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Short Communications

Influence of winding parameters on yarn content and package geometry of wound packages

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This study is aimed at evaluating the step-precision assembly winding in terms of its potential to accommodate maximum yarn content on a given size of tube. The influence of various parameters related to step-precision winding on yarn content and package geometry of a close step-precision wound package has been studied. The outcome of this study is presumed to be very useful to manufacturers of winding as well as buyers of assembly winding systems. Step-precision winding parameters, like coil angle at start, angle up to which it is allowed to change and the number of diamonds along the circumference (Y value), influence yarn content on package; lower values of start angle and Y but higher value of change angle give increased yarn content. At the same time, it is also observed that the package with lower start angle and higher change angle give greater projection of package side flanks.

Keywords: Assembly winding, Package geometry, Precision winding, Random winding, Step-precision winding, Winding parameters, Wound package,Yarn

Assembly winding is a process where two or more yarns are assembled together and wound to form a package that goes further for TFO twisting. Many researchers[1-3] have discussed the typical characteristics of assembly winding. An assembly wound package, fed to a spun yarn TFO, is unwound over-end at slower speed (around 20-30 m/min); making its unwinding behaviour less critical. The full size of package is determined by the size of the pot, and therefore, it becomes essential to retain maximum yarn content in the package volume without sacrificing twisting performance, productivity and efficiency, so that doffing frequency is reduced.

Winding mode of an assembly winder may be random, precision or step-precision. Among these, precision winding is capable of producing packages with the highest density through close wind, followed by step-precision winding and random winding. However, decreasing coil angle besides changing package density with increasing package diameter are drawbacks associated with precision winding. This tends to produce packages with non-parallel side flanks where bulge is more prominent at higher package diameters, as shown in Fig. 1.

Practical solution to this would be to leave empty space on both the sides of empty tube at the start of winding process, but this would indirectly lead to lower yarn content. If an assembly winder operating on random winding mode with grooved drum is chosen then yarn content would be compromised. Drums with higher pitch can be used to overcome the same but may lead to improper flanks, which however can be taken care of by using a low pitch drum (with coil angle range 13° - 14°), but that, in turn, can lead to lower yarn content. So in short to produce packages with different coil angles/densities, drums with different pitch are required; curtailing flexibility of such winders. The machine cost is the highest for step-precision assembly winding and therefore it is the least preferred mode; as already discussed in detail[4-7].

Step-precision winders with programmable drive to package and traverse motion have opened several avenues in package building[5,8]. The problem of package side faces bulging beyond tube ends along with possibility of yarn spreading over greater length of tube due to increased yarn content seems feasible due to them. This study focuses on influence of various close step-precision winding parameters on

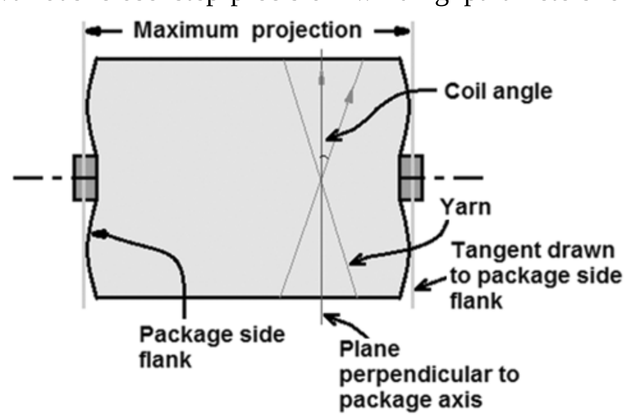

Fig. 1 — Measurement for projection of package side flanks

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yarn content and package geometry, and it is presumed that the outcome will be useful for manufacturers of assembly winders.

Earlier works[7-14] have discussed the winding terms especially the traverse ratio and can be written in its generalized fraction form as (*X*/*Y*), where *X* and *Y* do not have any common factor. *Y* also indicates the number of double traverses after which the coil comes to the same starting point; the smaller the value of *Y*, the more prominent is the pattern formation[11,12]. During precision winding it is also necessary to shift the coil after every pattern repeat[8,11-14]; smaller shift results in close wind and greater shift in open wind.

