Study on Yarn Density and Net Winding Rate

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ABSTRACT

Winding is the process prior to war preparation during weaving. Cone winding is very important before warping and for weft insertion in modern loom. Constant rate of winding with the increase of diameter by traversing is the most important task in this type of cross winding. This study is done to know the change of net winding and yarn density during winding with time and yarn properties specially extension at break. Here, three different yarns are used and marked as white, red and olive to understand the result. This shows significant effect of winding time and yarn extension at break percentage on net winding rate and yarn density of yarn package. Other properties of yarn found no significant effect on them

Keywords : Cross winding, surface speed, traverse rate, yarn density, net winding rate.

1 INTRODUCTION

IN order the obtain information on the distribution of yarn weight with package diameter, it was necessary to find the volume and the weight of the packages, as they were wound from the minimum size to the final size. The weight readings were obtained on an accurate weighing scale. The gross weight of the package minus the weight of the tube gave the total weight of yarn on the package at each stage of completion of it (1). It was found that packages with even density dyed with poorer levelness than the packages having varied density profiles (2). Traverse velocity is defined as the amount of traverse happened during winding per unit of time i.e. the length of traverse in m/min is called traverse velocity. The angle contained between a wrapped yarn on the surface of the package and the diametrical plane of the package is known as angle of wind. Net winding velocity is obtained by dividing the traverse velocity by sine value of winding angle (3). As, with the constant traverse and surface speed, the diameter of the package changes with the change of diameter and coil length. For cone package the diameter of the package is different at top to bottom. In case of cone winding, to achieve uniform build up, coil angle should be increased from base to nose. Putting this in simple terms, yarn traverse speed must be increased from base towards nose and vice versa (4). This study found that the yarn density in the package and net winding rate also changes with the time of winding and yarn extension without significant influence of other parameters. Graphical methods and correlation are analyzed to support this result and winding parameters are also measured to know the relation. Taking yarn of three different counts, yarn properties are analyzed and winding parameters are measured during winding at same tension and time difference. The present paper reports a study of the yarn package density and net winding rate of yarns as a function of properties of yarns specially count, yarn breaking extension and winding time.

2 LITERATURE REVIEW

While the textile industry was dealing with only a few types of yarn, and anyone technologist was usually dealing with only one type of fiber, the volume of a yarn was adequately indicated by its count and twist. Consequently, in order to appreciate the amount of space which a particular yarn will occupy it is necessary to know both its count (linear density) and specific volume. The specific volume is important in many applications: in the relations between count and diameter and between twist factor and twist angle; in the geometry of fabrics; in the warmth of materials; in the amount of yarn which can be wound on a package; in the theory of yarn properties; and so on. The measurement of specific volume essentially involves the measurement of yarn diameter and yarn mass per unit length, and a variety of methods can be used (5). In recent years some new methods have been described (6) and (7). Various authors (8), (9), (10), (11) have considered the influence of count and twist on the specific volumes of cotton and rayon yarns. The value of the coil angles the yarn density of yarn decreases and vice versa. Increasing the values of the coil angles the color strength% increase as a result of the decrease of cheese density (12)**.** In winding, the linear speed of traverse is always directly linked to the rotational speed of the package and any package build is, basically, a combination of a large number of micro traverses expressed in terms of package revolution. Energy absorption is dependent on many parameters like fiber type, matrix type, and fiber architecture, specimen geometry, processing condition, fiber volume fraction and testing speed (13). Bigger packages are taken to a soft dye package winder which produces soft packages, these packages being soft are not suitable for high speed unwinding. If two strips of same width at different diameters on cone are taken and yarn is wound with same coil angle at both the strips then length of yarn crossing both the strips would be the same. Speed of yarn traverse in relation to rotational speed of the package at given diameter influences coil angle. Faster the traverse speed greater is the coil angle and vice versa. The traverse ratios with small value would cause pattern formation. Minimum displacement should be at least equal to diameter of the yarn at the end of pattern repeat. Within a single package, the density variation is high at inside and outside portion of a package than the middle of the package. Coarser count yarn provides more density variation (higher CV %) than the finer count with equal machine setting (4). In case of cone winding, to achieve uniform build up, coil angle should be increased from base to nose. Putting this in simple terms, yarn traverse speed must be increased from base towards nose and vice versa (4). A conical package has different diameters at different cross-sections. When the package rotates, the peripheral speeds along its surface are therefore different. The diameters of the cross-section of the conical package grow bigger, the peripheral speeds change correspondingly. The high guide velocity produces a large yarn winding angle that makes the end of the package more stable. The magnitude of winding error drops due to their low winding velocity (14). Winding tension should be maintained constant at as low a figure as is consistent with the build of a suitable package which will readily unwind at the next process and which will with stand internal transport without yarn sloughing off (15). Winding error contributes a constant winding tension to the yarn. At the first quarter of the half cycle, the winding tension in the yarn is almost zero. Only at the second quarter does the tension gradually build up and then come down. Tension in running yarn can be reduced by decreasing the frictional forces at all points where the yarn comes in contact with parts of the machinery. The amplitude of winding tension variation largely depends on the position where yarn is wound onto the package (14). This paper shows that the density achieved by reverse tension mechanism is very uniform at different layers of a package and also at the packages themselves than the conventional machine settings for both carded and combed cotton double ply yarn of finer and coarser count (16). So many researcher are working on various aspects of package winding like shock in the yarn during unwinding (17), the impact of yarn tension and coil angle (12), imperfection and hairiness of yarn on winding (18), quality improvement of yarn by waste removal (19), shade variation in dyeing (20), yarn defects (21), effect of winding tension (22), fly generation (23), winding system of twisting machine (24), effect of winding angle on unwinding (25), oscillations in the yarn tension (26), density on winding (27) and etc. Here, this study is to analyze the effect of time of winding and yarn extension to break percentage to net winding rate and specific volume of yarn on cone package for different yarn properties.

