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RESEARCHES UPON THE TENSILE STRENGTH AND ELONGATION AT BREAK OF THE LEATHER SUBSTITUTES

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Abstract. The paper presents the results of the research upon the mechanical characteristic of some leather substitutes used in footwear manufacturing.
Tensile tests were carried out in order to observe the breaking strength and elongation for a load of 10 N/mm2, using the tensile testing machine SATRA (STM 466) with 466F attachment, and SATRA software, providing quick and simple-to-understand results.

1. INTRODUCTION

In the lasting process, the footwear uppers are submitted to a tensile stress– that occurs when they are pulled on the last- and have to maintain their spatial shape.
The behavior of materials in the manufacturing process and use is established through a series of features such as:

- *Elongation at target load (10 N/mm^2), ε_i,* which allows to highlight the deformation capacity of the leather and leather substitutes at the lasting process for machines that work with loads close to this value;
- *Elongation at break, ε_r*, respectively the break extension;
  The elongation at break results from the relation:

$$E_r = (L_r - L_0)/L_0 * 100 = \Delta L/L_0 * 100$$

Where:
L_0- the initial length of the sample;
L_r- the sample's length between clamps at break;
ΔL- the absolute value of the elongation at break .

The elongation at break varies from one leather substitute to another, so that the highest elongation of a leather substitute is on the diagonal direction, and the smallest elongation is on the length direction.
For some leather substitutes the elongation at break of the layer presents a great importance, even if the maximum elongation at break is bigger than the pellicle's elongation at break.
In footwear manufacturing it is necessary to consider the minimum elongation of the leather substitute with view to the maximum elongation of the shoe patterns.
The tensile strength at break, characterized by the load at break, in N/mm^2, is dependent of the nature and structure of the leather substitute, the direction of breaking, layer's thickness and the cross sectional area.
The present paper presents the test results carried at break of some leather substitutes.

2. EXPERIMENTAL PART

Fig.1 tensile testing machine SATRA (STM 466) with 466F attachment

The behavior of these leather substitutes has been observed using the testing the tensile testing machine SATRA (STM 466) with 466F attachment, and SATRA software, providing quick and simple-to-understand results.
The tests were carried out with leather substitutes type polyurethane layer on fabric and non woven support, used at manufacturing footwear uppers:

IP_1- PVC matte coated fabric, δ=1,0 mm

IP_2 - shiny PU pellicle on non woven layer, δ =1,0 mm

IP_3 – matte PU leather substitute with non-woven fabric, δ =1.0 mm

IP_4- matte PU leather substitute with doubled fabric art.375 , δ=0.8 mm

IP_5 – shiny PU leather with fabric, δ=1.0mm.

The testing of the samples has been done as to register the maximum breaking force, the force at break of the layer, the tensile strength at break in N/mm^2, the elongation at break and the longitudinal elasticity modulus, E, in N/mm^2. For each sample tested there have been registered the load- elongation graphs, illustrated in figure 2,3….and 6.

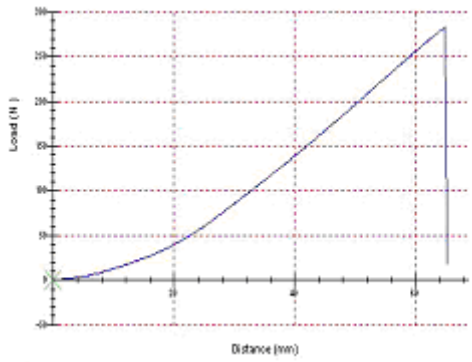


Fig. 2 . Load-distance graph for IP1

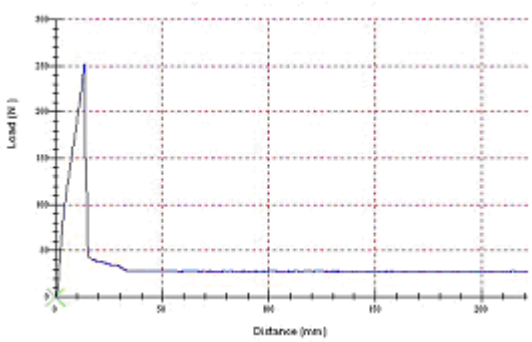


Fig.3. Load-distance graph for IP_2

For the leather substitute IP_1 (PVC matte coated fabric) the maximum elongation at break reflects both the elongation of the layer and the elongation of the pellicle. The behavior of this leather substitute is explained by the layer's nature (fabric). As figure 2 shows there can be noted that the elongation corresponding to a tensile stress of $10N/mm^2$, is of 50%, respectively inferior to the maximum value of the elongation at break. This value highlights the deformation capacity of the leather substitute during the lasting process, considering the fact that the tensile stresses are of 0,7-0,8 daN/mm^2 for the lasting process.

The behavior of the IP_2 leather substitute (shiny PU pellicle on non woven layer) is different of one of the leather substitute IP_1.

This type of leather substitute has a maximum value of the force at break of the woven layer, respectively an elongation of 15%; the maximum elongation at break of the pellicle applied to the fabric being of 228%.

