Comparative study of ring, semi-compact, and compact spun yarns

Magdy ElMessiry
Textile Eng Dept., Faculty of Eng., Alexandria University, Alexandria, Egypt

In the last decade, the introduction of compact spinning is considered as a breakthrough in the spinning technology due to the improvement of the yarn quality. All the systems for the production of compact spun yarns consist of a modification of the drafting system on the ring spinning machine, so that the spinning triangle dimension decreases. In this work the reduction of the spinning triangle is obtained by suggesting changing the path of the yarn, so that the angle between the front roller nip line and the yarn becomes smaller. This method was called "semi-compact" spinning. The properties of the yarns processed on the different systems (ring spinning, compact spinning, and semi-compact spinning) are investigated. It was found that semi-compact spun yarns had superior properties than the conventional ring spun yarns, specially the yarn tenacity, 10% higher, as well as the increase in the elongation by 5%. The semi-compact spinning method requires no additional attachments, thus no additional cost.

يعتبر من المنجزات العلمية فى مجال صناعة الغزل ادخال نظام انتاج الغزل المدمج على ماكينات الغزل الحلقى. و لقد تحسنت خواص الخيوط المدمجة بصورة كبيرة. و فى نفس الوقت مازالت نظريات تكوين الخيط على هذا النوع من الماكينات تحتاج الى دراسات مستفيضة. و فى هذا البحث تم تقديم طريقة بسيطة لانتاج الخيوط أطلق عليها الشبه مدمجة و التى أدت الى تحسين فى خواص خيوط الغزل الحلقى بصورة كبيرة و خاصة متانة الخيط التى زادت بنسبة ١٠% و كذلك نسبة الاستطالة بنسبة ٥% عن الخيوط التقليدية نتيجة صغر زاوية ميل الخيط على نقطة أو الخط السطحى لاسطوانة السحب الأمامية و فى نفس الوقت لم تكن هناك حاجة لاستخدام جزء اضافى فى مثل هذه الطريقة المستخدمة و بالتالى هناك خفض فى تكلفة الانتاج النهائى.

Keywords: Yarn, Compact spinning, Spinning triangle, Migration

1. Introduction

In conventional spinning a spinning triangle is formed immediately after the drafting mechanism in the ring spinning machine. While in compact spinning, the spinning triangle associated with conventional ring spinning is eliminated by pneumatic compaction. This happens by suction and compaction on a perforated revolving apron or drum in front zone of the drafting system [1-2]. The introduction of a fourth nip point downstream of the exit drafting system and the use of the aerodynamic condensing of the fibers through suction results in narrower spinning zone with the individual fibers more effectively bound into the yarn assembly. That changes the properties of compact yarn compared with that of conventional yarn. The properties of compact spinning were thoroughly investigated by several researchers [3-16]. The results of their studies indicated that compact spun yarn strength is higher by about 15% and elongation at break by about 20%. Furthermore, the yarn hairiness becomes 70% less, and the coefficient of variation of the yarn lowered by 15% than that for the equivalent ring spun yarn. Compact spun yarns had better abrasion resistance. These advantages can be reflected on down-stream processing. Fabric properties in terms of breaking strength, breaking elongation and tear strength are also better with compact spun yarn. Clinging tendency of compact yarn shows considerably fewer and less pronounced clinging phenomena. Lower clinging tendency of the yarn results in the improvement of the warp yarn separation. This reduces the cost of sizing and subsequent desizing, and at the same time, resulting in less environmental pollution. Despite the lower degree of sizing, thread break rates are lower, which significantly improves loom efficiency, and fabric appearance.

In compact yarn less twist is possible without any loss of the strength. This results in lower manufacturing cost and softer twisted yarns.

The improvement in the strength of compact yarns is claimed to be due to the increase of the rate of fiber migration as well as the amplitude of migration [6].

The recovery parameters of compact yarn are superior to the corresponding ring yarns. The immediate elastic recovery is increased, whereas delayed recovery and permanent set are decreased for compact yarns [13].

In spite of the superior properties of compact spinning systems, the cost of the yarns production is still higher than in ring spinning. Further trials are needed to get the advantage of the compact yarns at less cost through new inventions to reduce the spinning triangle.

This work suggests the reduction of the spinning triangle by the inclining of the yarn path to nip line of the front roller. That will reduce the size of the spinning triangle, but partially compact the produced yarn because the point of the twist insertion will be moved further towards the nip line. This method was called “semi-compact” spinning.

