# Effect of strain rate on mechanical properties of both cotton and cotton/Lycra yarns

Naglaa Mohamed and Rania El Deeb
*Textile Eng. Dept., Faculty of Eng., Alexandria University, Alexandria, Egypt*

Recently, there has been a growing demand for stretchable fabric of varying styles and functions made with Lycra filament. There has also been a marked increase of production speed of weaving and knitting machines. Considering those two facts, this work aims to study the mechanical properties of core spun yarn containing Lycra filament at high strain rates to determine the response of these yarns to dynamic loads during processing at high production speed. Cotton core spun yarns containing Lycra filament were tested under a range of strain rates ranging from 10000 to 80000 % per min. Cotton yarns were also tested at the same strain rates to compare the tensile behavior of both yarns. Results showed that the measured tenacity has a strong association with the strain rate; the increase of the rate of strain results in an increase of the measured tenacity of cotton/Lycra yarn. The tensile behavior of cotton/Lycra yarn mimics that of cotton yarn. On the other hand cotton/Lycra yarn shows lower tenacity and higher breaking extension as compared to cotton yarn.

فى السنوات الأخيرة ، زاد استهلاك الأقمشة المطاطية التى تحتوى على الياف الليكرا المستمرة حيث تستخدم في مجالات متعددة ، وزادت ايضاً سرعة ماكينات النسيج والتريكو بشكل ملحوظ . بوضع فى الأعتبار هاتين الحقيقتين فإن هذا العمل بهدف إلى دراسة الخواص الميكانيكية للخيوط المحورية التى تحتوى على الياف الليكرا وذلك عند معدلات استطالة عالية حتى نتمكن من معرفة سلوك هذه الخيوط عند تشغيلها عند سرعات الانتاج العالية. خيوط محورية مصنوعة من القطن والليكرا تم اختبارها عند معدلات استطالة تتراوح من 10000% لكل دقيقة إلى 80000 % لكل دقيقة و تم ايضاً اختبار خيوط قطنيةعند نفس معدلات الاستطالة حتى نستطيع المقارنة بين تأثير الشد على الخواص الميكانيكية للخيطين. النتائج أظهرت أن متانة الخيوط للخيوط القطنية المحتوية على الليكرا تتأثر بمعدلات الاستطالة. حيث تزيد قيمة المتانة المقاسة بزيادة معدلات الاستطالة بمعدل متناقص. وأن تأثير معدلات الاستطالة المختلفة علي الخواص الميكانيكية للخيوط القطنية التى تحتوى على الليكرا يشابه تأثيرها على تلك للخيوط القطنية وأظهرت النتائج ايضاً أن الخيوط القطنية التى تحتوى على الليكرا أقل متانه من الخيوط القطنية بنسبة تتراوح ما بين 5% و12% وأكثر أستطالة من الخيوط القطنية بنسبة تتراوح ما بين 15 % الى 37%.

**Keywords:** Core spun yarn, Cotton yarn, Lycra, High production speed, Strain rate, Tenacity, Breaking extension

## 1. Introduction

Lycra (Spandex) filament is a long chain synthetic polymeric fiber and is characterized by a high breaking extension (exceeding 100%; generally 500 to 800%) and a superior elastic recovery. Moreover, it is resistant to hydrolysis, ultraviolet radiation, oxygen and heat. Lycra filament is always used in combination with other natural or synthetic fibers to produce elastic yarns which can be used to produce woven or knitted fabrics. Elastic fabrics play an important role in terms of wear properties, comfort and functionality; therefore they have a secure place in the world of textile industries [1-3].

The properties of elastic yarn and fabric have been investigated by several researchers [3-8]. However, despite the considerable increase of production speed of weaving and knitting machines that results in a higher load on the yarn being processed, the performance of cotton/Lycra yarn in high-speed processing has not been adequately studied.

In this present work, a study of the mechanical properties of the cotton/Lycra yarn was performed at different rates of strain to determine the response of these yarns to dynamic loads which affect yarn during processing at high production speeds.

## 2. Material and methods

In this study, four different core cotton spun yarns containing Lycra filament produced on modified ring spinning machine were used. Their specifications are seen in table 1.