If traverse ratios with smaller value of Y are considered like 17/3 (5.6667; Y=3), 11/2 (5.5; *Y*=2), 6/1 (*Y*=1) or 31/5 (6.2; *Y*=5), then the wraps of coils overlap after few double traverses, leading to faulty package with pattern formation. Such numbers with smaller value of Y are called nominal traverse ratios. The actual traverse ratio is taken slightly smaller or greater than nominal traverse ratio to avoid patterning. Smaller the difference between them, compact package (close wind) will be produced, which, in turn, would facilitate increased yarn content.

In step-precision winding, traverse ratio is decreased in steps during package build[5] due to which extent of coil angle variation can be reduced, resulting in packages with nearly parallel side faces. Selecting close wind traverse ratios in all steps during step-precision winding, a package with higher package density can be produced.

Experimental

Winding trials were carried out on 3 spindles on Peass UFLEX rewinding machine (Instruction manual of Peass Uflex-A/S rewinding machine – labmodel). One spindle was used for assembly winding and the other two were used for soft package winding/ rewinding of dyed packages. This machine allows operation in two modes, viz (i) precision winding and (ii) step-precision winding. The available program for open step-precision winding was modified for use in close step-precision winding in precision mode.

A tool was developed in Microsoft excel to generate package diameter versus traverse ratio tables for close step-precision winding of Ne 2/12 single cotton yarn. The parameters related to close step-precision winding are:

(i) Start angle (coil angle), that is restored at each change over to a new traverse ratio (range 10˚-15˚ in increment of 1˚).

(ii) *Y* value of 1, 3, 4 and 5. With Y value of 3, nominal traverse ratios that can be taken have generalized form as $N\frac{2}{3}$, $N\frac{1}{3}$, and with *Y* value of 5, nominal traverse ratios are $N\frac{4}{5}$, $N\frac{3}{5}$, $N\frac{2}{5}$ and $N\frac{1}{5}$. Here, N is a natural number. *Y* indicates the number of double traverse, after which yarn may come to place nearer from where its lay was started.

(iii) Yarn to yarn distance was optimised as 0.55 mm by trial and error for yarn count Ne 2/12 in such a way that wraps of yarn touch one another to give close wind.

With above parameters, two trials were conducted. One with change angle of 1˚ and the other with change angle of 2˚. Change angle is the extent to which decrease in coil angle from start angle is allowed. For example, if start angle is 12˚ and change angle is 2˚, at every decrease in traverse ratio, system will restore coil angle to 12˚. Next new traverse ratio decrease takes place when coil angle decreases to 10˚ as shown in Table 1. Following machine parameters were used:

Bare package diameter	: 48 mm
Full package diameter	: 125 mm (set on machine setting panel)
Mode of winding	: Precision (selected on setting panel of machine)
Winding speed	: 800 m/min
Cradle pressure	: 3 kg (set on machine)
Winding tension	: 100 cN (10% of single yarn strength) measured with Schmidt make yarn tension meter ZEF- 200
Yarn used	: 2/12 Ne single cotton yarn
Yarn strength	: 96 gf

Table 1 — Package diameter and actual traverse ratio (ATR) for value=3 and start angles 11˚ and 12˚ (change angle of 1˚)

Start angle 11˚ (change angle 10˚)		Start angle 12˚ (change angle 11˚)	
Diameter, mm	ATR, mm	Diameter, mm	ATR, mm
48.0	10.3269	48.0	9.6606
52.4	9.6607	50.9	9.3275
56.1	9.3275	52.7	8.6613
58.1	8.6613	56.7	8.3281
62.5	8.3281	59.0	7.6619
65.0	7.6619	64.1	7.3288
70.7	7.3288	67.0	6.6625
73.9	6.6625	73.7	6.3294
81.3	6.3294	77.6	5.6631
85.6	5.6631	86.7	5.3299
95.6	5.3299	92.2	4.6638
101.6	4.6638	105.3	4.3306
116.1	4.3306	113.4	3.6644
Upto 125	-	Up to 125	-

The above parameters were kept same and close step-precision traverse ratios were calculated, in such a way that coil angle could be restored to the start angle allowing only one degree drop as the package diameter got built-up (Table 1). This exercise was done only for the *Y* value of 3 and two values of start angles as prototype.

