DYNAMIC BEHAVIOR OF COTTON BLENDED ELASTOMERIC AND SLUB YARNS

Sayed Ibrahim
Jiri Militky
Dana Kremenakova
Rajesh Mishra
Faculty of Textile Engineering, Technical University of Liberec
Czech Republic

Abstract

The importance of dynamic mechanical behavior of yarns is emphasized in this paper. The study is focused on elastomeric yarns and slub yarns for special applications. The properties of cotton and blended yarns with elastomeric core are studied under cyclic loading conditions. The observations prove to be essential to analyze the behavior of these yarns in subsequent operations like weaving, knitting etc. Performance of these yarns changes substantially when slubs are present in regular intervals. The results for cotton and blended yarns for all these test methods have been analyzed and compared.

Introduction

Improvement of the consumer properties of textile materials is heightening the interest in elastomeric fibres. The elastomeric fibres with elongation at break of more than 100%, can be shrunk to a length close to the initial length, and the elasticity of the fibre is ensured by its chemical composition. Light industry has three kinds of elastomeric fibres: rubber (spun and cut) based on natural rubber; synthetic obtained from man-made rubber, and polyurethane. Polyurethane fibres have many important advantages over rubber fibres. They have higher strength (by 2-3 times), higher elasticity (by 2-3 times), higher abrasion resistance, much higher resistance to repeated deformations (by 10-20 times).

These elastomeric yarns are widely used for high stretch garments like ladies denim, sports wear, socks etc. With introduction of slubs into these kind of yarns, not only the fancy appearance is improved but the dynamic properties are substantially changed. The literature available on this topic is really rare and a need is felt to investigate the dynamic behavior of these unconventional type of yarns. The current research work fulfills this objective to understand the structure and dynamic properties of these yarns so that their suitability for weaving/knitting into a fabric and application can be predicted.

Materials

Three types of cotton based yarns are examined for their dynamic mechanical behaviour. They are 100% cotton, Cotton-Polyester and Cotton-Viscose blends of 25 Tex, with/without slubs and elastomeric core. Total 12 yarn samples are investigated for the dynamic behavior.

Methods

Dynamic Modulus Testing (Lawson & Hemphill)

The Dynamic Modulus Tester is a complete system that measures the velocity of the sonic pulses in materials such as fibers, yarns, films, tapes and papers. The test material is contacted by two transducers. The accurate measurement of the sound velocity between the transducers results in correct and repeatable dynamic modulus of elasticity. The instrument gives sonic velocity over a range of lengths of the sample. The effect of elastane component on sonic velocity through different cotton blended yarns is studied. Comparisons are made between normal yarns and elastomeric yarns of corresponding blends for 25 Tex.
The sonic modulus can be calculated using the formula:

$$E = c^2 \times d \qquad (1)$$

Where, E = Sonic modulus
c = Sonic velocity
d = Density of the material

Dynamic Mechanical Analysis (Labortech Tiratest)

The Labortech Tiratest instrument is used for measurement of dynamic modulus of the yarn samples. The instrument also is capable of testing the cyclic tensile behaviour of linear textile materials. 50 cycles of tensile elongation and relaxation were applied to all yarns at 1N load. It is a digital single column electromechanical testing machine with load cells ranging from 0 - 3 kN.

Results & Discussion

Sonic Modulus of Yarns

The sonic velocity was measured by the Lawson Hemphill instrument. The sonic modulus is directly proportional to square of the sonic velocity, so the trend is simillar.
The results are given in Table 1.

Table 1 Sonic velocity of yarn samples

Yarn types	Sonic velocity (m/sec)
cotton normal	2632
cotton slub	2455
cotton elastane normal	1707
cotton elastane slub	1288
cotton polyester normal	2110
cotton polyester slub	2120
cotton polyester elastane normal	1433
cotton polyester elastane slub	1503
cotton viscose normal	2515
cotton viscose slub	2294
cotton viscose elastane normal	1660
cotton viscose elastane slub	1634

A comparative diagram for all 100% cotton yarns is shown in fig. 1.