Table 1
Specifications of cotton/Lycra yarns

| Sample code | Yarn count Ne | Twist factor | Material | |
|---|---|---|---|---|
| | | | Lycra | Cotton type |
| 1 | 30 | 3.8 | 78 dtex | Giza 80 |
| 2 | 32 | 3.8 | 78 dtex | Giza 80 |
| 3 | 36 | 4.2 | 78 dtex | Giza 86 |
| 4 | 54 | 4.9 | 78 dtex | Giza 86 |

Cotton/Lycra yarns were tested by using Uster tensojet which could produce up to 30,000 individual breaks per hour. Therefore, it provides more information on yarn behavior in processing than traditional yarn testing methods. The cotton/Lycra yarns were tested at different strain rates which are 10000, 20000, 40000 and 80000 % per min by utilizing testing speeds 50, 100, 200 and 400 m/min. In order to compare the tensile behavior of cotton/Lycra yarn with cotton spun yarn, cotton yarns having similar specifications to cotton/Lycra yarns were tested at the same strain rates.

## 3. Results and discussion

Figs. 1 to 4 show that strain rate influences cotton/Lycra yarn tenacity. The increase of the rate of strain results in an increase of the measured tenacity of cotton/Lycra yarn. This occurs till a certain point beyond which any further increase of the strain rate has no significant effect on the measured tenacity. The increase of yarn tenacity with increase of strain rate may be due to the increase of impact load on the fibers as the strain rate increases which leads to increasing the proportion of fiber breakage due to the increase of inter-fiber friction. In addition the creep effect on fiber rupture is minimized at high strain rate contributing to higher tenacity of fibers. On the other hand, under strain the yarn is compressed radialy leading to fiber realignment which increases the contribution of fibers to yarn tenacity. This fiber realignment is progressively reduced with the increase of strain rate. The increase of yarn tenacity due to the former two effects is dominant up to a certain point after which the influence of fiber realignment counteracts these effects resulting in no significant change of yarn tenacity from this point forward [9-10].

Despite the difference in yarn structure between cotton yarn and cotton/Lycra yarn, it was noticed that the strain rate has a similar effect on both types of yarns. This may be due to the low core/sheath ratio in cotton/Lycra yarn**.** It was also found that the tenacity of cotton/Lycra yarn was lower than that of cotton yarn by 5% to 12 %. This may be attributed to the fact that most of the stress applied to the core spun yarn is mainly taken up by the staple fibers. Since the presence of Lycra filament can disturb the fiber stream during spinning which in turns can reduce yarn tenacity. Moreover, cotton /Lycra yarn contains Lycra filament as core ranging from 3-6% which has a lower tenacity as compared to cotton fibers. Therefore the cotton/Lycra yarn will inevitably be of lower tenacity than cotton yarn.

Figs. 5 to 8 show that yarn breaking extension for both cotton yarn and cotton/Lycra yarn is not influenced by the strain rate. It was also noticed that the breaking extension of cotton/Lycra yarn is higher than that of cotton yarn by 15% to 37%. This is due to the presence of Lycra.

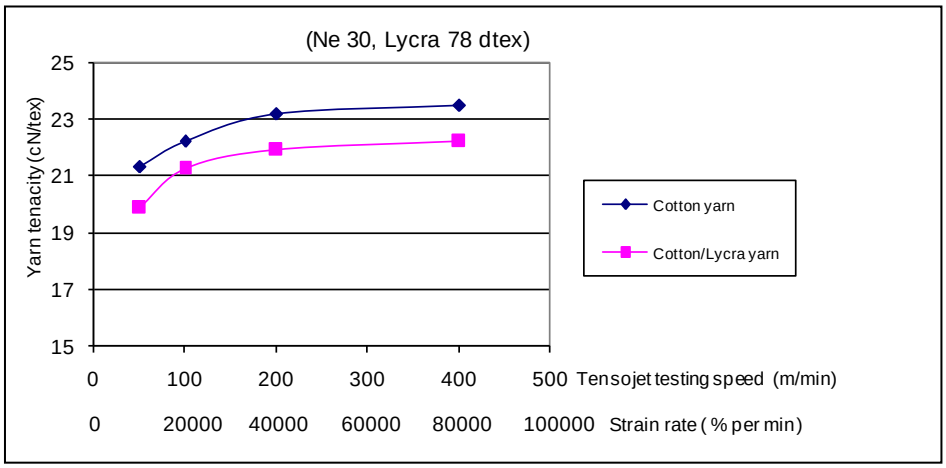


Fig. 1. Effect of strain rate on yarn tenacity (Ne 30, Lycra 78 dtex).

