BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 66 (70), Numărul 4, 2020
Secția
CONSTRUCȚII DE MAȘINI

# METHOD AND EQUIPMENT FOR TEXTILE MATERIALS TESTING

BY

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Received: October 16, 2020
Accepted for publication: December 9, 2020

**Abstract.** In order to evaluate the performances of the textile materials to be used for the conception and design of protection products with superior performances to those existing on the market at present, it was necessary to carry out an experimental research leading to an evaluation of the mechanical properties of proposed materials and their combinations, so that following this analysis based on the experimental results obtained a series of conclusions can be drawn regarding the possibilities of using these materials.

This paper presents a method and an equipment for mechanical properties evaluation of some textile materials and combinations of these materials.

**Keywords:** loading force; testing machine; testing conditions.

## 1. Introduction

Due to the very rapid development of industrial activities, there was a need to develop equipment to ensure adequate protection for human operators (Ziegenfuß and Klein, 2000; Scott, 2005; Roshan, 2019). This required the development of research that would lead to obtaining new textile materials, with different compositions and structures compared to those existing until now

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(Shishoo, 1995), which, based on superior mechanical characteristics and in correctly chosen combinations (base material, intermediate material or filling and facade material) to lead to the realization of much better protective equipment.

In this paper we tried to test some materials and some combinations of materials, following their behavior at tests in identical conditions (strength, speed, etc.), the parameters followed (Wang *et al.*, 2008) being mainly the elasticity of materials (by relative elongation or absolute elongation), as well as the breaking limit (by punching in two variants).

## 2. Experimental Method

During the experiments, were evaluated the characteristics of the materials coded as follows:

- Basic material 1 - MBV1;
- Basic material 2 - MBV2;
- Basic material 3 - MBV3;
- Basic material 4 - MBV4;
- Basic material 5 - MBV5;
- Basic material 6 - MBV6;
- Filling material 7 - MUV7;
- Material PAD.NO5 BLUE TRIATHLON;
- Material SV3R.2;
- SV3-L material;
- SV3-LN material;
- Material OBV3-R.

The programming of the experiments was performed as follows:

Stage I: Study of each individual material: MBV1, MBV2, MBV3, MBV4, MBV5, MBV6, MUV7, PAD.NO5 BLUE TRIATHLON, SV3R.2, SV3-L, SV3-LN, OBV3-R.

Stage II: Study of the characteristics of the packages obtained through the combinations of two materials:

- MBV1 + MUV7;
- MBV2 + MUV7;
- MBV3 + MUV7;
- MBV4 + MUV7;
- MBV5 + MUV7;
- MBV6 + MUV7;
- MBV3 + MBV3;
- MUV7 + MUV7.

The study of each material and each combination of material was performed at a breakthrough request, each experiment (Hasçelik and Eren, 2016) being performed in two variants:

1. Piercing with a steel tip (Fig. 1);
2. Piercing with a 20 ml syringe needle (Fig. 2).

We considered that both variants can provide important information, because in the case of the first variant has an important influence the elasticity of the material, while in the case of the second variant only the structure of the material is important.

Compared to the first set of experiments, we considered that the support surface of the material must be reduced in order to reduce the effects due to the elasticity of the material and thus be able to reduce the penetration stroke. For this, a piece was conceived and made which, compared to the first set of experiments, allows the realization of a support surface ∅ 20 (Fig. 3).

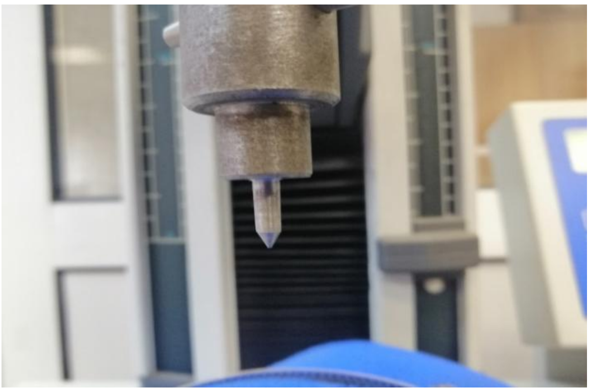


Fig. 1 – Piercing with a steel tip.