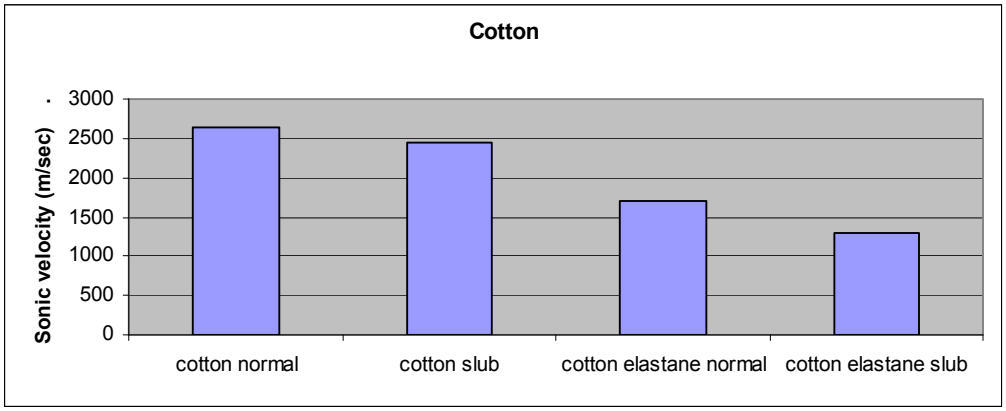

Fig. 1 Sonic velocity through 100% cotton yarns

The presence of slub in 100% cotton yarns reduces the sonic velocity due to transverse propagation of sound at the slub regions. Thus the sonic modulus also decreases.

It is also observed that, the sonic velocity through elastomeric yarns of same fineness value reduces as compared to normal yarns. This is because of the increase in bulk of elastomeric yarns and related transverse propagation of sound, which reduces the longitudinal velocity.

In order to study the effect of elastomer on the sonic propagation of slub yarns, a comparative study was carried out between normal slub yarns ans slub elastomeric yarns. Further presence of elastomers on a 100% cotton slub yarn increases the bulk of yarn and facilitates the transverse propagation, so that the sonic velocity reduces to almost 50%.

Fig. 2 shows a comparison between cotton polyester blended yarns.

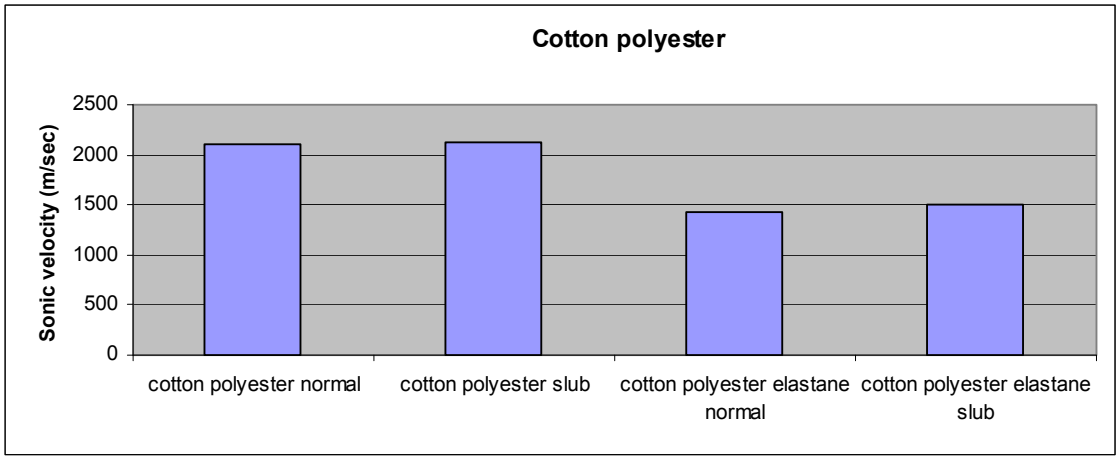

Fig. 2 Sonic velocity through cotton polyester yarns

In cotton-polyester blended yarns there is no significant difference in sonic velocity due to presence of slubs. This may be due to the compactness and higher level of uniformity in polyester blended yarns. Also in case of cotton-polyester blends the presence of elastane component decreases sonic velocity through the yarns. As is earlier observed, in case of normal and slub yarns with polyester blended elasomeric yarns, there is not much of variation with the presence of slub in these yarns. It is due to more compactness and relatively higher degree of uniformity.

Comparison for cotton viscose yarns is shown in Fig. 3.