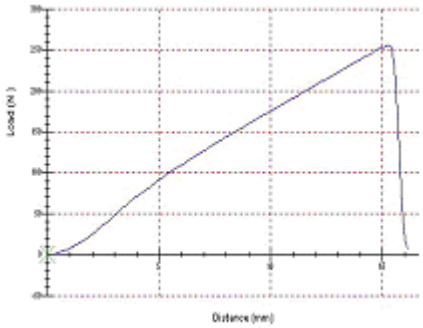


Fig.4. Load- distance graph for IP_3

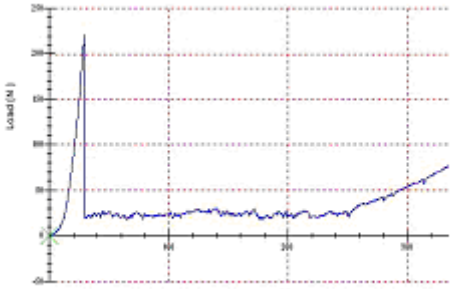


Fig.5. Load- distance graph for IP_4

For the leather substitute IP_3 (PU on non woven layer), the elongation at break is approximately of 16%, corresponding to a maximum force of 259N. The elongation corresponding to a load of 10N/mm^2, is approximately 12%, inferior to the maximum elongation at break.

The behavior of the leather substitute IP_4 (PU on coated fabric), is similar to that of the IP_2 leather substitute. The maximum force corresponds to moment when the layer breaks. In this case the PU pellicle elongates a lot, the maximum elongation at break being over 300%.

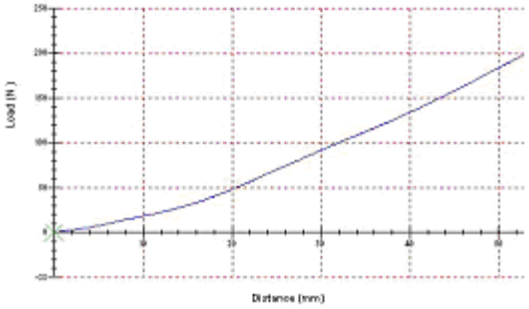
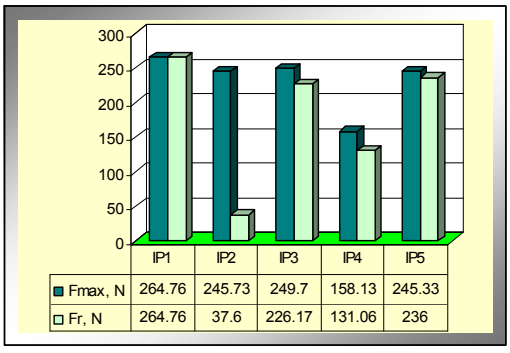


Fig.6. Load-distance graph for IP_5

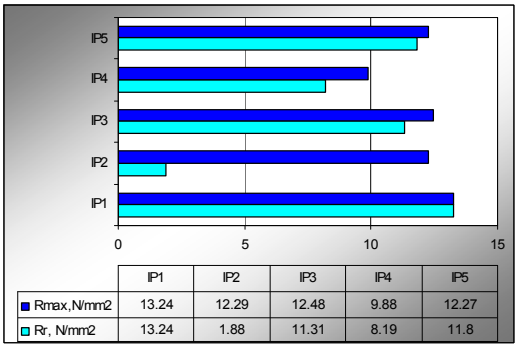
From fig. 6 it results that the behavior of this leather substitute on fabric layer (IP_5) is similar to behavior of the IP_1, with an elongation at break of 59% and a force of 245N. The elongation is 56% for a target load of 10N/mm^2.

The maximum force at break for the leather substitutes is illustrated in figure 7, and the variation of the tensile strength at break is shown in figure 8.



	IP1	IP2	IP3	IP4	IP5
Fmax, N	264.76	245.73	249.7	158.13	245.33
Fr, N	264.76	37.6	226.17	131.06	236

Fig.7.The variation of the breaking force



	IP1	IP2	IP3	IP4	IP5
Rmax,N/mm2	13.24	12.29	12.48	9.88	12.27
Rr, N/mm2	13.24	1.88	11.31	8.19	11.8

Fig.8. The variation of the tensile strength at break

The graphs indicate that the most resistant leather substitute is IP_1- matte coated fabric, respectively with the same value for the maximum strength and the maximum tensile strength at break of the layer.