2. Theoretical considerations

On the conventional ring spinning machine, the fibers coming from the front roller of the drafting system will be forced to pass through the spinning triangle to the point of the twist insertion. The spinning tension acting on the yarn will cause an unequal loading on the fibers in the spinning triangle which in its turn will cause the fiber migration [9].

In the case of compact spinning, special attachment is provided to reduce the spinning triangle which leads to the reduction of the yarn hairiness and produces highly compacted yarn structure. Oxenham [6] shows that in the ring spinning the thin ribbon–like fiber bundle is transformed into a roughly circular shape by twist insertion, fibers at the edges of the bundle are forced with the tension, whereas fibers in the middle are subjected to compression. To release the stress, the edge fibers try to shorten their path and migrate between yarn layers leaving their perfect helical path. In the case of compact spinning the same mechanism is presented in compact yarns, but a major difference is that everything is happening in a very short length. However, the rate of change of fiber radial position is higher in compact spinning [6].

Moreover, the value of the strain of the fibers in spinning triangle will depend on their position at the base of the triangle [9] so that the minimum strain will be for the fibers at the middle of triangle base, which is the core fiber, and maximum will be for the edge fibers. The value of the strain of the fibers will be distributed according to the following equation, fig. 1.

$$Ei = Ec/ \cos \theta i$$

Where:

Ei is the strain of the fiber at the angle θi

Ec is the strain of the fiber at the center of the yarn, and

θi is the angle of inclination of the fibre to the yarn axis.

From this equation, it is clear that the fibers located at higher value of θi will have a higher tension which will accelerate fiber migration. In compact spinning the strain of the edge fibers is increased due to the change of the spinning triangle size which leads to the increase of the maximum angle of the inclination. That increases the migration rate and causes the increase of compact yarn tenacity.

In the suggested method (semi-compact spinning), the reduction of the spinning triangle dimensions is reached by inclining the yarn path towards the nip line of the front roller which allows the twist to move upward towards the nip line reducing the size of the spinning triangle, thus the fiber strain distribution in the spinning triangle will be completely different than that in compact spinning. Fig. 1 shows the shape of the expected spinning triangle for three spinning systems, which indicates that in the semi-compact spinning the minimum strain will be for the fibers at the left edge of the spinning triangle, while the fibers at the core of the yarn are subjected to the higher strain.

The strain of the fibers in the case of the semi-compact spinning can be increased

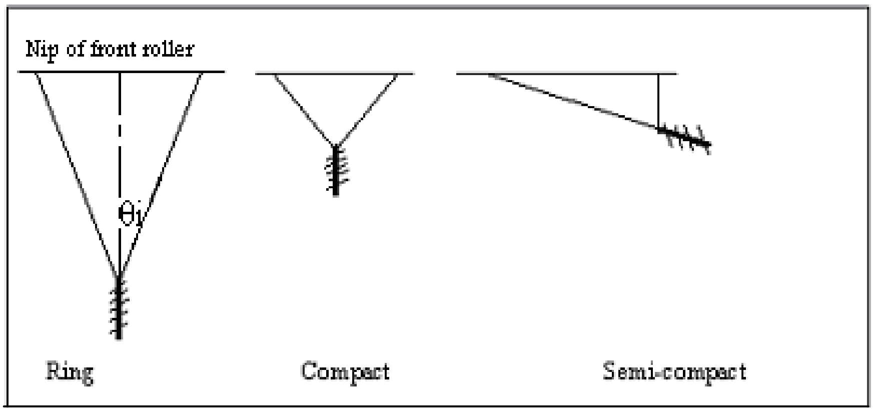

Fig. 1. Spinning triangle for ring spinning and semi-compact spinning.

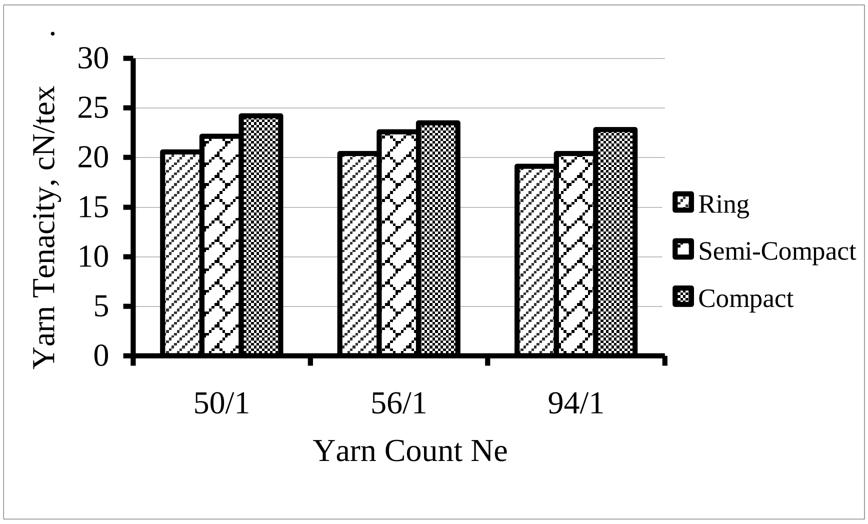

Fig. 2. The effect of yarn count on the yarn tenacity.