3 Methodology

Samples: Sample yarn are selected from the available yarn count 32 Ne, 30 Ne and 20 Ne whose are colored as white, red and olive respectively. Their TPI, strength, CSP, breaking extension are tested and used for further analysis and their influence on net winding rate and yarn density of the package during winding.

Techniques: Graphical representation and correlation analysis are used to analyze the data found through the experiment. Laboratory condition are room temperature at 67% relative humidity. Cone package winding machine is used with grooved drum for constant traverse rate at constant surface speed. To measure different winding parameters and specific volume of yarn on the package are calculated using winding geometry. The assumptions are considered as below-

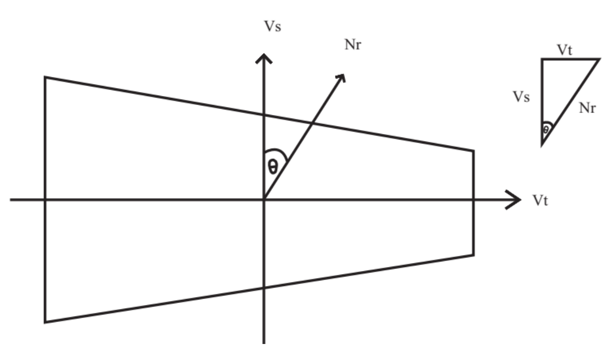

Figure 1: Winding Parameters

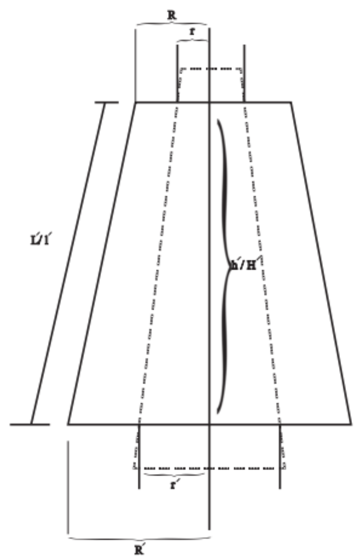

Figure 2: Cone packages and different parameters

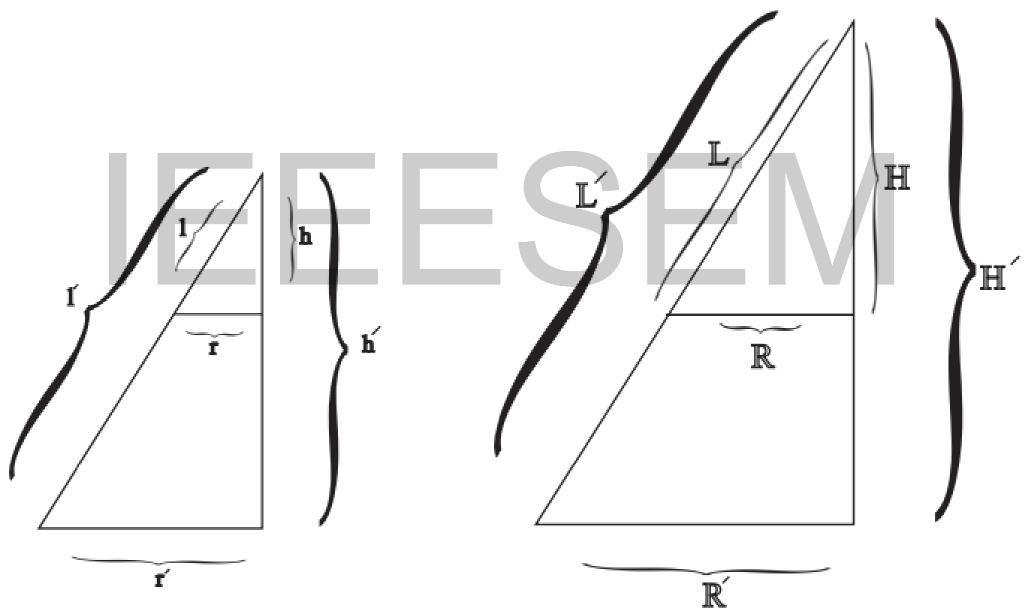

Figure 3: Symmetry of empty and full package

Here, r, r', h, h', l, l', R, R', H, H', L, L'
From symmetrical trigonometry, $\frac{r}{r'} = \frac{h}{h'} = \frac{l}{l'}$ for empty package and $\frac{R}{R'} = \frac{H}{H'} = \frac{L}{L'}$
And, volume of yarn in the package = Volume of full package – Volume of Empty package