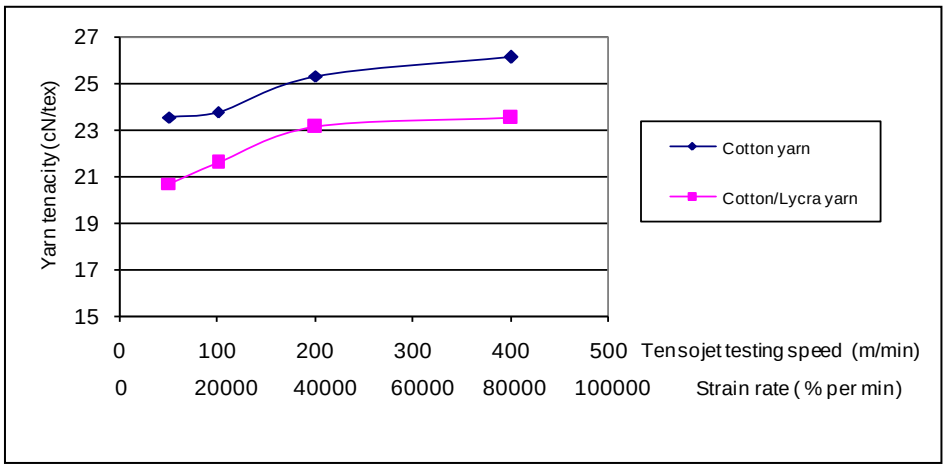


Fig. 2. Effect of strain rate on yarn tenacity (Ne 32, Lycra 78 dtex).

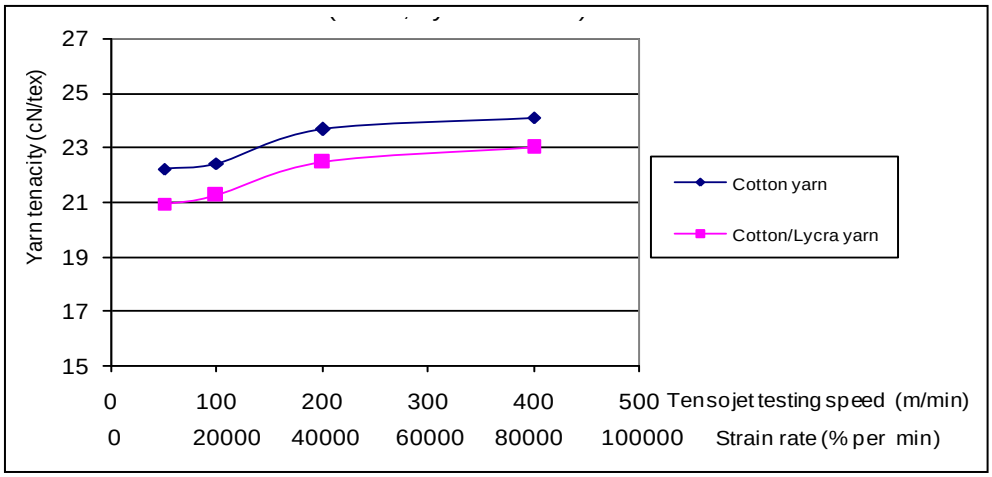


Fig. 3. Effect of strain rate on yarn tenacity (Ne 36, Lycra 78 dtex).

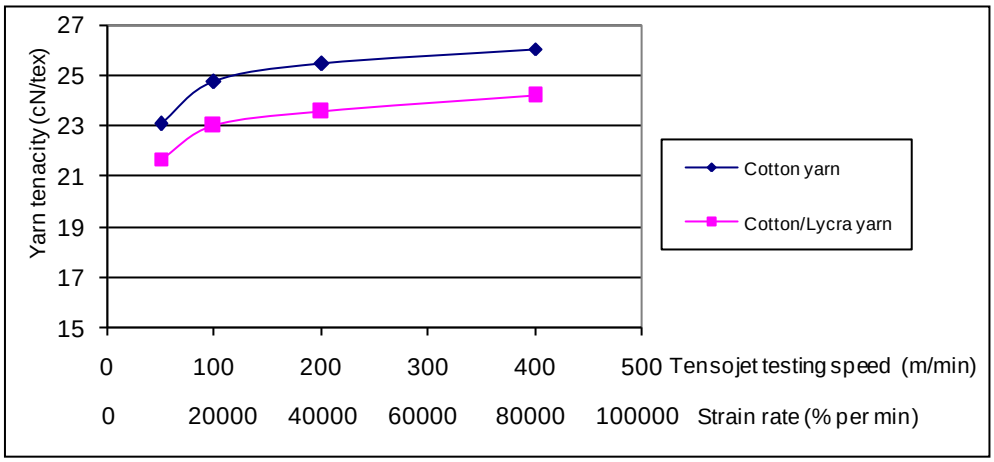


Fig. 4. Effect of strain rate on yarn tenacity (Ne 54, Lycra 78 dtex).