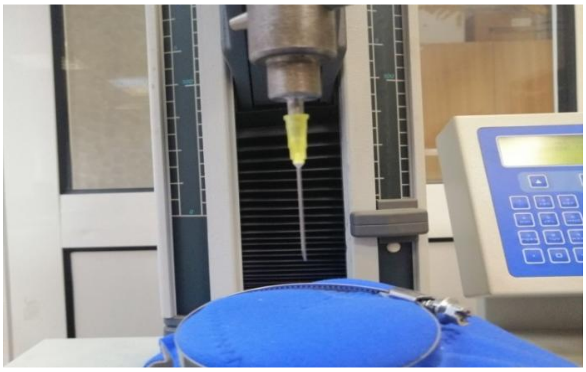


Fig. 2 – Piercing with a 20 ml syringe needle.

## 3. Experimental Equipment

The tests were performed on the LRX Plus tension/compression material testing machine (Lloyd Instruments Ltd -AMETEK-England - Fig. 4).

Fig. 3 – Intermediate part for obtaining a support surface ∅ 20.

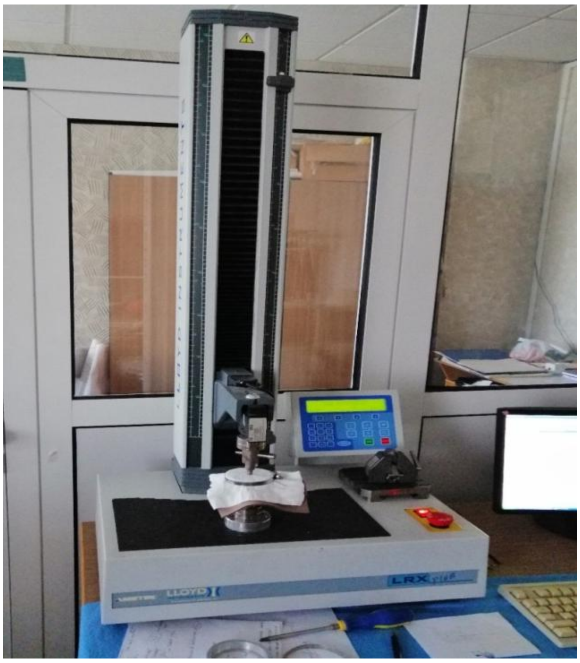


Fig. 4 – Testing machine Lloyd Instruments Ltd -AMETEK-England.

Testing machine Lloyd Instruments Ltd –AMETEK has the following functional characteristics:

– The load force is measured with a force transducer (load cell), XLC-5000-Al, which allows force measurements of up to 5000 N, with an accuracy of 0.5%, according to ASTM E4 and DIN 1221.

– The speed of force application can be in the range (0.01-1016 mm/min), with an accuracy of 0.2%;

– The axial displacement (deformation) is measured with the help of the numerical axis of the test machine with an accuracy of 0.001 mm.

Data acquisition and processing were performed using the integrated software NEXYGEN Data Analysis, of the LRX Plus test machine (https:// www.jlwinstruments.com/products/products-library/lrx-series-materials-tes-ting-machine/).

Fig. 5 – Detail about the working zone.

All tests were scheduled to be performed under identical conditions (same force, same punch speed, same stress cycle - "tension and compression", same way of fixing the material). In Fig. 6 is presented the interface through which the conditions for carrying out the experiment are programmed.

The testing of the textile materials was performed on the LRX Plus machine (Lloyd Instruments-Ametek-England), under the following conditions:

– Travel speed of the punch head: 300 mm/min (made with an accuracy of 0.2%);

– Material prestressing force: 0 N;

– Force from which the breaking detector acts: 1 N;

– Punch head stroke: 20 mm;

– The piercing was performed with the help of the two tools presented above, for each variant being calculated the parameters presented in Fig. 9.