$$= (V'-V)-(v'-v)$$

$$= \left(\frac{1}{3}\pi R'^2 H' - \frac{1}{3}\pi R^2 H\right) - \left(\frac{1}{3}\pi r'^2 h' - \frac{1}{3}\pi r^2 h\right)$$

Yarn density $= \frac{\text{Weight of yarn in package}}{}$
$= \frac{\text{Weight of full package} - \text{Weight of empty package}}{\text{Volume of yarn in package}}$

4 Result

From gearing and measurement of diameter of pulley and grooved drum. Surface speed of the package and traverse rate is calculated as below-

Motor rpm	2800	rpm
Motor pulley	3.7	cm
m/c pulley	4.23	cm
Inner circumference of groove drum	25.8	cm
Depth of groove	1.9	cm
Diameter of groove drum	4.41	cm
Traverse length	14.5	cm

Surface Speed,	Vs	339.3195	m/min	Per Traverse	2.9	cm
Traverse Rate,	Vt	142.052	m/min	No. of Traverse	2	

Table 1: Yarn Specification

Yarn	Empty package data			Wt/120 yds			Count	TPI	TM
	Helical length	Circumference at top (cm)	Circumference at bottom (cm)	1	2	3	Ne		
White	17.1	3.9	7	2	1.99	2.04	32.24	17	2.99
Red	17.1	3.7	7.34	2.29	2.28	2.04	29.41	10	1.84
Olive	17.3	3.8	7.38	3.23	3.26	3.27	19.92	10	2.24

Table 2: Breaking strength and time to break

Yarn	Strength (lb)				Time to break				lb/sec
	1	2	3	Avg.	1	2	3	Avg.	
White	65	60	67	64	9.9	12	12.8	34.7	1.84
Red	68	75	77	73.33	12.5	13.8	11.5	37.8	1.94
Olive	133	131	127	130.33	13.5	12.7	14	40.2	3.24