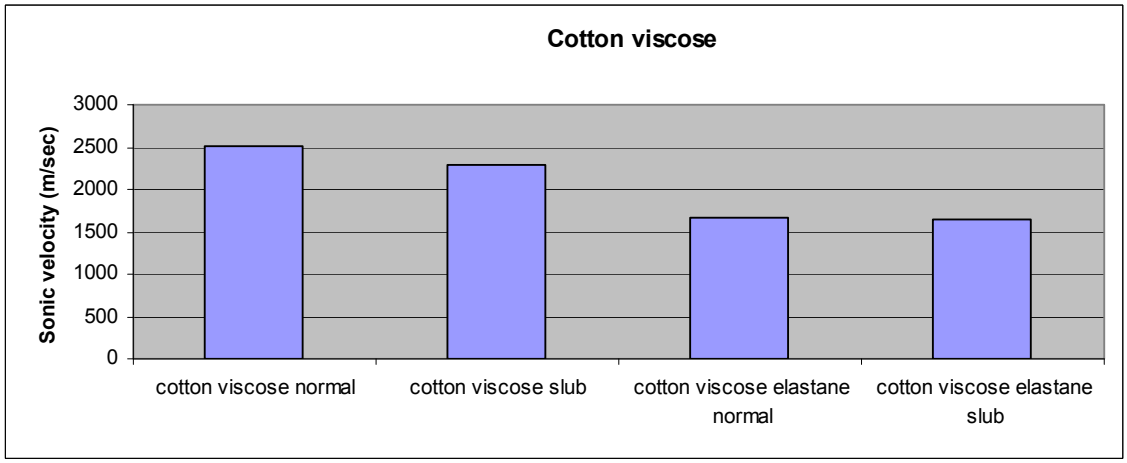

Fig. 3 Sonic velocity through cotton viscose yarns

The same trend as 100% cotton yarns, is observed for cotton-viscose blend and the sonic velocity reduces with presence of slubs. As in earlier cases, cotton-viscose blend also reduces sonic velocity with an elastomeric component in the yarn. Simillar to polyester blends, the viscose blends of cotton yarn also show no significant variation in sonic velocity between normal elastomeric and elastomeric slub yarns. This is attributed to the compactness and uniformity to some extent.

Table 2 shows the CV% for sonic velocity.

Table 2. Coefficient of Variation of Sonic velocity

Yarn types	CV%
cotton normal	3,23
cotton slub	4,82
cotton elastane normal	5,05
cotton elastane slub	10,4
cotton polyester normal	3,47
cotton polyester slub	3,61
cotton polyester elastane normal	4,25
cotton polyester elastane slub	6,6
cotton viscose normal	2,52
cotton viscose slub	4,44
cotton viscose elastane normal	9,71
cotton viscose elastane slub	9,92

A comparison of CV% for all yarns is shown in Fig. 4 to 6.