– A “zero” position of the punch head has been established and in the case of each test the departure is made from this position (from the zero value of the force) and after the programmed stroke the punch holder head returns to this position.

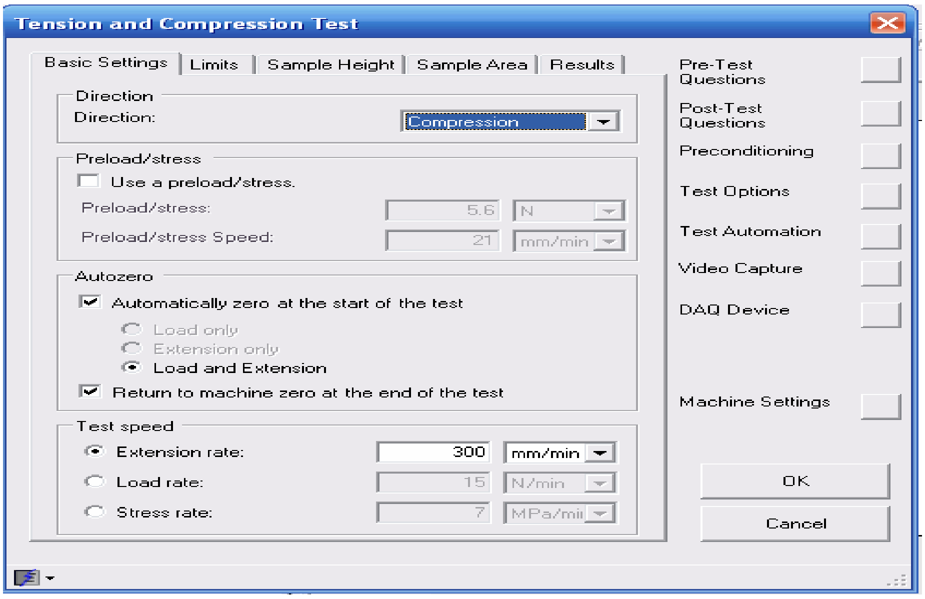
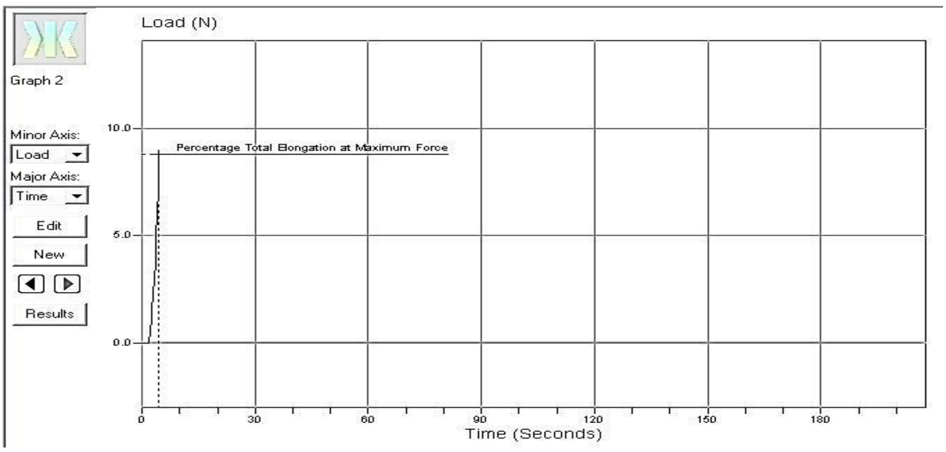
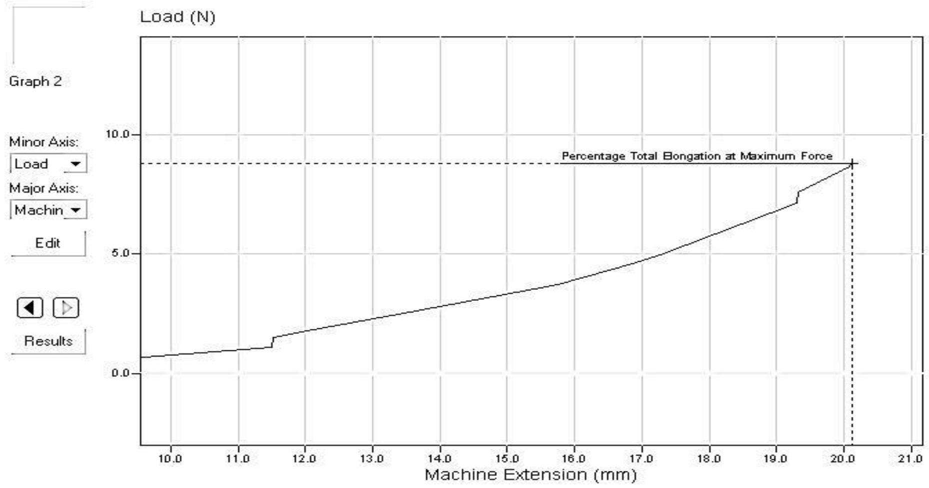