Table 3: Yarn extension percentage

Yarn	Initial length inch	Extension at break inch				Extension%
		1	2	3	Avg.	
White	26.75	28.75	29.25	28.875	28.96	8%
Red	26.75	28.75	29.125	28.12	28.67	7%
Olive	26.75	29.75	29	29.125	29.292	10%

Table 4: Winding parameters at different diameters for white yarn package

Time	Package wt. (gm)	Bottom		Top		Average		Winding angle (θ)	Surface speed (Vs) m/min	Traverse rate (Vt) m/min	Net Winding Speed (Nr) m/min
		Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)				
Empty package	44.47										
After 5 min	98.56	24.7	4	17	2.7	20.85	3.35	17.37	339.30	106.12	355.51
After 10 min	157.22	24.6	4.5	20	3.5	22.3	4	14.48	339.30	87.60	350.40
After 20 min	277.57	31.4	6	23.1	4.5	27.25	5.25	10.98	339.30	65.83	345.63

Table 5: Winding parameters at different diameters for red yarn package

Time	Package wt. (gm)	Bottom		Top		Average		Winding angle (θ)	Surface speed (Vs) m/min	Traverse rate (Vt) m/min	Net Winding Speed (Nr) m/min
		Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)				
Empty package	42.27										
After 5 min	94.84	23.7	3.58	15.6	3	19.65	3.29	16.99	339.30	103.67	354.79
After 10 min	149.85	27.3	4	18.3	3.5	22.8	3.75	15.47	339.30	93.88	352.05
After 20 min	263.53	31.4	5.3	22.4	4	26.9	4.65	12.42	339.30	74.72	347.43

Table 6: Winding parameters at different diameters for olive yarn package

Time	Package wt. (gm)	Bottom		Top		Average		Winding angle (θ)	Surface speed (Vs) m/min	Traverse rate (Vt) m/min	Net Winding Speed (Nr) m/min
		Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)	Circumference (cm)	Coil length (cm)				
Empty package	43.78										
After 5 min	114.91	25.5	4.5	17.6	3.64	21.55	4.07	14.22	339.30	86.00	350.03
After 10 min	203.01	28.98	4.6	21.6	4	25.29	4.3	13.45	339.30	81.13	348.87
After 20 min	386.14	35.3	5.3	27.8	4.2	31.55	4.75	12.15	339.30	73.07	347.08

Table 7: Data table for measuring yarn density (gm/cc) of the packages

	Empty Package				Full Package																	
Yarn	Weight (gm)	Helical length	Radius at top (cm) r	Circumference at bottom (cm) r'	Winding Time	Weight (gm)	Radius at Top (cm) R	Radius at Bottom (cm)R'	l	l'	h	h'	L	L'	H	H'	v	v'	V	V'	Va	Yarn Density (gm/cc)
White	44.47	17.1	0.6207	1.1141	After 5 min	98.56	2.7056	3.9311	21.51	38.61	21.50	38.60	37.75	54.85	37.66	54.71	8.68	50.17	288.67	885.41	555.25	0.0974
	44.47	17.1	0.6207	1.1141	After 10 min	157.22	3.1831	3.9152	21.51	38.61	21.50	38.60	74.35	91.45	74.28	91.36	8.68	50.17	788.13	1466.60	636.98	0.1770
	44.47	17.1	0.6207	1.1141	After 20 min	277.57	3.6765	4.9975	21.51	38.61	21.50	38.60	47.59	64.69	47.45	64.50	8.68	50.17	671.62	1686.84	973.74	0.2394
Red	42.27	17.1	0.5889	1.1682	After 5 min	94.84	2.4828	3.7720	17.38	34.48	17.37	34.46	32.93	50.03	32.84	49.89	6.31	49.25	211.99	743.34	488.41	0.1076
	42.27	17.1	0.5889	1.1682	After 10 min	149.85	2.9125	4.3449	17.38	34.48	17.37	34.46	34.77	51.87	34.65	51.69	6.31	49.25	307.78	1021.83	671.11	0.1603
	42.27	17.1	0.5889	1.1682	After 20 min	263.53	3.5651	4.9975	17.38	34.48	17.37	34.46	42.56	59.66	42.41	59.45	6.31	49.25	564.46	1554.82	947.42	0.2335