through the increase in the angle of inclination of the yarn path. Migration pattern of the fibers is expected to be different from that of the ring and compact spun yarns.

3. Experimental work

3.1. Yarn samples production

The first objective of the experimental work is to prove the possibility for the production of semi-compact spun yarns directly on the conventional spinning machine. In order to process semi-compact yarn, the yarns at any position on the conventional ring spinning machine are threaded through a guide, so that their paths are inclined to the nip line of the front roller. This gives the yarn angle of inclination to the original path by 30 degrees. Several yarns were produced on ring, compact, and semi-compact spinning machines. The raw material used in this study was G70 (2.5% span length, 35.1 mm, fiber micronair, 4.22, tenacity, 35 cN/tex), and G86 (2.5% span length, 32.4 mm, fiber micronair, 4.44, tenacity, 30 cN/tex).

In order to compare the yarn properties, three yarns are spun on three spinning systems into counts of Ne 50/1, 56/1, 94/1.The results of the testing of the yarns produced on the three spinning systems are analyzed. Figs. 2-8, show the comparison between the properties of the yarns spun by the different spinning principles.

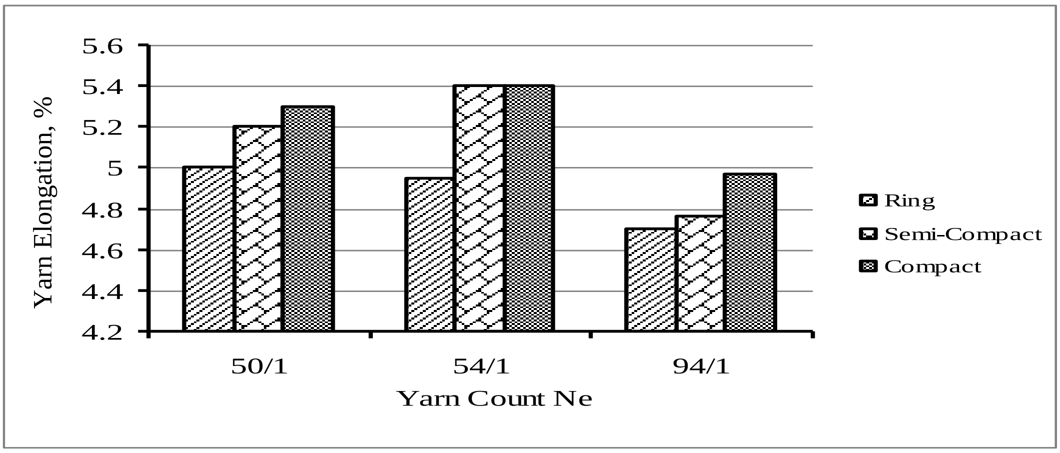

Fig. 3. The effect of yarn count on the yarn elongation.

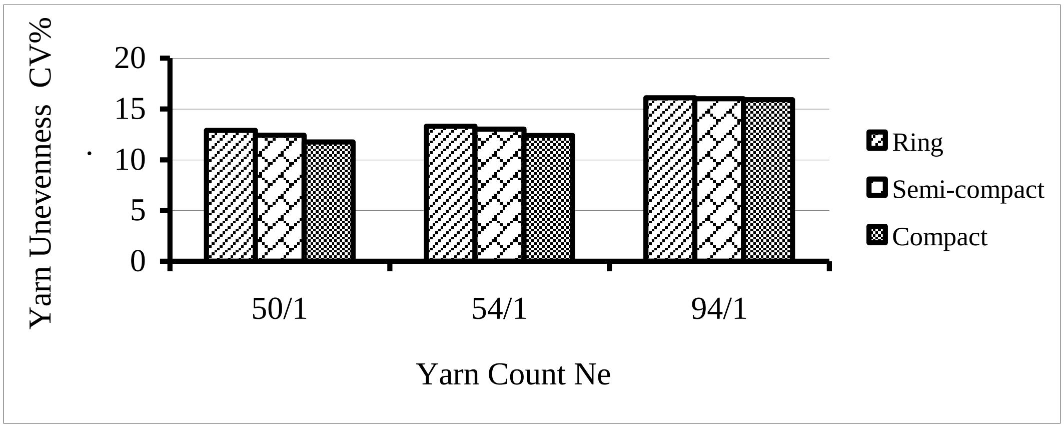

Fig. 4. The effect of yarn count on the yarn unevenness.