Fig. 6 – The programming interface.

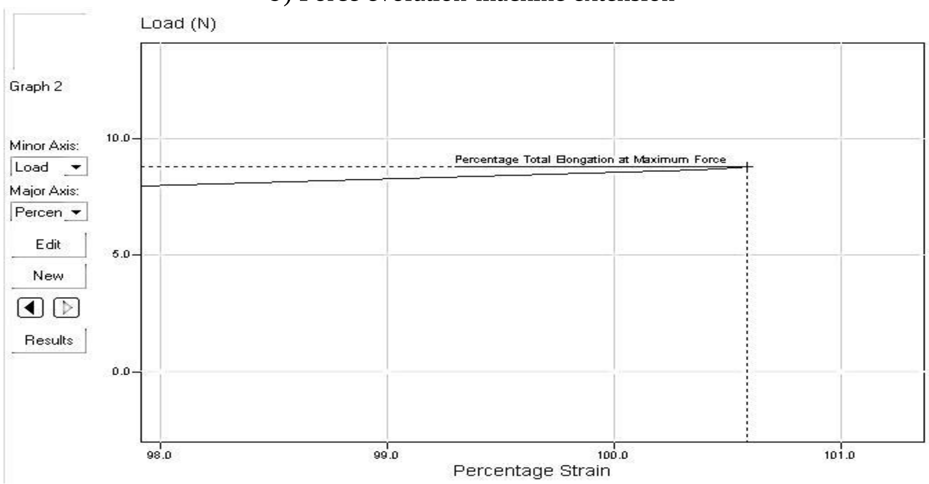
For each test, using the NEXYGEN software, the following categories of graphs were drawn (Fig.7 a-c).




*a*) Force evolution-time




*b*) Force evolution-machine extension




*c*) Force evolution-percentage strain

Fig. 7 – The evolutions of some parameters provided by the NEXYGEN software.

For each material, two rows of such graphs were made (needle and needleless version) but also other evolutions (stroke-time, tension-stroke, real-length elongation-stroke, etc.). Also, for each material tested, the software generated a complete statistic (*e.g.* - Fig. 8).

The data acquisitions were made in 16000 points for each test, and the values of the parameters mentioned above were also saved in ".txt" format, so that it is possible to export the data and process them in the MATLAB programming environment or in EXCEL.