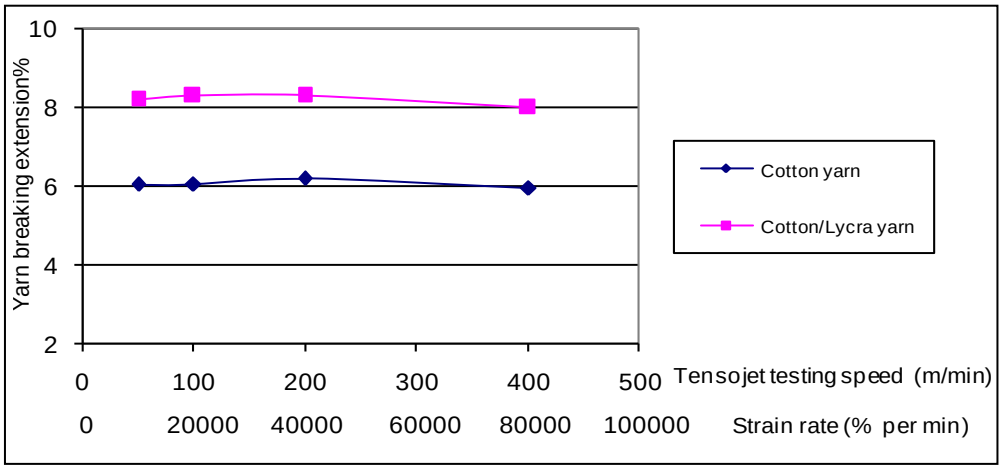


Fig. 5. Effect of strain rate on yarn breaking extension (Ne 30, Lycra 78 dtex).

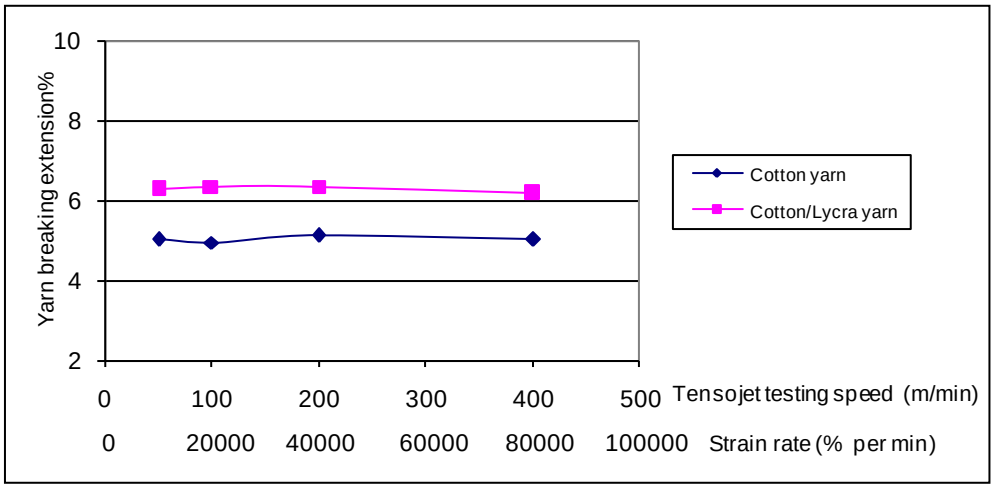


Fig. 6. Effect of strain rate on yarn breaking extension (Ne 30, Lycra 78 dtex).

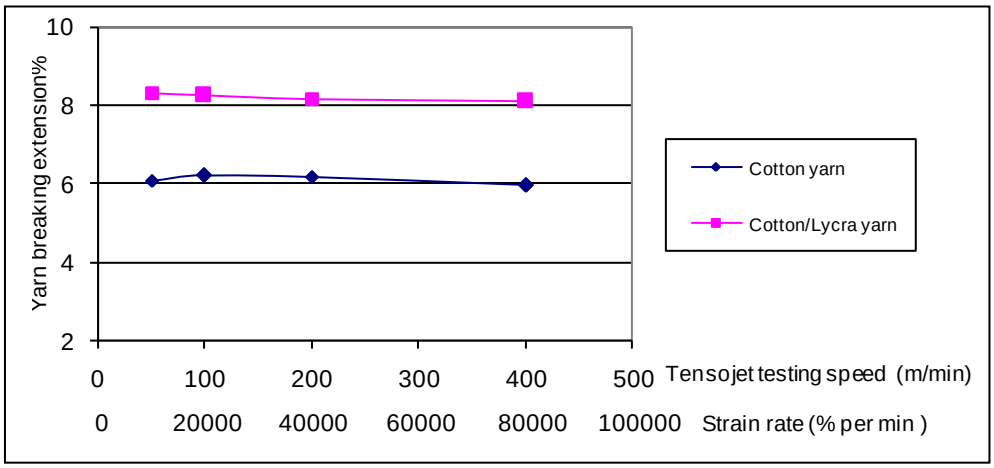


Fig. 7. Effect of strain rate on yarn breaking extension (Ne 36, Lycra 78 dtex).