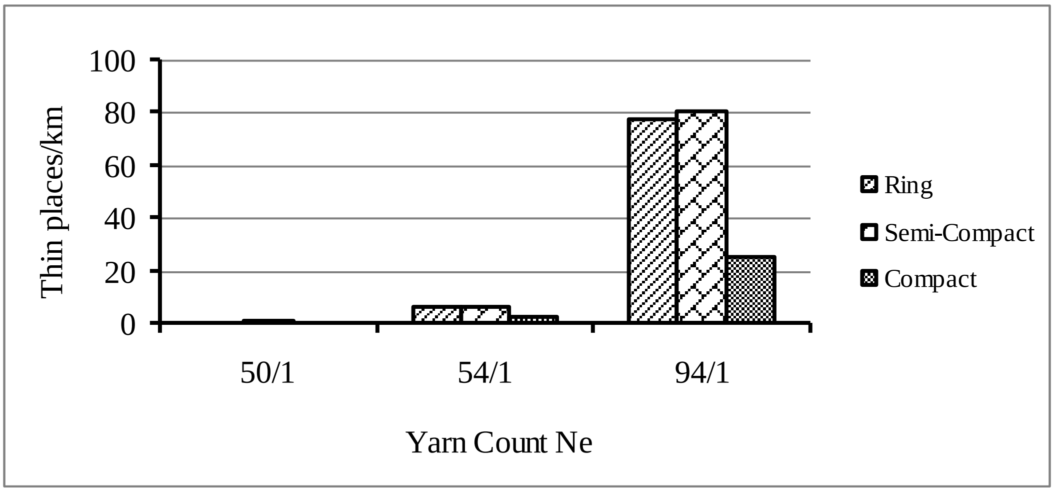

Fig. 5. The effect of yarn count on the number of thin places.

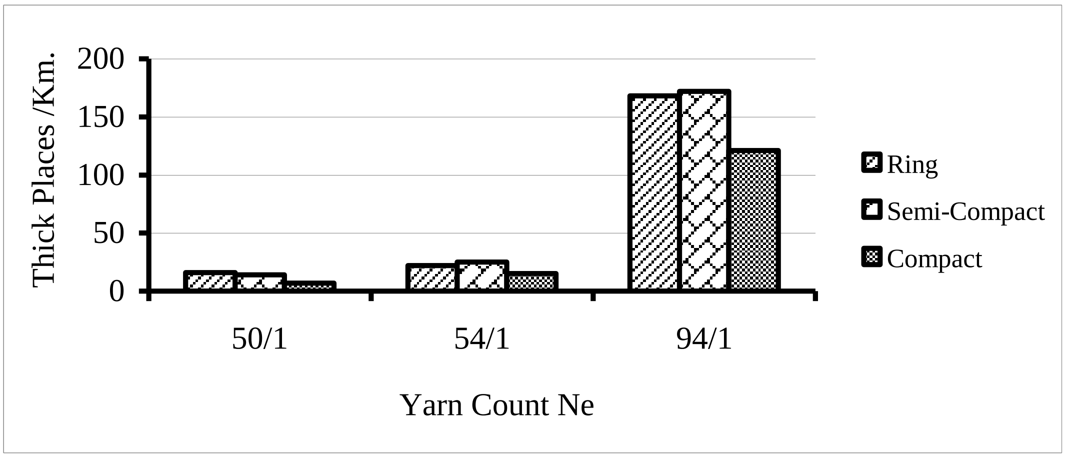

Fig. 6. The effect of yarn count on the number of thick places.