| | Maximum | Minimum | Mean | Median | Coefficient of Variance | Standard Deviation (N) | Standard Deviation (N-1) | True |
|---|---|---|---|---|---|---|---|---|
| SamplePassed | | | | | | | | 100.00% |
| Speed | 300.00 mm/min | 300.00 mm/min | 300.00 mm/min | 300.00 mm/min | 0.00% | 0.00000 mm/min | 0.00000 mm/min | |
| Height | 20.000 mm | 20.000 mm | 20.000 mm | 20.000 mm | 0.00% | 0.00000 mm | 0.00000 mm | |
| Diameter | 20.000 mm | 20.000 mm | 20.000 mm | 20.000 mm | 0.00% | 0.00000 mm | 0.00000 mm | |
| Area | 314.16 mm² | 314.16 mm² | 314.16 mm² | 314.16 mm² | 0.00% | 0.00000 mm² | 0.00000 mm² | |
| Timestamp | | | | | | | | |
| Limit | 20.000 mm | 20.000 mm | 20.000 mm | 20.000 mm | 0.00% | 0.00000 mm | 0.00000 mm | |
| Load at Maximum Load | 8.7639 N | 0.063578 N | 4.4138 N | 4.4138 N | 98.56% | 4.3502 N | 6.1521 N | |
| Stress at Maximum Load | 0.027896 MPa | 0.00020238 MPa | 0.014049 MPa | 0.014049 MPa | 98.56% | 0.013847 MPa | 0.019583 MPa | |
| Machine Extension at Maximum Load | 20.117 mm | 20.046 mm | 20.081 mm | 20.081 mm | 0.18% | 0.035329 mm | 0.049963 mm | |
| Extension at Maximum Load | 20.117 mm | 20.046 mm | 20.081 mm | 20.081 mm | 0.18% | 0.035329 mm | 0.049963 mm | |
| Strain at Maximum Load | 1.0058 | 1.0023 | 1.0041 | 1.0041 | 0.18% | 0.0017664 | 0.0024981 | |
| Percentage Strain at Maximum Load | 100.58 | 100.23 | 100.41 | 100.41 | 0.18% | 0.17664 | 0.24981 | |
| Work to Maximum Load | 3.9287 Ncm | -0.15307 Ncm | 1.8878 Ncm | 1.8878 Ncm | 108.11% | 2.0409 Ncm | 2.8863 Ncm | |
| Load at Maximum Extension | 8.7639 N | 0.063578 N | 4.4138 N | 4.4138 N | 98.56% | 4.3502 N | 6.1521 N | |
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| Percentage Strain at Maximum Extension | 100.58 | 100.23 | 100.41 | 100.41 | 0.18% | 0.17664 | 0.24981 | |
| Work to Maximum Extension | 3.9287 Ncm | -0.15307 Ncm | 1.8878 Ncm | 1.8878 Ncm | 108.11% | 2.0409 Ncm | 2.8863 Ncm | |
| Tensile Strength | 0.028535 MPa | 0.00020608 MPa | 0.014371 MPa | 0.014371 MPa | 98.57% | 0.014164 MPa | 0.020032 MPa | |
| Percentage Total Elongation at Maximum Force | 100.58 | 100.23 | 100.41 | 100.41 | 0.18% | 0.17664 | 0.24981 | |
| Number of Rows that Passed | 2 | | | | | | | |
| Number of Rows that Failed | 0 | | | | | | | |

Fig. 8 – Software generated statistics.

Such results were generated for each material and material combinations.

## 4. Results and Discussion

In the case of all materials tested for the steel tip breakthrough version, the calculated parameter values are higher than for the needle breakthrough version.

Based on the statistics generated by the software for each material (or combinations of materials) a series of conclusions can be drawn. For example, for the material MBV1 the analysis of the generated statistic (presented in Fig. 8) leads to the following conclusions:

– at the test with the steel tip the maximum force is 34.714 N while at the needle load a force of only 0.70037 N develops (the coefficient of variation is 96.04%);

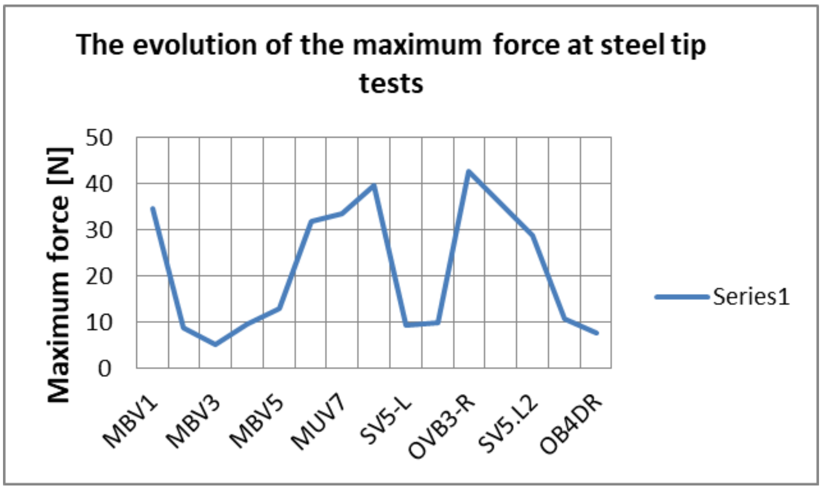
– maximum forces are obtained at stroke values of 20.134 mm and 10.469 mm respectively (coefficient of variation 31.58%);