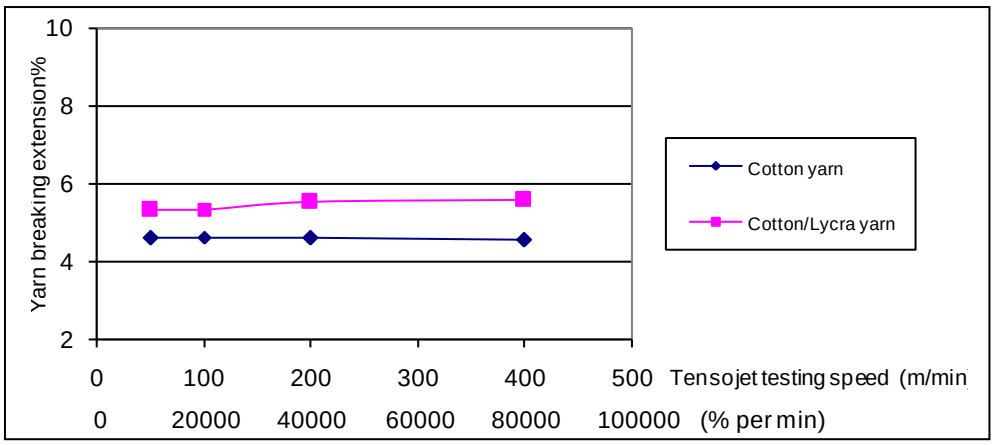


Fig. 8. Effect of strain rate on yarn breaking extension (Ne 54, Lycra 78 dtex).

## 4. Conclusions

From the results obtained, it was deduced that the tenacity of cotton/Lycra yarn is influenced by the strain rate; yarn tenacity is increased with increase of the strain rate. This occurs up to a certain limit beyond which any further increase of the strain rate has no significant effect on cotton/Lycra yarn tenacity. The tensile behavior of cotton/ Lycra yarn mimics that of cotton yarn. Tenacity of cotton/Lycra yarn is lower than that of cotton yarn by 5% to 12%. The breaking extension of cotton/Lycra yarn is higher than that of cotton yarn by 15% to 37%. The slight decrease in cotton/ Lycra yarn tenacity as compared to cotton yarn is largely overweighed by the advantages of stretch and elasticity of garments made of these yarns.

## References

[1] M. Reisch, "What's That Stuff" Chemical and Engineering News", Vol. 77 (7), p. 70
[2] http://www.fabrics.net/amyspandex.asp
[3] C. Lou, C. Chang and W. Hsing "Production of a Polyester Core- Spun Yarn with Spandex Using Multi-Section Drawing Frame and a Ring Spinning Frame", Textile Research Journal, Vol. 75 (5), pp. 395-401 (2005).
[4] J.H Lin, C.W. Chang C.W. Lou and W.H Hsing, "Mechanical Properties of Highly Elastic Complex Yarns with Spandex

Made by a Novel Rotor Twister", Textile Research Journal, Vol. 74 (6), pp. 480-484 (2004).

[5] C.I. Su, M.C. Maa and Y.Y. Hsiao, "Structure and Performance of Elastic Core-Spun Yarn", Textile Research Journal, Vol. 74 (7), pp. 607-610 (2004).

[6] H.G. Ortek, "Influences of Selected Process Variables on the Mechanical Properties of Core-Spun Vortex Yarns Containing Elastane", Fibers and Textiles in Eastern Europe, Vol. 14 (3), pp. 42-44 (2006).

[7] A.B. Marmarali, "Dimensional and Physical Properties of Cotton/Spandex Single Jersey Fabrics", Textile Research Journal, Vol. 73 (1), pp. 11-14 (2003).

[8] E.P. Easter, "Evaluation of Care and Performance of Comfort Stretch Knitted Fabrics", AATCC Review, Vol. 6 (11), pp. 1-6 (2006).

[9] A. Ghosh, S.M. Ishtiaque and R.S. Rengasamy, "Analysis of Spun Yarn Failure. Part I: Tensile Failure of Yarns as a Function of Structure and Testing Parameters", Textile Research Journal, Vol. 75 (10), pp. 11-14, (2005).

[10] P. Balasubramanian and K.R Salhotra, "Effect of Strain Rate on Yarn Tenacity", Textile Research Journal, Vol. 55 (1), pp. 74- 75. (1985).

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