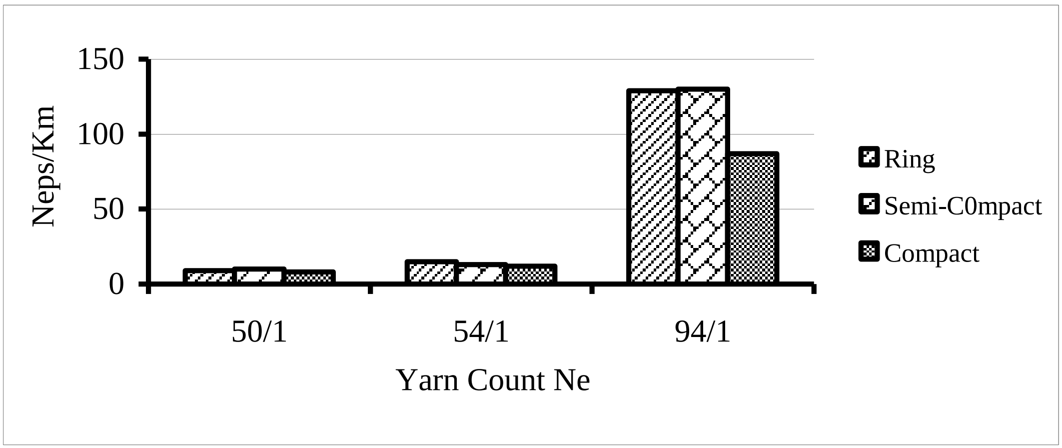

Fig. 7. The effect of yarn count on the number of neps.

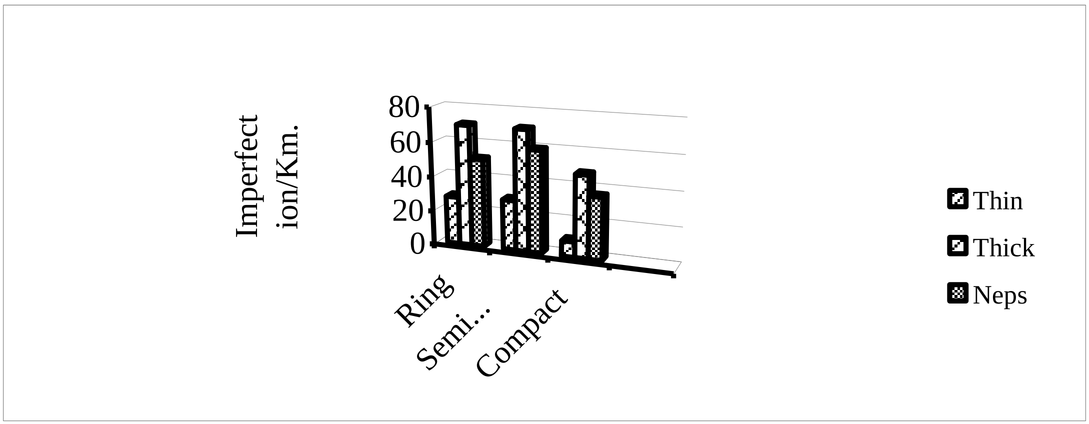

Fig. 8. The effect of yarn technology on the number of imperfections.

Fig. 8 shows a comparison between the yarn imperfections for the three spinning systems, which indicates that the both ring and semi-compact yarns have the same yarn imperfections while compact yarns have less.

Fig. 9 shows a comparison between the average values of the different properties of the yarns spun on the three spinning systems. The comparison between the average results of the three systems indicates that:

- The yarn unevenness CVm% is the same for ring and the equivalent semi-compact yarn.
- The tenacity of the semi-compact spun yarns is higher by 10% than that of the equivalent ring spun yarns. While the tenacity of the compact spun yarns is superior to the semi-compact spun yarns only by 4.3%.
- The yarn hairiness of the ring and semi-compact spun yarns is the same, but the compact spun yarns have less hairiness by 50%.
- The elongation of the semi-compact spun yarns is higher by 5% compared to the ring spun yarns.

From the above results it is clear that the properties of the semi-compact yarns are better than that of the ring spinning yarns, especially in the yarn tenacity and elongation.

The increase of the semi-compact yarn tenacity indicates that there is a change of the migration behavior of the fibers due to the change of the strain distribution of the fibers at the spinning triangle as it was explained above. The hairiness was not reduced due to the increase of the rubbing angle on the yarn surface at the yarn guide. Further investigation is needed to study this effect in order to improve the yarn hairiness of the semi-compact yarns.

This indicates that the quality of the yarns spun on the three different systems can be graded as Compact spun yarns, Semi-Compact, and then Ring spun yarns

The second part of this study is to confirm the above results which indicate that the semi-compact yarns possessed improved yarn tenacity than that of the conventional ring spun yarns. Different yarns of counts ranged between Ne 30/1 and Ne 94/1 are spun on the ring and semi-compact spinning systems.

Figs. 10-14 give the comparison of the different yarn properties.