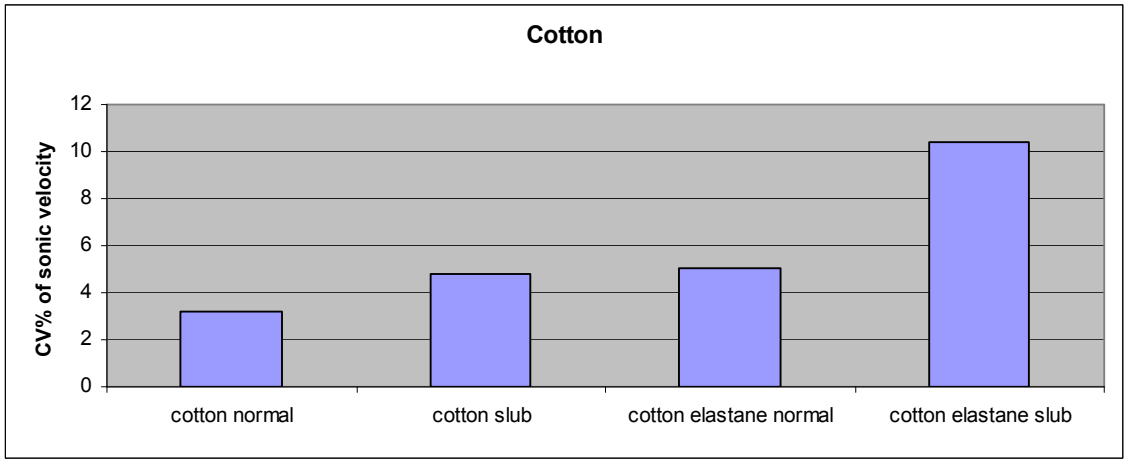

Fig. 4 Coefficient of Variation of Sonic velocity for 100% cotton yarns

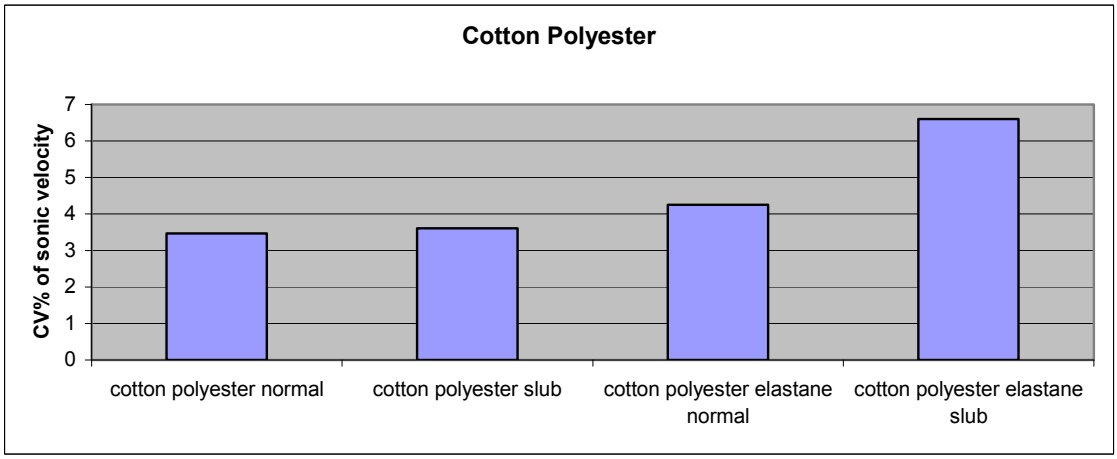

Fig. 5 Coefficient of Variation of Sonic velocity for cotton-polyester yarns

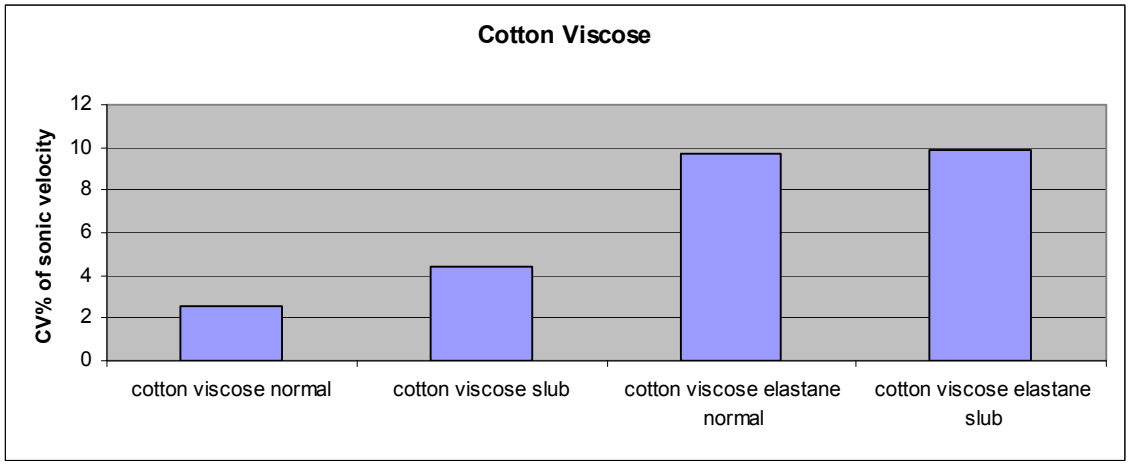

Fig. 6 Coefficient of Variation of Sonic velocity for cotton-viscose yarns

It is observed in all the yarns that, the CV of sonic velocity increases with introduction of slub and/or elastane in the core. This can be well attributed to the bulk of yarns with slub and elastomeric core which leads to higher CV in diameter and corresponding variation in sound propagation through the yarn.

Dynamic Mechanical Analysis

Fig. 7 to 9 show the stress strain behavior of 100% cotton, cotton polyester and cotton viscose yarns respectively. The notations are as follows:

1 – Normal yarn
2 – Slub yarn
3 – Normal elastane yarn
4 – Slub elastane yarn

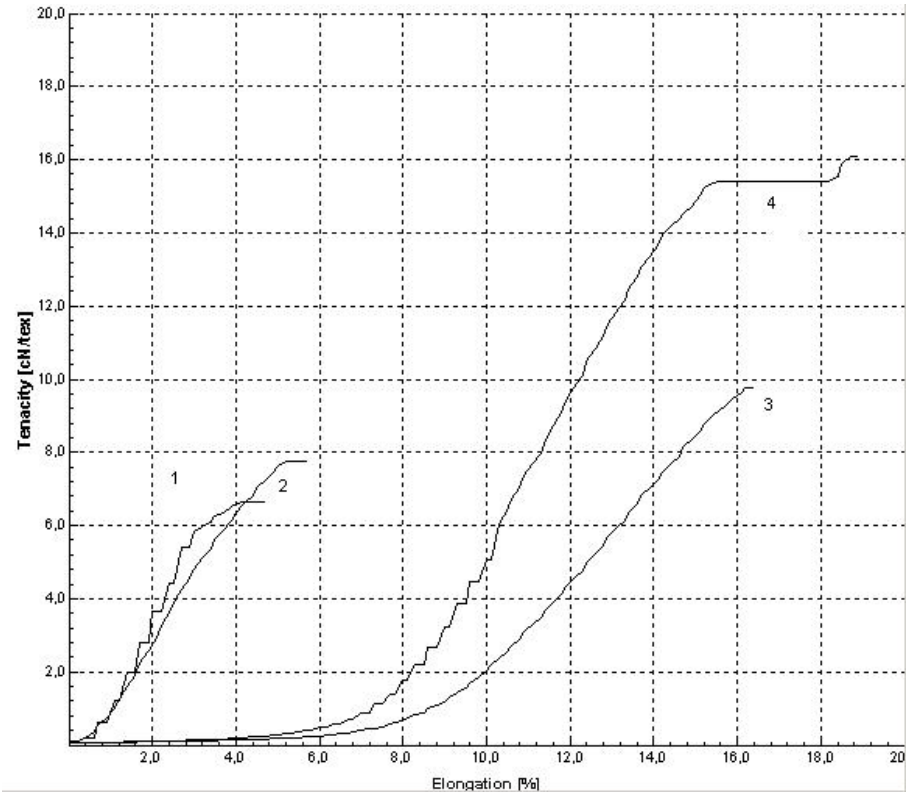

Fig. 7 Stress strain behavior of 100% cotton yarns.

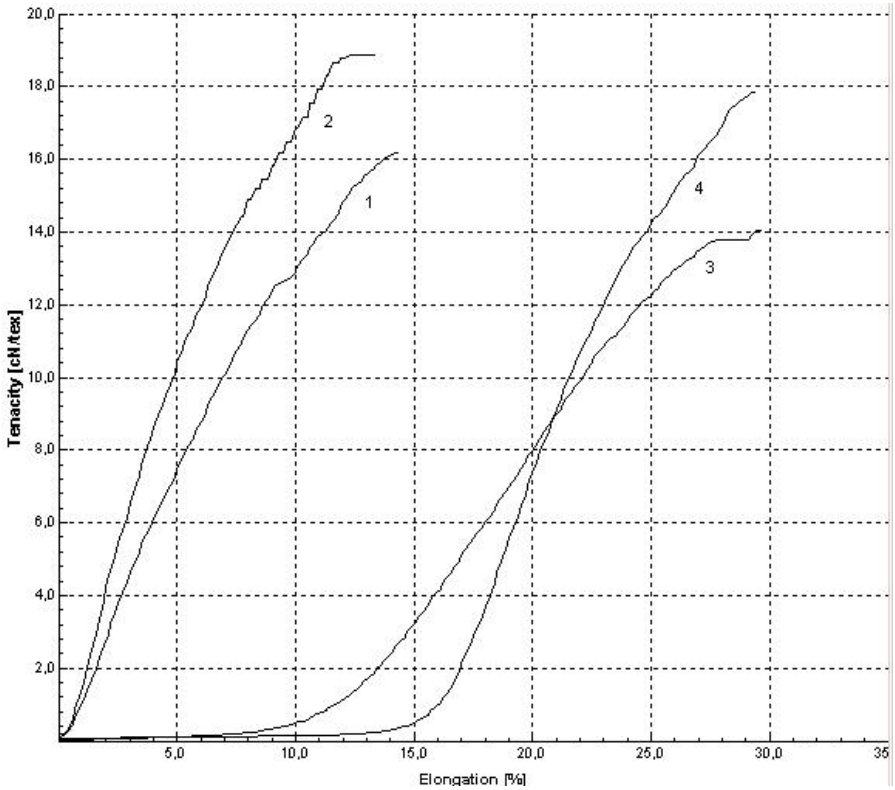

Fig. 8 Stress strain behavior of cotton polyester yarns.

