The Effect of the Winding Process on Yarn Structure

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ABSTRACT

It is often claimed that the quality of the yarn is improved as a result of winding. This is based on the assumption that during winding thick, thin and weak places are eliminated.

Although the use of a clearer and slub-catcher devices in the winding machine result in the elimination of these undesirable places, most of the tensioning and clearing devices impart a frictional drag on the yarn and have the effect of a rubbing or scraping action on the yarn. Such actions will change the yarn surface structure.

In this paper the properties studied were the yarn hairiness, regularity and tenacity. Carded cotton ring-spun and open-end spun yarns were used. By rewinding the same yarn from each type several times, and measuring those properties, after each rewinding process, it was found that there were significant changes in the yarn hairiness, regularity and tenacity. The changes were more significant for the ring-spun yarn this could be explained as follows; after rewinding, the separation of the yarn from the package surface can only be achieved by the breaking of this mechanical interlocking. Therefore, some fibres will be removed from the yarn body thus resulting in some changes in the yarn structure. The results also showed that the direction of unwinding has an effect on the yarn structure.

It was inferred from the results obtained that during the winding process there was a mechanical interlocking action between the protruding fibres on the yarn surface. This interlocking is mainly caused by the rolling action of the yarn during winding, effected by the grooved drum, and the rolling of the incremental length of yarn at the unwinding point, owing to the drag between the withdrawn moving yarn and the supply package surface.

INTRODUCTION

Important objects of the winding process are to improve the yarn quality by removing yarn faults, such as thin and thick places and slubs, and to produce larger and firm packages, in order to increase the running time and machine efficiency in the subsequent processes.

The removal of yarn faults is mainly achieved by using detecting and clearing devices and by applying a certain amount of tension to the yarn during winding, i.e. the winding tension. It has been reported (Peykamian and Rust, 1992, Barella and Castro, 1973) however, that the winding process can cause a significant change to the yarn surface structure. Furthermore, during the winding process, and as a result of the high rotation of the take-up package, the outer layers of the yarn that are not covered will be subjected to a high centrifugal force which may increase the number of outstanding fibres on the yarn surface.

When a moving yarn comes into contact with any machine element several events may occur. Frictional stresses may be induced in the yarn at the contact region, heat may be generated due to the friction, the frictional contact with the machine elements may change the twist distribution along the yarn length, damage may be caused to the element or to the fibres on the yarn surface, and fibre fly may be generated (Mohamed1994, 2001).
The friction between the yarn and machine elements will depend on the element's surface finish, the radius of curvature of the element, the contact length, the wrapping angle, the machine speed, the amount and viscosity of the lubricant on the yarn surface, and the yarn structure (Mohamed and Lawrence, 1996).

It was therefore, considered important to study the effect of winding on yarn structure.

VISUAL OBSERVATION

m/min.), close visual observation of 5 By running the winding machine at a very low speed (1. the yarn movement from the supply package to the take-up package showed that during winding using a rotating traverse grooved drum, the yarn is subjected to a rolling action by the sides of the grooves of the drum, and that the direction of rolling depends on the direction of traverse.

As shown in Plates (1and 2), when the yarn movement is from the left-hand side to the right-hand side of the grooved drum, the yarn rolls about its axis in a clockwise direction, and when the yarn movement is from right to left it rolls in an anti-clockwise direction.

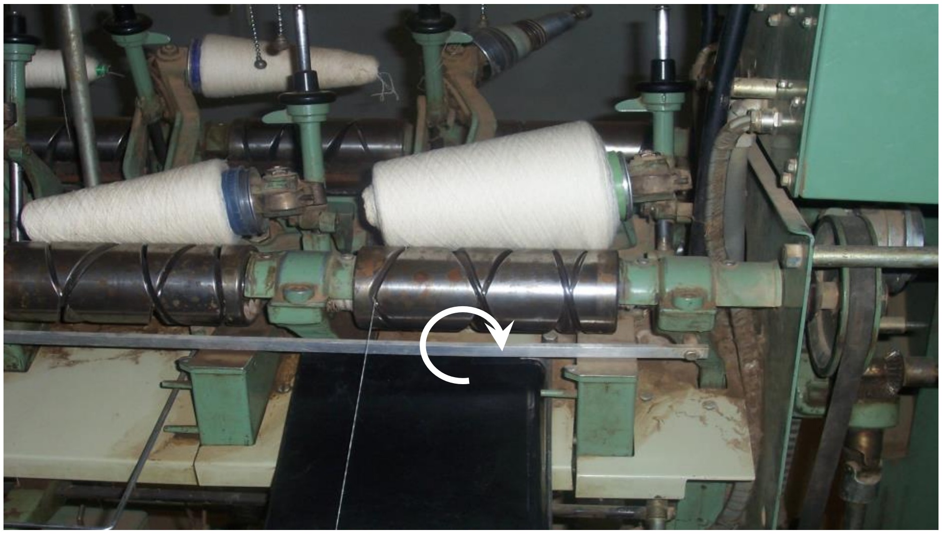

Plate (1)

Plate (2)

At this very low running speed, it was also observed that the rate of rolling increases as the yarn traverses from the small diameter to the large diameter of the take-up crease package and des as the yarn traverses from the package base to its top. Observation at the supply package showed that, the incremental length of yarn on the supply package surface at the unwinding points is not oriented in line with the withdrawn length at the package apex, but follows a path which deviates from the vertical as shown in Figure (1). This was particularly noticeable when unwinding from the supply package base.