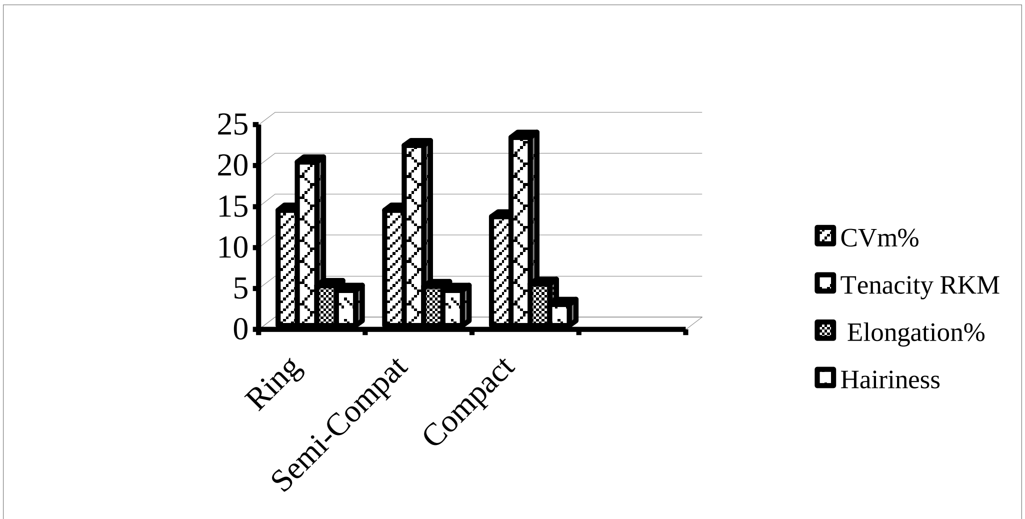

Fig. 9. The effect of yarn technology on the yarn unevenness, tenacity, elongation, and hairiness.

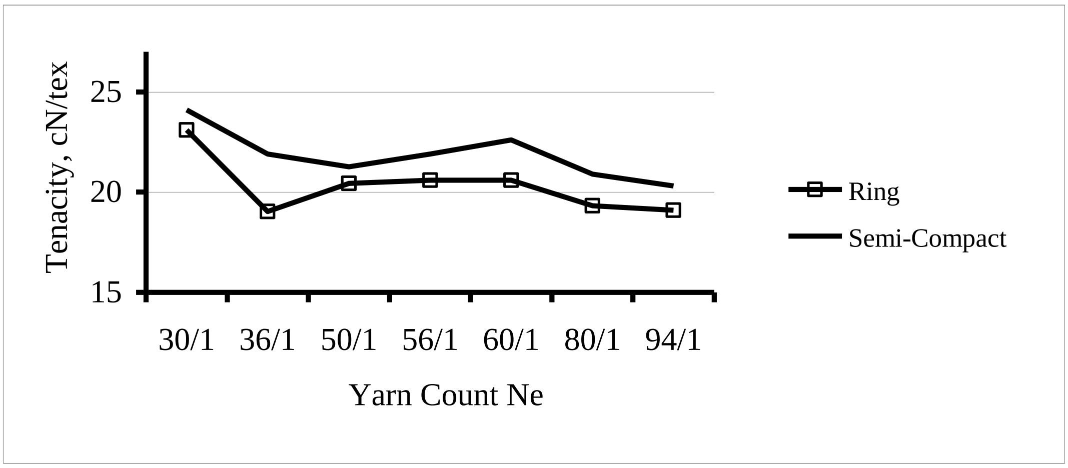

Fig. 10. The effect of yarn count on the yarn tenacity of ring and semi compact spinning technology.