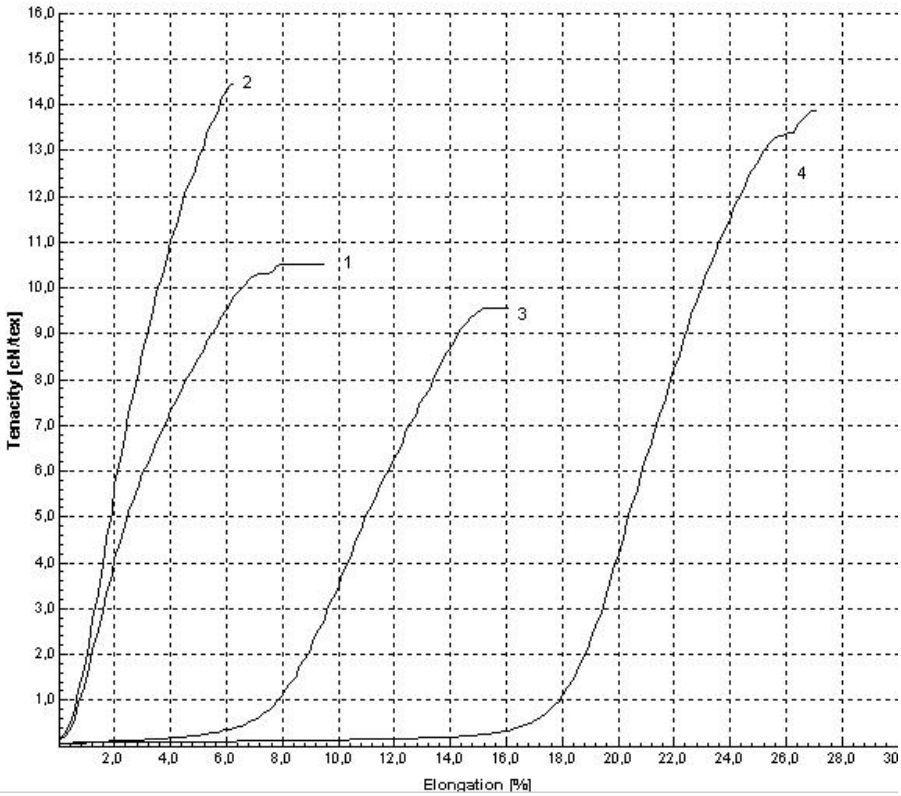

Fig. 9 Stress strain behavior of cotton viscose yarns.

In all yarns it is observed that the modulus increases with presence of slubs. This is mainly due to the higher number of fibres in the slub regions, leading to higher cohesion between fibres and more contribution towards

the load bearing capacity. However, with elastomeric component, the modulus decreases due to a very high strain rate.

Cyclic Loading of Elastomeric Yarns

All the elastomeric yarns were subjected to cyclic loading, so as to study their behaviour under multiple deformations. The results are given in table 3.

Table 3. Cyclic loading of elastomeric yarns

Type of yarn	Initial Upper Level of load (N)	Initial lower Level of load (N)	Initial Elasticity [%]	Final Upper Level of load (N)	Final Lower Level of load (N)	Final Elasticity [%]	Deformation Upper [%]	Deformation Lower[%]
CO/ elast.	60,5	60,5	100	62,4	62,35	95	1,9	1,85
CO elast slub	5,12	4,58	89,45	6,79	6	21	1,67	1,42
CO/ PES/ elast.	10,8	9,96	92,22	12,44	12,36	92	1,64	2,4
CO/ PES/ elast.slub	37,23	36,39	97,74	38,84	38,77	93	1,61	2,38
CO/V/ elast.	7,96	8	100,50	10,05	9,76	71	2,09	1,76
CO/V/ elast.slub	7,61	6,99	91,85	10,83	9,99	16	3,22	3

The figures below show the cyclic loading conditions for all elastomeric yarns without and with slubs respectively.