All packages produced during the test trials were checked for their yarn content by measuring their weights using digital electronic weighing machine of ME – TECH™ make and projection of package side flanks in mm using dial Vernier Calliper of "Mitutoyo" make (Fig. 1) for *Y* values of 1, 3, 4 and 5 and for range of coil angles (10˚-15˚) in step of one degree.

Results and Discussion

Table 2 shows yarn content (g) and projection of package side flanks (mm) for change angle of 1˚ and 2˚ for all start angles and for different *Y* values.

Effect of Start Angle on Flank Projection

Table 2 shows that for a given value of *Y*, as the start coil angle increases there is a decrease in the projection that is measured on the package sides, and its extent varies for different start angles. The extent to which yarn is spread on winding tube initially as well as during package build depends upon coil angle. As yarn is laid at an angle, the yarn does not reach on tube up to the extreme point where traversing guide reaches. Moreover, yarn tension tends to drag yarn towards tube centre at reversal. Therefore, actual length on which yarn spreads on package tends to be less than the stroke of traversing guide. Greater the coil angle, the lesser is the extent to which yarn spreads on the package and vice versa. In precision winding, coil angle keeps on reducing progressively with increase in package diameter. Hence, the extent to which yarn spreads on package also keeps on increasing gradually. The step-precision winding principle includes precision winding in steps where the traverse ratio is reduced in each step to achieve/maintain the start coil angle. In step-precision winding, the coil angle keeps on reducing during winding with a given traverse ratio. When the traverse ratio is decreased at step there is sudden rise in coil angle. Due to this, the extent to which yarn spreads on the package, keeps on rising with a given traverse ratio. It also implies that the volume of yarn would then increase, resulting in increase in the yarn content. On switch over to a new lower traverse ratio, the extent to which yarn spreads instantaneously decreases. With too low start angle, the side flanks may project beyond tube ends or may leave very small gap between tube ends and yarn on package.

In either case, package will not be suitable for use. For example, with start angle of 10˚ and *Y* value of 4, the projection of package side flanks exceeds 170 mm; i.e. tube length. Due to this, side face of close step-precision assembly wound package would touch TFO pot at bottom and flyer at top. Therefore, it is necessary to optimise start angle so that maximum possible yarn content is achieved with package side flanks projection well within tube ends allowing

Table 2 — Yarn content and projection of package side flanks

Start angle-Change angle deg	Y1		Y3		Y4		Y5	
	Yarn content, g	Flank projection, mm	Yarn content, g	Flank projection, mm	Yarn content, g	Flank projection, mm	Yarn content, g	Flank projection, mm
Change interval of 1°								
10 - 9	943	163.1	937	169.1	931	170.2	924	171
11 - 10	941	161	931	161	927	165.3	918	164.4
12 - 11	915	156.8	908	159.4	903	160	897	160.2
13 - 12	906	165.2	894	157.6	889	156	882	157.6
14 - 13	876	153.6	867	156	854	155.7	851	155.8
15 - 14	843	151.7	830	152.4	826	154.2	823	156.1
Change interval of 2°								
10 - 8	961	162.6	955	169.7	949	171	941	171.8
11 - 9	957	162.6	950	162	946	166.6	930	165.2
12 - 10	930	158.7	92	160.3	915	161.4	909	161.5
13 - 11	918	157	907	158.5	898	159.8	888	158.6
14 - 12	886	154.4	877	156.3	861	156.8	857	157.3
15 - 13	856	153	847	153.3	841	154.9	838	155.4

easier package handling as well as mounting in TFO pot; without any chances of yarn touching pot base and/ or flyer. For close step-precision assembly winding, it is generally recommended to leave 10 mm of tube on either side without yarn winding. It is also observed that for a given start coil angle but greater difference in the between start and change angle, greater is the projection of package side faces due to increased extent of drop in coil angle as seen in (Fig. 2).