Olive	43.78	17.3	0.6048	1.1746	After 5 min	114.91	2.8011	4.0584	18.36	35.66	18.35	35.64	38.54	55.84	38.44	55.69	7.03	51.50	315.85	960.63	600.32	0.1185
	43.78	17.3	0.6048	1.1746	After 10 min	203.01	3.4377	4.6123	18.36	35.66	18.35	35.64	50.63	67.93	50.52	67.78	7.03	51.50	625.20	1509.90	840.24	0.1895
	43.78	17.3	0.6048	1.1746	After 20 min	386.14	4.4245	5.6182	18.36	35.66	18.35	35.64	64.13	81.43	63.97	81.23	7.03	51.50	1311.45	2684.98	1329.06	0.2576

Results found are summarized in the following table.

Table 8: Summery data table of the winding parameters and specific volumes

Yarn	Time	Winding angle (θ)	Surface speed (Vs) (m/min)	Traverse rate (Vt) (m/min)	Net Winding Speed (Nr) (m/min)	Yarn density (gm/cc)
White	**After 5 min**	17.37	339.30	106.12	355.51	0.0974
	After 10 min	14.48	339.30	87.60	350.40	0.1770
	After 20 min	10.98	339.30	65.83	345.63	0.2394
Red	**After 5 min**	16.99	339.30	103.67	354.79	0.1076
	After 10 min	15.47	339.30	93.88	352.05	0.1603
	After 20 min	12.42	339.30	74.72	347.43	0.2335
Olive	**After 5 min**	14.22	339.30	86.00	350.03	0.1185
	After 10 min	13.45	339.30	81.13	348.87	0.1895
	After 20 min	12.15	339.30	73.07	347.08	0.2576

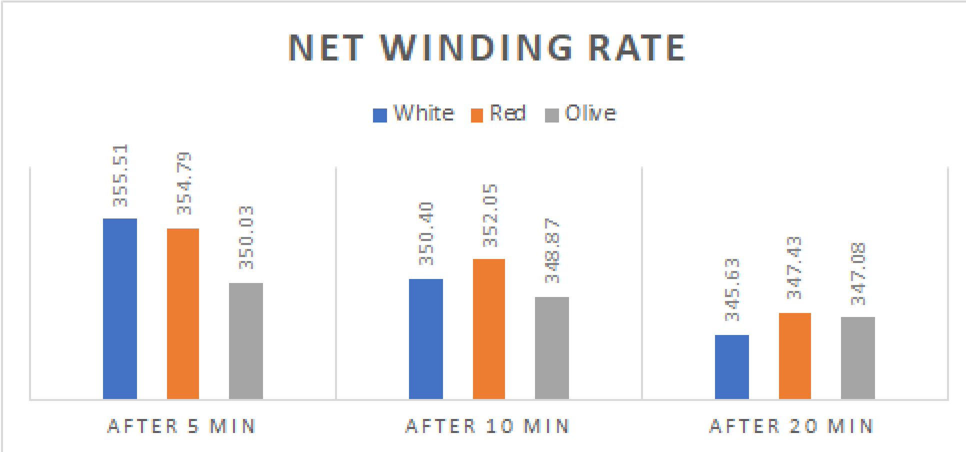

Figure 4: Net winding rates for different packages

Here, it is found from the data table and bar chart (table-8, Fig.-4), although the surface speed and traverse speed is same the net winding rate for different count of yarn are not same. During 5 minutes of winding with the decrease of yarn count net winding rate also decreased. But when winding time increased the net winding rate decreased with the increase of diameter which follow the constant rate of winding. But, the net winding rate for 32 count of yarn shows more than that of other yarn count after 10 min. Hence, upto 10 minutes of winding the result are almost same. Again, after 20 minutes of winding the results shows that with the decrease of yarn count the net winding rate is increasing.

This shows that, time has an effect to the net winding rate for different yarn count with different yarn properties. To find the change in yarn density of yarn during winding. It shows following graphical results.