DISCUSSION OF THE VISUAL OBSERVATION

From these visual observations mentioned above it may be assumed that this rolling action may result in the interlocking of the protruding fibres from the surface of the yarn length which is about to be wound onto the take-up package with the protruding fibres from the yarn coils already wound onto the take-up package. The high rotational speed of the take-up package could cause the fibres that protrude from the yarn coils to point radially outwards. This effect would make the interlocking more firm and effective.

Furthermore, during the winding process the yarn traverses across the package surface. The combined effects of rolling and traversing may increase the entanglement and the interlocking of the protruding fibres. The traverse motion also results in tension variation. Under these complex conditions, it is quite possible that the yarn would be extended and momentary untwisted [1, 2].

The disorientation of the incremental length of yarn on the package surface with the withdrawn yarn at the package apex is mainly due to the fact that, there is a long length of the package surface over which the moving yarn rubs and this will change the direction of the yarn movement as shown in Figure (1). The high dragging

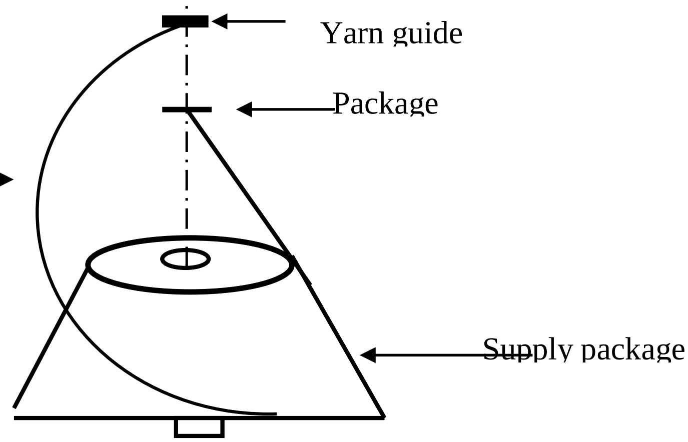

Figure (1) Dragging between the withdrawn yarn and package surface during different manufacturing Processes

Tension between the withdrawn yarn and the underneath yarn coils on the supply package surface will cause the yarn to roll on the package surface and therefore increase the interlocking and entanglement of the protruding fibres on the yarn surface.

DESIGN OF EXPERIMENTS

Equipment and Experimental Conditions

The experimental work was conducted on a winding machine, type (MOSS), which used a grooved drum for yarn traverse and was equipped with a variable speed motor. The work was carried out with carded cotton ring-spun and open-end rotor spun yarns of approximately similar count (25 Tex). The yarn packages were stored for at least 24 hours in a standard atmosphere. The winding speed was kept at 450 m/min and the winding tension was 20 grams. For each type of yarn two samples were prepared and one of them was used for measuring the initial yarn hairiness, coefficient of variation, and tenacity.

To measure yarn hairiness, a Shirley Hairiness Meter (S.H.M) was used, which is based on a photoelectric technique.

In accordance with the test method (Slack, 1977; Walton1968) the distance between the yarn axis and the center of the light beam was adjusted to 3 mm. Only hairs longer than 3 mm were therefore detected by the photocell. It is very difficult to detect extremely short hairs in the yarn because the measurements can be distorted by variations of yarn thickness and by the jerky running of the yarn during the experiment. The test speed and the test duration were 50 m/min and one minute respectively. The yarn coefficient of variation and tenacity were measured by Uster (4) and Uster Tensorapid respectively.

Experiment Procedure

Each yarn sample was rewound four times. The yarn hairiness, coefficient of variation and tenacity after each rewinding process were measured. For each sample, at least ten independent readings were record-ed, and the average values were then calculated. These measurements gave yarn hairiness, coefficient of variation and tenacity values for the spinning thread line direction and the counter spinning direction.

Results and Discussion

The results are given in Table (1) for the ring-spun yarn, and in Table (2)) for the open-end rotor yarn. Figs (1 and 2) shows the changes in the hairiness for the ring-spun yarn and for the open-end yarn respectively. The values are the mean number of hairs per meter.