– the torque developed when reaching the maximum force: 14.575 N·cm, respectively 0.23689 N·cm (coefficient of variation 96.8%);

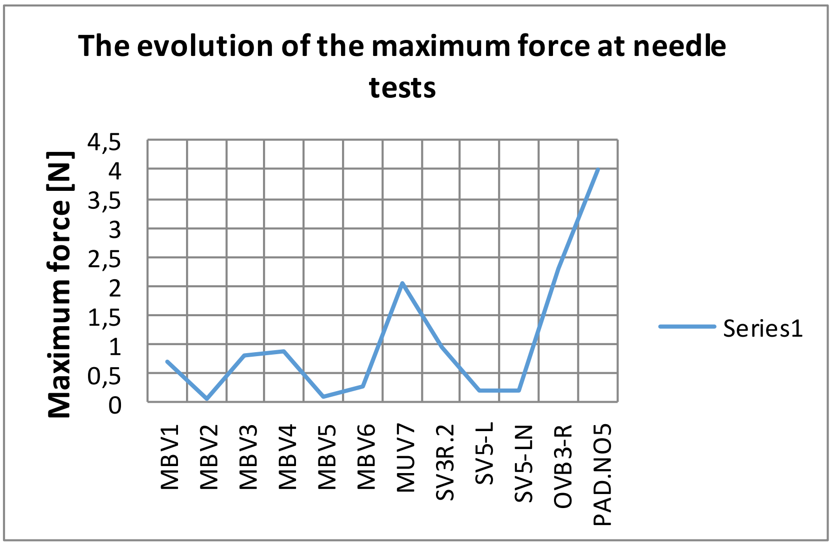
– the stresses developed when reaching the maximum force are:
0.11050 MPa, respectively 0.0022293 MPa (coefficient of variation of 96.04%);

– couple developed at the end of the race: 14.575 N·cm-respectively 0.36065 N·cm (coefficient of variation of 95.17%);

– there is a very small coefficient of variation (0.03%) for the relative elongation obtained at the maximum stroke (both for the case of expression in percent and for expression as number).




*a*)




*b*)

Fig. 9 – The evolution of the maximum force in the two test variants.

Based on the values of the parameters obtained for each material, evolutions can be obtained based on which conclusions can be issued concerning the behavior of each material and thus we can achieve a classification of them.

Fig. 9 shows two such evolutions.

## 5. Conclusions

The analysis of the values of the maximum force results lead to a hierarchy of materials.

These results can be interpreted as a strength of the material structure. Higher force values obtained in the case of steel tip tests can be explained by the fact that the contact surface in these cases was much larger, which lead to a much greater elongation (relative and absolute).

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METODĂ ŞI ECHIPAMENT PENTRU TESTAREA MATERIALELOR TEXTILE

(Rezumat)

Pentru a evalua performanțele materialelor textile, care vor fi utilizate pentru conceperea și proiectarea produselor de protecție cu performanțe superioare celor existente pe piață în prezent, este necesară efectuarea unei cercetări experimentale care să conducă la o evaluare a proprietăților mecanice ale materialelor propuse și combinațiile acestora, astfel încât să poată fi trase o serie de concluzii cu privire la posibilitățile de utilizare a acestor materiale.

Această lucrare prezintă o metodă și un echipament pentru evaluarea proprietăților mecanice ale unor materiale textile și combinații ale acestor materiale.