Hence, it becomes necessary to optimise difference between start and change angle to balance between yarn content and projection of package side flanks.

Effect of Start Angle on Yarn Content

Low start angle spreads yarn on greater length on package and therefore yarn content on package is found to increase with the decrease in start angle.

Effect of Change Angle on Number of Steps Involved in Winding

Smaller difference between start angle and change angle leads to earlier switch over from one traverse ratio to the other. Therefore, number of steps involved in formation of step-precision wound package up to given full package diameter increases with smaller difference between start angle and change angle and vice a versa. Increased number of steps (caused with smaller difference between start angle and change angle) would reduce the extent of coil angle variation due to which package side flanks tend to be more even without the appearance of prominent rings (Fig. 3). For TFO feed packages, appearance of rings on side flanks of close step-precision wound packages is not objectionable as assembly winding is just an intermediate process.

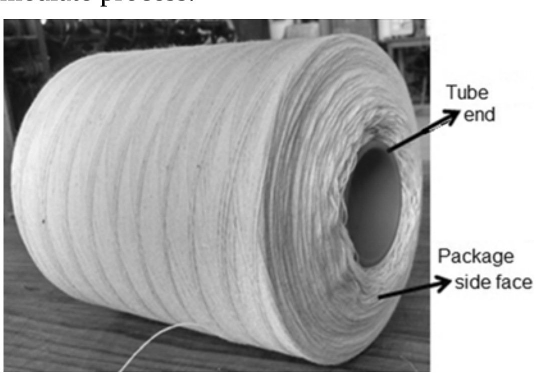

Fig.2 — Side face projection with start angle 10° - change angle 8˚ for Y=4

Effect of *Y* value on Yarn Content and Flank Projection

It is revealed from Tables 1 and 2, that *Y* value of 1 gives maximum yarn content on close step-precision wound package with given combination of start angle and change angle because least number of diamonds and cross-over points are obtained with *Y* value of 1. Increase in *Y* value decreases yarn content on full package. This can be attributed to the increase in number of diamonds along the circumference of package, which increases number of thread crossing points on the package. Similarly it is also seen that the close step-precision wound package built with *Y* value of 1 gives minimum projection of package side flanks as compared to packages wound with other *Y* values.

Yarn content on package is influenced by start angle, change angle and *Y* value. Lower start angle, higher change angle and lower *Y* value give increased yarn content. However, a package with lower start angle and higher change angle gives greater projection of package side faces. A package with higher yarn content with projection of package side faces well within tube ends can be built by optimising start angle, change angle and *Y* value.

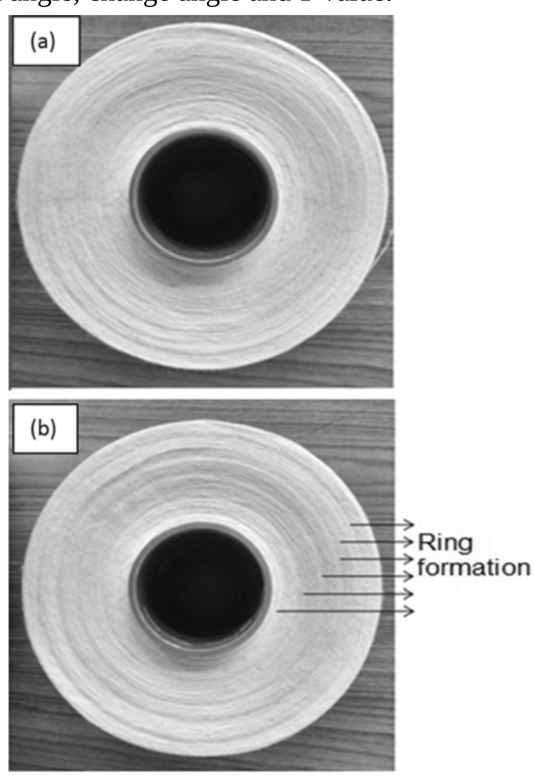

Fig. 3 — Appearance of package side flanks wound with (a) 9 steps (less prominent rings) and (b) 6 steps (more prominent rings)

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