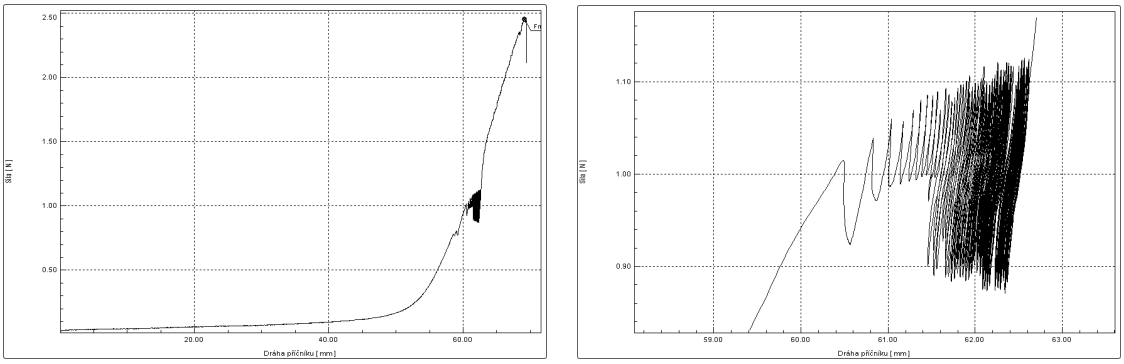

Fig. 10 (a) Cotton elastane

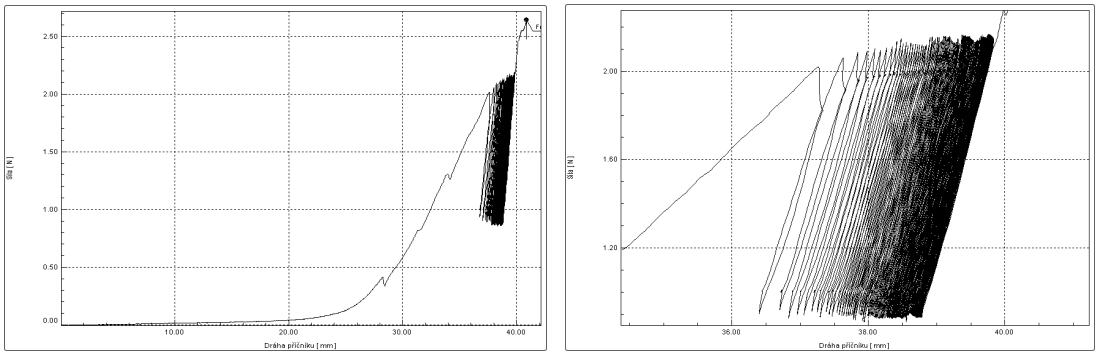

Fig. 10 (b) Cotton slub elastane

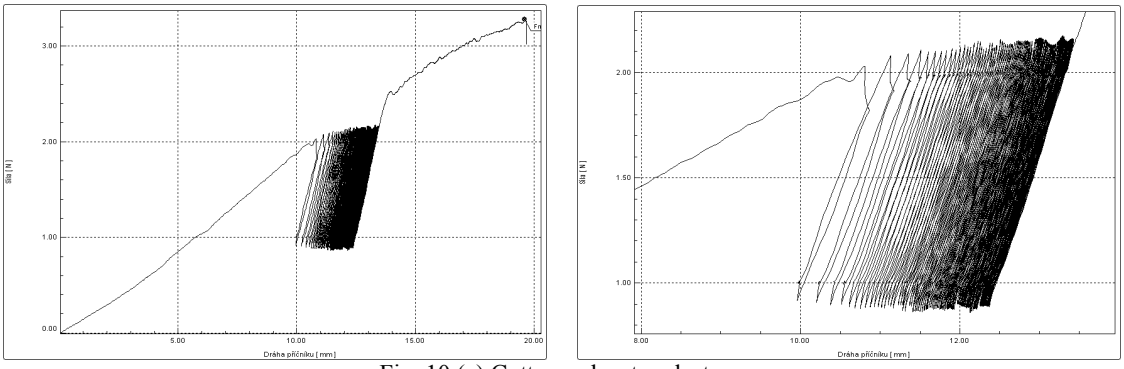

Fig. 10 (c) Cotton polyester elastane

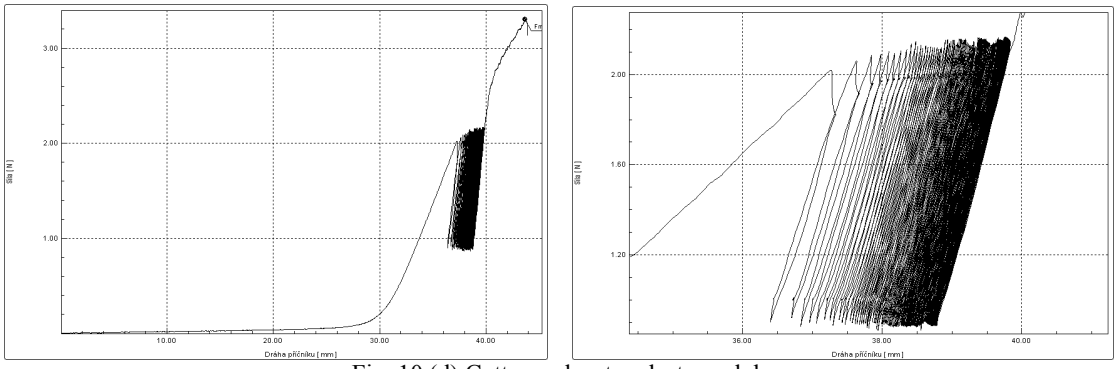

Fig. 10 (d) Cotton polyester elastane slub

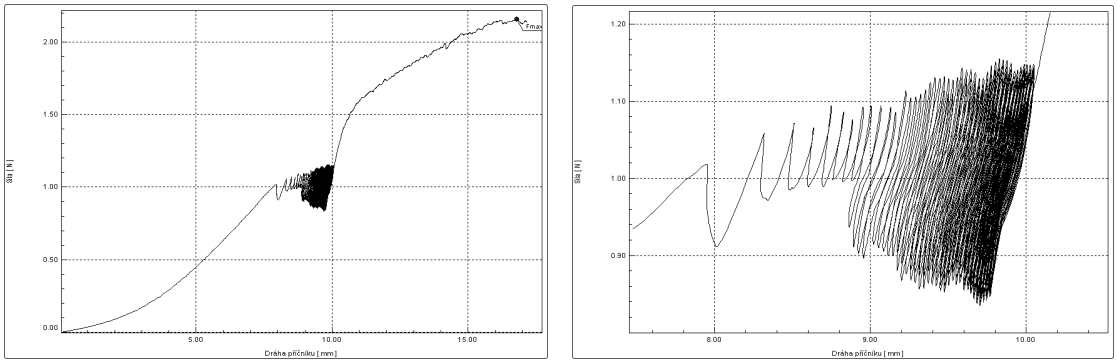

Fig. 10 (e) Cotton viscose elastane

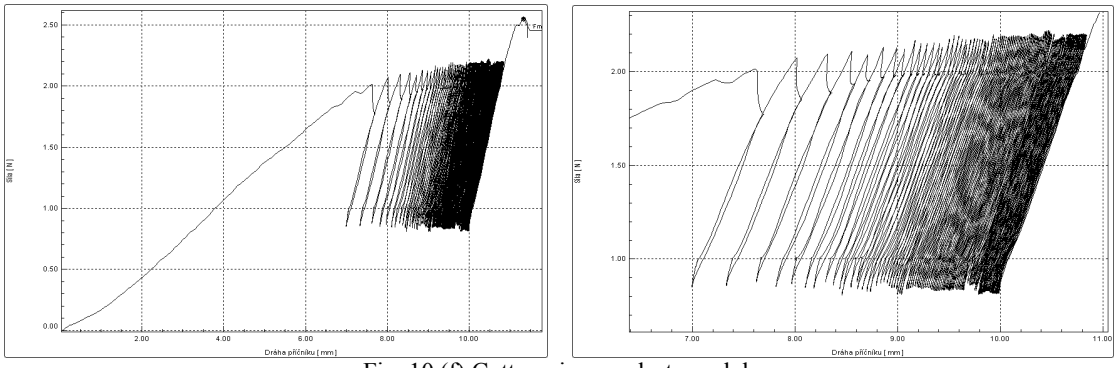

Fig. 10 (f) Cotton viscose elastane slub

It can be observed that after the cyclic deformation for 50 cycles, the slub elastomeric yarns show a higher load bearing capacity compared to normal elastomeric yarns and an associated lower strain rate. Therefore, higher modulus value obtained from slub yarns. In all cases it can be observed that presence of slubs in the elastomeric

yarns leads to a more uniform cyclic deformation behavior. This means a higher number of fibres in the cross-section of slub regions are responsible to share the load and compensate for the dynamic changes in internal stresses developed within the yarn. The fibres act as damper to absorb the deformations caused by cyclic loading.

Conclusion

The study of dynamic behavior shows that slub yarns show a higher elastic modulus but, lower sonic modulus compared to normal yarns. Elastomeric yarns have a lower modulus (both elastic and sonic) compared to normal yarns. The slub and elastomeric yarns show higher CV% in modulus in relation to yarn diameter variation. Slub elastomeric yarns prove to be better compared to normal elastomeric yarns under cyclic loading conditions.

References

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