As can be seen from Tables (1 and 2) and Figs (1 and 2) these results support the view that the winding process modified the surface structure of the yarn. Also, it can be seen that the winding process increases the hairiness of the ring-spun yarn, but has less effect on the open-end spun yarn. This may be attributed to the structure of Table (1) The Effect of Winding on Hairiness, Coefficient of variation and Tenacity for the Ring-Spun Yarn

Unwinding direction from the supply package	Number of windings-re	Hairs /meter (≥ 3 mm)	Coefficient of variation	Tenacity cN/Tex
Spinning	Original	23.6	14.93	13.82
Counter Spinning	1	54.8	15.63	12.68
Spinning	2	41.3	15.28	12.45
Counter Spinning	3	32.2	15.39	12.40
Spinning	4	33.6	15.24	12.27

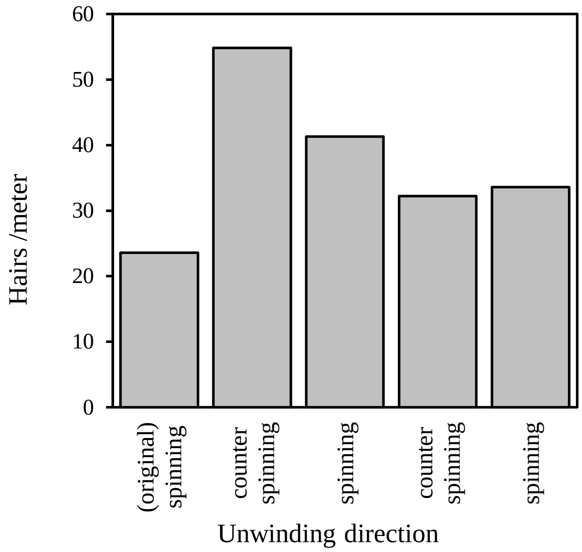

Figure (1) the Effect of Winding on Hairiness for the Ring-Spun Yarn

Table (2) The Effect of Winding on Hairiness, Coefficient of variation and Tenacity for the Open-end Spun Yarn

Unwinding direction from the supply package	Number of windings-re	Hairs /meter (≥ 3 mm)	Coefficient of variation	Tenacity cN/Tex
Spinning	Original	8.1	13.71	10.48
Counter Spinning	1	11.3	14.08	10.27
Spinning	2	12.1	13.79	10.27
Counter Spinning	3	9.6	13.81	10.26
Spinning	4	8.7	13.89	10.19

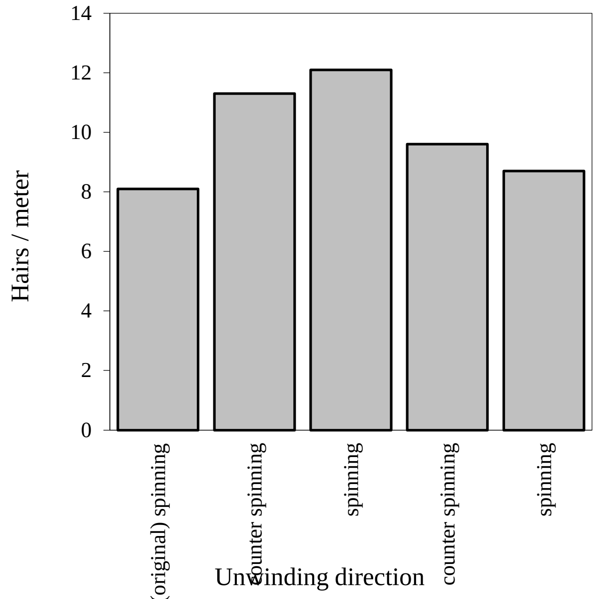

Figure (2) the Effect of Winding on Hairiness for the Open-end Spun Yarn

d yarn and the way the twist binds the fibres inside the yarn body. Less hairy yarns means, -Open less fibres ends contact the winding machine elements and therefore a lower yarn friction. Also the presence of wrapper fibres in the yarn surface structure will increase the abrasion resistance of the open-end yarn.

The results for the successive rewinding of the ring-spun sample suggest that for this yarn type, the winding direction may have an effect on yarn abrasion resistance. As can be seen from Table (1), when the winding direction coincided with the spinning direction there was a slight increase in the amount of hairiness. It thus appears that the nature of the yarn surface plays an important part in yarn tension variation and abrasion resistance.

However, it is clear from Tables (1 and 2) that the hairiness after the first and the second winding process was higher than the third and fourth rewinding runs.

The changes in the yarn coefficient of variation and tenacity shows the same trends as for hairiness. See tables (1 and 2). From the results it can be concluded that the winding process has also an effect on the yarn coefficient of variation and tenacity and furthermore, the effect is more significant in the case of the ring-spun yarn. This can be explained as follows; the removal of any fibres from the yarn body or the shifting of any fibres from their original position on the yarn surface will directly affect its regularity and strength.