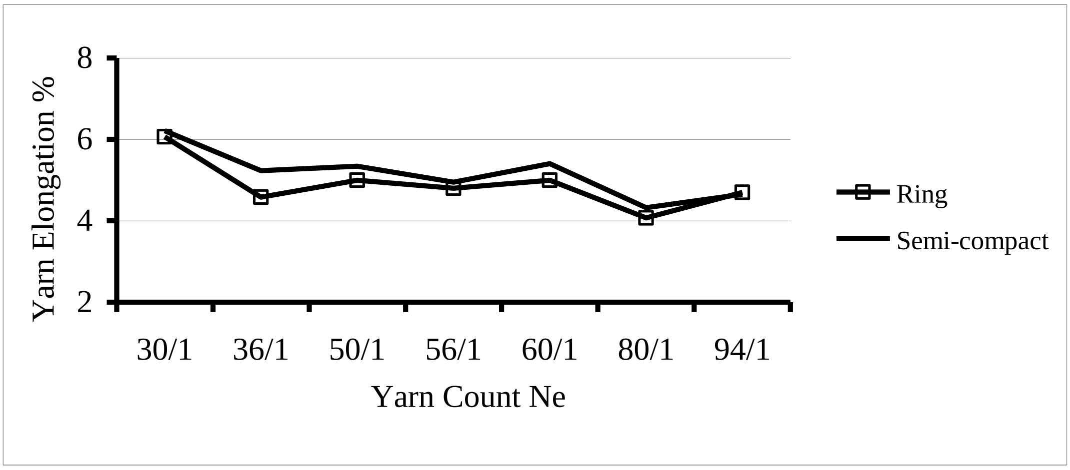

Fig. 11. The effect of yarn count on the yarn elongation of ring and semi compact spinning technology.

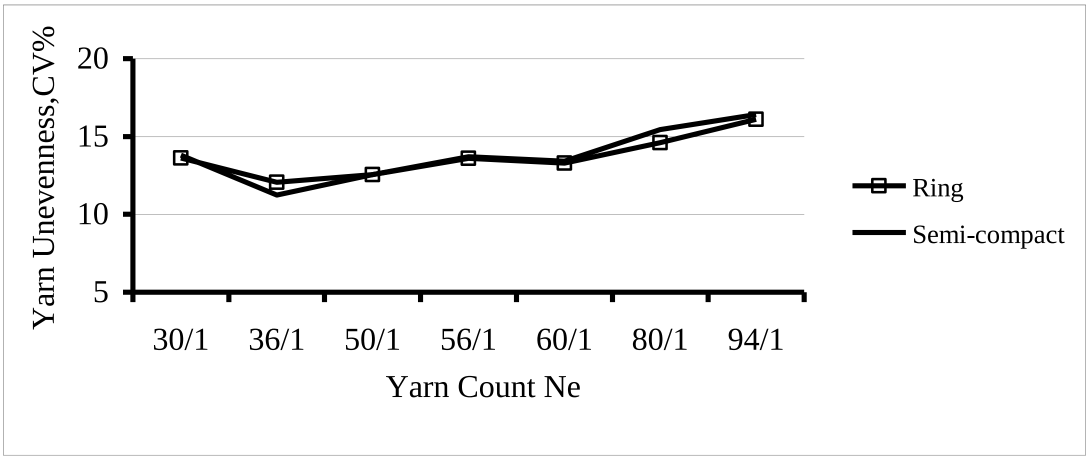

Fig. 12. The effect of yarn count on the yarn unevenness of ring and semi compact spinning technology.

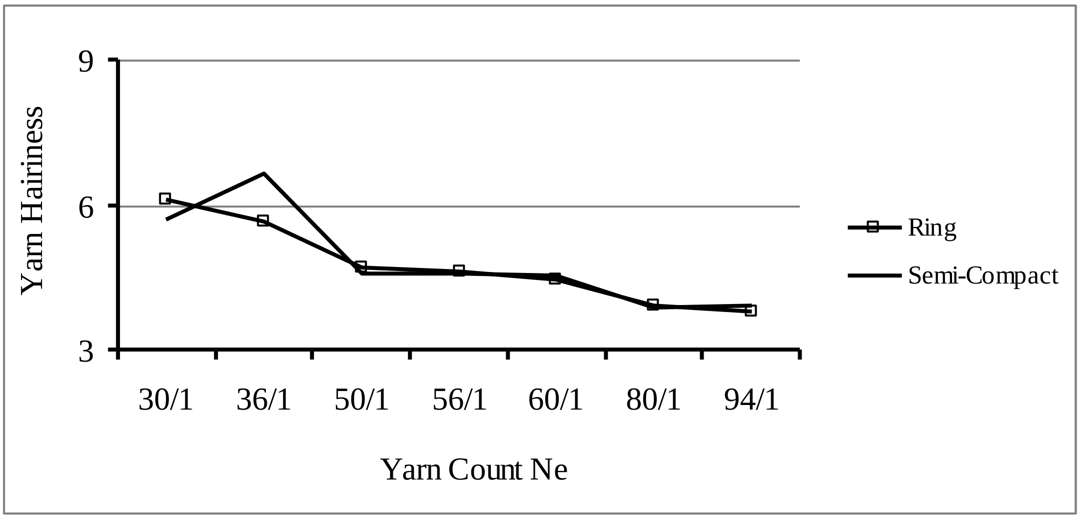

Fig. 13. The effect of yarn count on the yarn hairiness of ring and semi compact spinning technology.

