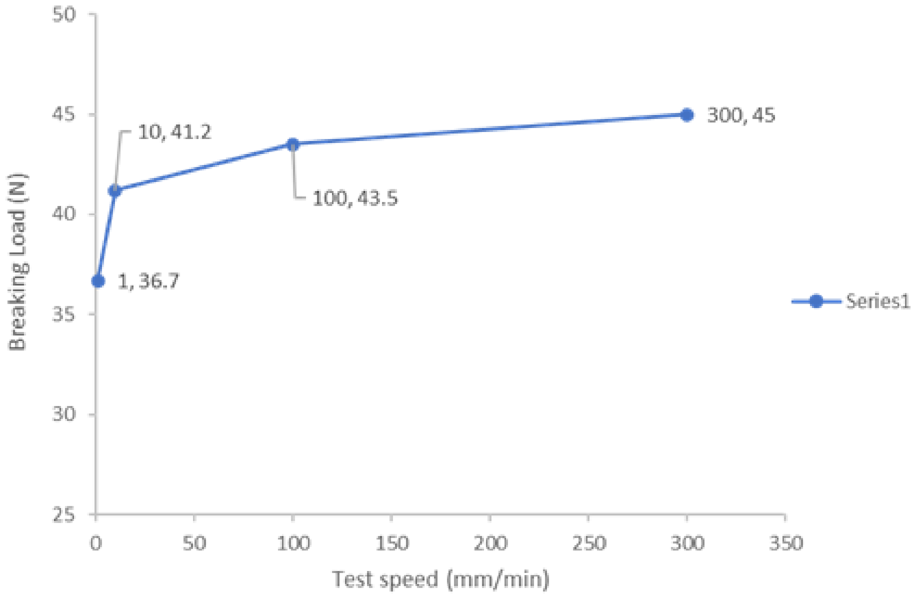

FIGURE 9. Variation of load in different test speed for 480 tex yarn

TABLE 9. Strength-time coefficient (k-value) of different count of jute yarn in different test speed

S.L. No.	Sample code	1 mm/min and 10 mm/min	10 mm/min and 100 mm/min	100 mm/min and 300 mm/min
1.	Y_1	0.19	0.04	0.04
2.	Y_2	0.10	0.17	0.07
3.	Y_3	0.08	0.05	0.08

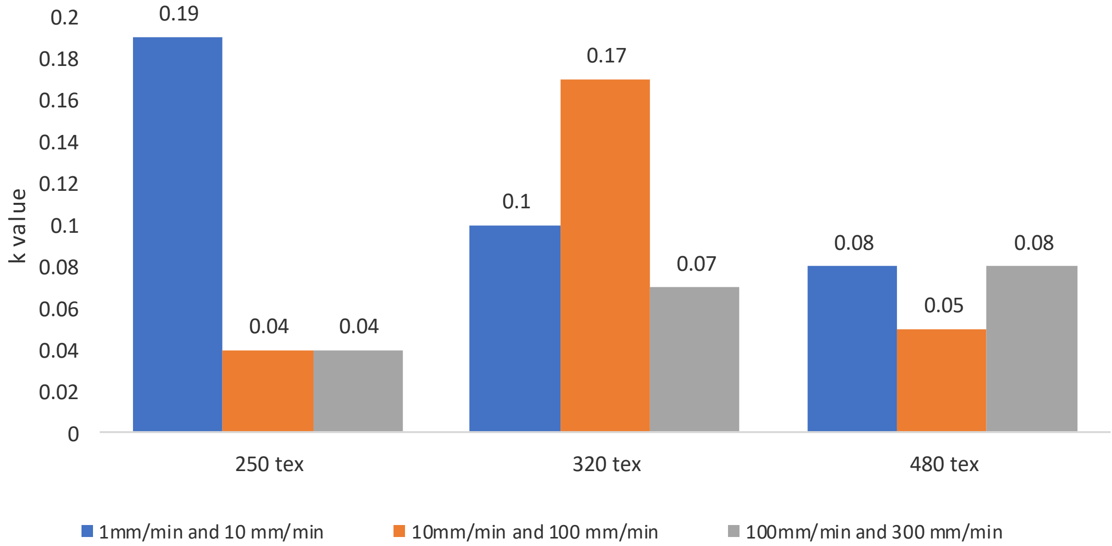

FIGURE 10. Comparison of strength time coefficient, k- value at different test speed.

The aforementioned table shows the Strength-Time coefficient k-values of different jute yarns. These values are obtained from Meredith's equation and grand average of strength time coefficient (k) value is 0.09 which is nearly equal to the other fibres.

4. CONCLUSION

There is reasonable agreement between the experimental values and the values obtain from equation (1). Peirce derived this equation assuming a normal distribution of the strength values but in the present work it has been found the distribution of strength is not normal distribution and there is slight skewness in the distribution of strength. 4.2 The breaking load is increased with increasing the test speed. Therefore, the breaking load increases as the rate of loading increases. This trend matches with Meredith's statement. 4.3 Strength-Time coefficient (k) values of jute yarn. These values are obtained from Meredith's equation and grand average of strength time coefficient (k) value is 0.09 which is nearly equal to the other fibres.

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