Because of the high speeds involved in winding and the effect of the movement of the twisted yarn over the surface of the winding machine elements (such as tension devices, pigtail, traverse guides), where its path is diverted from a straight line, it will be compressed and flattened under the applied force. In the case of this distortion, the yarn tends to inhibit a rotation about its axis because of the internal friction which will be generated over the contact surface. For the yarn to move or slip over the contact region, work of deformation would need to take place. Under these conditions, twist blockage may occur, either at a random or at the frequency of traverse, and may result in changes in the yarn structure [(3)].

CONCLUSION

Close observation of the operation of the winding machine will clearly disclose that yarns are subjected to large stresses during winding that may result in a significant changes in the yarn structure. The high speed of modern winding machines increases these stresses and consequently produces greater changes in the yarn surface structure.

During the winding process of staple yarns, the withdrawn yarn from the supply package rubs on the outer surface of the supply package and on machine elements, its path is diverted from a straight line as it bends around the different winding machine elements. These include guides, stop-motion and tensioning devices. For the yarn to move over these machine elements, it has to overcome the frictional forces of the contact regions. The stresses resulting from these forces may alter the yarn surface structure, increases yarn hairiness, loosening surface fibres and increasing the tendency of the yarn to shed fly.

Furthermore, during the winding process the yarn traverses across the supply package surface. He combined effects of rolling and traversing may increase the entanglement and the interlocking of the protruding fibres. The traverse motion also results in tension variation. Under these complex conditions the separation of the yarn from the package surface can only be achieved by the breaking of this entanglement and interlocking. Therefore, some fibres will be removed from the yarn body. The removed fibres may be a whole fibre or a broken fibre. This will depend on the length of the protruding fibre and the amount of twist in the yarn.

In over-end unwinding, a small amount of twist is added to the yarn length between the unwinding point on the supply package surface and the first guide at the top of the package. Owing to twist contraction, the added twist will decrease the yarn length which in turn increases the tension on the yarn. The increase in the yarn tension results in greater drag force between the withdrawn yarn and the supply package surface. This increases the rolling of the moving yarn on the package surface which in turn results in a high abrasion between the yarns, and consequently more entanglement and interlocking of the protruding fibres. The separation of the yarn from the package would then involve the breaking of the interlocking fibres and thus result in changes in the yarn structure.

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الخلاصة

هنالك اعتقاد سائد بان عملية التدوير تحسن جودة الخيوط وذلك ارتكازا على أنه خلال عملية التدوير تتم إزالة بعض العيوب من الخيوط (الأماكن السميكة، الرفيعة، و الأماكن ذات المتانة المتدنية) باستعمال أجهزة إزالة العيوب، صياد الأماكن السميكة و أجهزة الشد. هذه الأجهزة تعيق حركة الخيط نتيجة لاحتكاك الخيط مع هذه الأجهزة مما يؤدى إلى حدوث بعض التغيرات في الخواص السطحية للخيط.

في هذه الدراسة تم استعمال خيوط قطنية منتجة من الغزل الحلقي و أخرى من غزل الطرف المفتوح. بإعادة تدوير عينة من كل نوع من أنواع الخيوط المستعملة عدة مرات ثم قياس التشعر ، الانتظامية والمتانة للخيط بعد كل عملية إعادة تدوير، وجد أن هنالك اختلافات كبيرة في الخواص المذكورة و خاصة بالنسبة لخيط الغزل الحلقي مقارنة بخيوط غزل الطرف المفتوح. أثبتت الدراسة بان اتجاه إعادة التدوير له اثر كبير في إحداث تلك الاختلافات و كان الأثر أيضا واضحا في خيط الغزل الحلقي.

النتائج أوضحت بأنه خلال عملية التدوير و نتيجة للتغيرات التي تطرأ علي البنية الخارجية لسطح الخيط يحدث تشابك ميكانيكي بين الشعيرات البارزة من سطح الخيط. هذا التشابك ناتج من الحركة الدحروجية (دوران الخيط حول محورة) التي يتعرض لها الخيط عند سحبة خلال الاسطوانة الأخدودية (المحززه) بالإضافة إلى تدحرج جزء الخيط المسحوب من البكرة علي السطح الخارجي للبكرة نتيجة للاحتكاك. عند إعادة التدوير ، فأنة لا يمكن سحب الخيط من البكره إلا بفك ذلك التشابك و الذي ربما يؤدي إلي تمزيق الشعيرات البارزة أو إزالة كاملة للشعيرات من داخل بنية الخيط. تمزيق الشعيرات أو إزالتها من سطح الخيط ينتج عنة تغيير في عدد الشعيرات البارزة من سطح الخيط (التشعر)، الانتظامية و متانة الخيط.