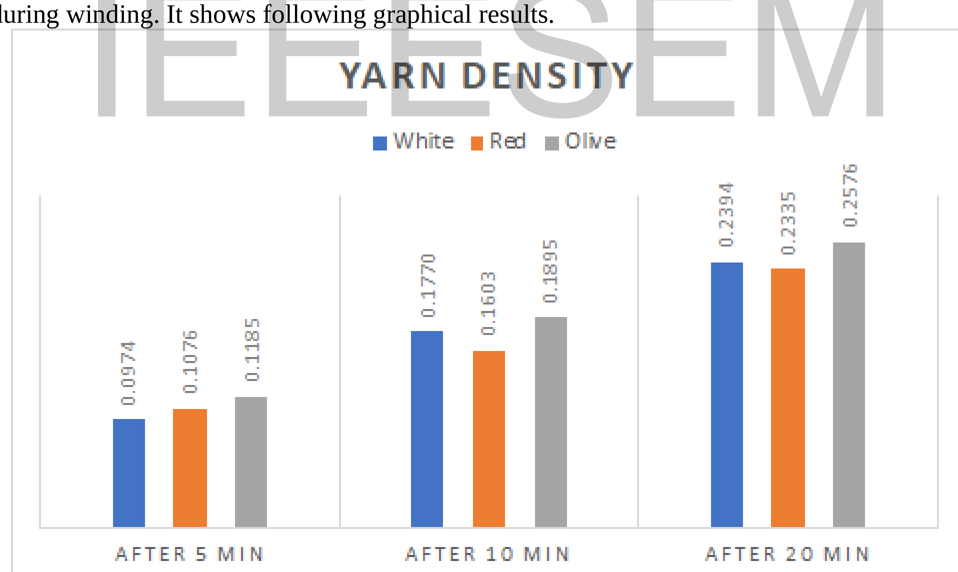

Figure 5: Yarn density for different packages

Here, with the decrease of yarn count yarn density of yarn on package increased after winding continues for 5 min. The results show same after winding upto 10 to 20 minutes except for 32 Ne red yarn whose extension at break is lower than that of other two yarns. Thus, net winding rate shows high negative correlation with extension at break percentage ($p<.01$) and positive relation with yarn density ($p<.10$) from table-9,10.

Table 9: Yarn properties, net winding rates and yarn density

Yarn	Count (Ne)	TPI	Breaking strength	CSP	Tenacity	lb/sec to break	Extension at break	Avg. Net winding	Avg. yarn density
White	32.24	17.00	64.00	2063.28	1.84	1.84	8%	350.51	0.1713
Red	29.41	10.00	73.33	2156.73	1.94	1.94	7%	351.42	0.1672
Olive	19.92	10.00	130.33	2595.98	3.24	3.24	10%	348.66	0.1885

Table 10: Correlation co-efficient for yarn properties to winding rates and specific volumes

Yarn	Avg. Net Winding	Avg. Yarn Density	Count (Ne)	TPI	Breaking Strength	CSP	Tenacity	lb/sec to break	Extension at break	Time
Avg. Net winding	1	-.989	.852	.193	-.896	-.880	-.924	-.924	-1.000***	-.850***
Avg. yarn densigy (gm/cc)	-.989	1	-.920	-.335	.952	.940	.970	.970	.989*	.965***
***. Correlation is significant at the 0.01 level (2-tailed).										
**. Correlation is significant at the 0.05 level (2-tailed).										
*. Correlation is significant at the 0.10 level (2-tailed).										

Hence, with the time the extension at break has significant effect on net winding rate and yarn density of yarn on package during winding is performed. From, the correlation co-efficient it is found that, winding time and yarn extension at break has negative relation to net winding rate and has positive correlation with yarn density of yarn package during winding.

5 CONCLUSIONS

As yarn is a flexible continuous strand with variable cross sections, the yarn density and net winding rate is affected by its properties although the machine setting is same. Time of winding effects the amount of yarn to be wound on the package with the yarn density for all studied counts. With the increase of winding time the net winding rate is decreased as diameter increased to maintain uniform build up. But, yarn density on the package decreases at the same time. It also shows the same relation to the specific yarn extension at break. More yarn extension reduces the net winding rate with same tension through yarn passage guides, Thus, volume of yarn decreases and yarn density increases. This study requires further experiments to know the change of winding rate with the change of yarn properties during winding. As, the yarn tension is remained constant for all the yarn taken into consideration in this study, there are scopes of further study in winding of cone packages.

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