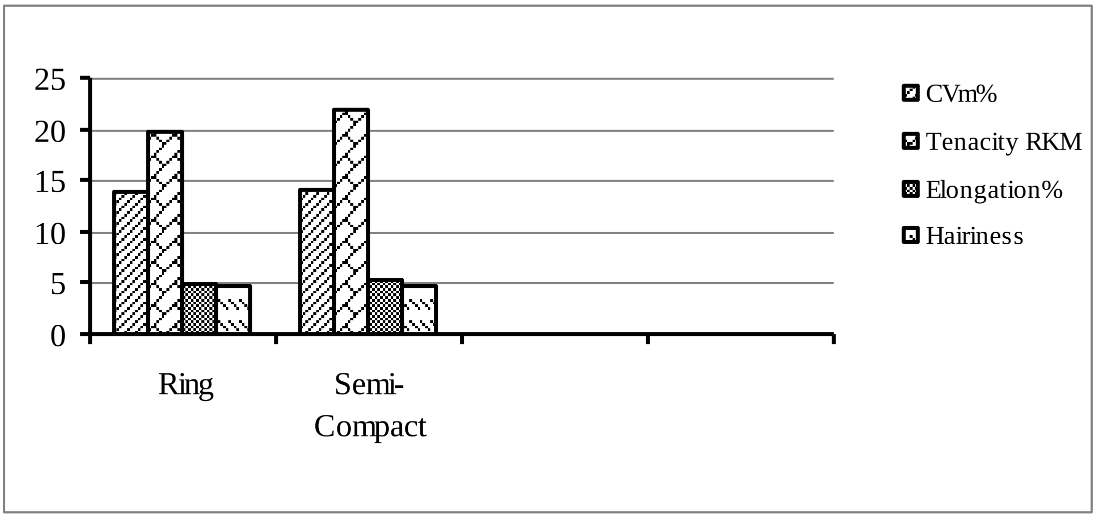

Fig. 14. The effect of yarn technology on the yarn unevenness, tenacity, elongation, and hairiness.

References

[1] H. Stadler, "New Spinning Process Comfor Spin", Melliand International, Vol. 6 pp. 1-22 (2000).

[2] R. Thum, Suessen, "Elite Spinning System for Long and Short Staple Fibre", Textile World, Vol. 150 (4), p. 38 (2000).

[3] W. Kampen, "Advantages of Condensed Spinning", Milliand International, Vol. 6, pp. 98-100 (2000).

[4] U. Meyer, "Compact Yarns: Innovation as a Sector Driving Force", Milliard International, Vol. 6 (2) (2000).

[5] H. Stadler, "Compact Spinning – A new Generation of Ring Spun Yarns", Melliand Textilberichtee, Vol. 76 (3), E29-E31 (1995).

[6] G. Basal and W. Oxenham, "Comparison of Properties and Structure of Compact and Conventional Spun Yarns", Textile Res. J. Vol. 76 (7), pp. 567-575.

[7] W. Klein, "A Practical Guide to Ring Spinning", The Textile Institute Manual of Textile Technology, MFP Design and Print, Manchester, UK (1987).
[8] M. El Messiry, "New Attachment for Compact Spinning", 1st International Textile Conference NRC (2004).
[9] H. Krause and H. Soliman, "Investigation of the Strength of the Spinning Triangle in Ring Spinning", Melliand Textilberichte, Vol. 72, p. 499 (1991).
[10] K. Cheng and C. Yu, "A Study of Compact Spun Yarns", Textile Res. J. Vol. 73 (2003).
[11] P. Artz, "The Special Structure of Compact Yarns-Advantages in Downstream Processing", ITB Yarn and Fabric Forming, Vol. 2, pp. 41-48 (1997).
[12] B. Behera, P. Hari and S. Ghosh, "Weavability of Compact Yarn", Melliand International, Vol. 9, pp. 311-314 (2003).
[13] A. Goyal, et al., "Comparative Study of Ring and Compact Spun Yarns", Melliand International, Vol. 2 (2007).
[14] Goktepa, et al., "A Comparison of Compact Yarn Properties Produced on Different systems", Textile Res. J. 76 (3), p. 226.
[15] Krifa, Ethridge, "Compact Spinning Effect of Cotton Quality Interaction with Fiber Characteristics", Textile Res. J., 76 (5), p. 388.
[16] M. Krifa and D. Ethridge, "Compact Ring Yarn: An Examination of Some Production Issues", Textile Topics Vol. 2 (2003).

Received October 18, 2007
Accepted November 12, 2007