The breaking strength in N/mm^2 is given by the ratio between the load at break Fr (corresponding to the moment when a break is detected), and the cross sectional area (b x δ), in mm^2, according to SR EN 13522/2003.
The maximum values of the tensile strength are obtained for the IP_3 and IP_5 leather substitutes, approximate to IP_1 value only with small differences with regards to the tensile strength at break of the layer.
The IP_2 and IP_4 leather substitutes with PU pellicle on different layers have a different behavior as compared to other leather substitutes. The IP_2 leather substitute with PU pellicle on non-woven layer, presents the smallest value of the tensile strength at break ($1.88N/mm^2$) which corresponds to the moment when a break is detected towards the maximum tensile strength at break of the pellicle ($12.29N/mm^2$).
In comparison to the other leather substitutes IP_4 presents the smallest value of the tensile strength at break, approximately $10N/mm^2$. Instead this leather substitute has the tensile strength bigger in comparison to the IP_2, fact explained by the layer's nature (doubled fabric).
It results that the tensile strength at break of the leather substitutes (9-13 N/mm^2) is smaller than the tensile strength at break of the genuine leathers (18-22 N/mm^2).
The variation of the leather substitutes' elongation is illustrated in fig.9.

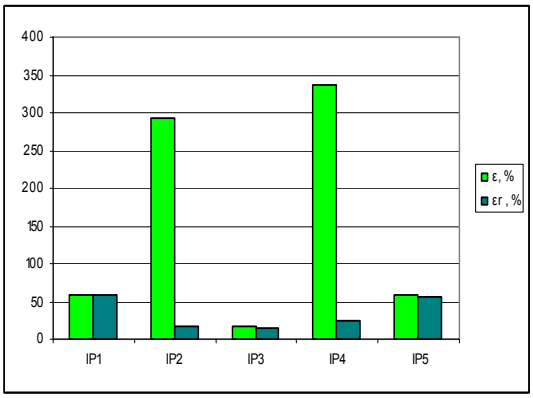


Fig.9. The variation of the elongation

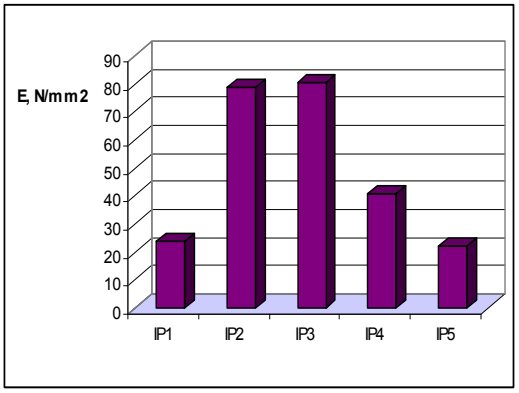


Fig.10. The variation of the elasticity modulus

The leather substitutes IP_1 and IP_5 present the highest value for the tensile elongation at break, approximately 60%. For the leather substitutes IP_2 (shiny PU pellicle) and IP_3 (matte pellicle of PU), both on non woven layer, there have been registered the smallest values of the elongation at break, respectively 16% and 15%. These leather substitutes have a maximum value of the tensile stress at break, value that corresponds to the pellicle's break.
The elongation at break for the tested leather substitutes has values between 15-60%. In comparison to the elongation at break of the genuine leather (20-30%), the elongation at break is much more bigger for two of the tested leather substitutes.
The variation of the longitudinal elasticity modulus is illustrated in fig.10 and the best values are those for IP_2 and IP_3 leather substitutes.

3. CONCLUSIONS

- The graphs resulted at the tensile testing machine SATRA, load-distance type, give useful information for describing how the leather substitutes break. For the tested leather substitutes there has been noticed that :
  - The tensile elongation at break of the layer synchronizes with the tensile elongation at break of the pellicle (IP_1, IP_3 and IP_5)
  - The tensile elongation at break on of the layer is more inferior to the tensile elongation at break of the pellicle (IP_2 and IP_4)
- The tensile elongation at break of the tested leather substitutes has values between 15-60%. In comparison to the elongation at break of the genuine leather (20-30%), the tensile elongation at break is higher for two of the tested leather substitutes (IP_1 and IP_5).
- The load-distance graphs registered at the tensile testing machine (STM 466) SATRA highlight the maximum breaking force of the leather substitute, respectively the breaking force of the layer.
- For the same tensile stress, the strength at break of the leather substitutes (9-13 N/mm^2) is smaller than the one of the leather (18-22 N/mm^2).
- The load-distance graphs registered at the tensile testing machine SATRA (STM 466) permit to establish the elongation at a target load of $10N/mm^2$. This highlights the deformation capacity of the leather substitutes at the lasting process considering the fact that the tensile load during the lasting process is of 7-8 N/mm^2.

REFERENCES:

[1].Harnagea F., Secan C., “Study regarding the leather substitutes behavior at tensile stress”, Annals of the Oradea University, Fascicle of Management and Technological Engineering,vol VII (XVII, ISSN 1583-0691, p.1462, 2008
[2] Harnagea F., Secan C., *Aspects regarding the elongation capacity of the leather substitutes*, International Scientific Conference Unitech’07, Proceedings, vol.II, , Bulgaria,pg. 199-202, ISSN 1313-230X, 2007
[3].Harnagea F., Study on deformability of reinforcement textile materials during footwear lasting process, International Scientific conference Unitech ’ 04 Gabrovo, Proceedings, vol.II, Technologies in textile production, ISBN 954-683-304-5, Bulgaria, p.305-309, 2004