Characterization of a New Bromobutyl Rubber Composite for NBC Protection

II. Mechanical properties

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Mechanical properties of the new bromobutyl rubber-based composite (BrBR) were evaluated in comparison with similar NBC protection materials, used either in Romanian Army or in other NATO country armies. The following parameters were determined: mechanical strength, tensile strength and elongation, and the tear force – trouser-shaped test specimen. From the data obtained, a real improvement of the break parameters of BrBR, both in warp and in weft, versus the performances of Romanian materials in use was noticed. Also, versus the foreign materials, the material obtained presents properties basically between the French material and the German one.

Keywords: NBC protection, composites, mustard gas, mechanical properties

Butyl rubber and butyl rubber-based mixtures display important protection properties, no matter the copolymer used or whether the butyl rubber is halogenated or not. Butyl rubber is cost-efficient, it can be processed with nontoxic additives and its mechanical properties make it a good choice for nuclear, biological and chemical individual protection equipment (NBCIPE) manufacturing. Halobutyl rubbers are less influenced by low temperatures and their protection times against mustard gas (yperite, 1,5-dichloro-3-thiapentane or HD) are 60 times better than natural rubber [1-4 and Part I of the paper].

Moreover, their mechanical properties influence positively the decision for their introduction in operational environment [5-6].

In the present study, mechanical properties of the new bromobutyl rubber-based composite (BrBR), characterized as NBC properties in Part I of the study, are presented. The characterization of the composite was based on the comparison of its properties with those of similar NBC protection materials, used either in the Romanian Army or in other NATO armies.

Experimental part

Materials and methods

The materials used to test comparatively the new NBC protection material submitted to evaluation (BrBR) were: Opanol material (OP), consisting in a composite of NR on cotton; BP/SP (Butyl rubber on Pandora polyester); BC/SP2 (Butyl rubber on a second generation Pandora polyester); M1 material (a German multilayer butyl rubber); M2 material (a French composite of bromobutyl rubber on polyester).

There are not provided in the literature composition data for the OP, M1 and M2 materials. The other three materials tested had the elastomer composition illustrated in table 1 and contained the following compounds: reinforcing agent (silicon dioxide), vulcanizing agents (sulfur, zinc oxide, and barium stearate[7-8]), flame retardant agents (paraffin chloride and antimony trioxide), and green pigment (chromium oxide).

In order to evaluate the mechanical properties of the BrBR, the material was characterized accordingly to the end user requirements. For the validation of the obtained results, comparative tests were performed, either with materials used for the manufacturing of the NBCIPE existent in the Romanian army (Opanol material, BP material, BC/SP2 material), or with materials used abroad for NBCIPE manufacturing (M1- German material, M2 – French material).

Table 1
ELASTOMER COMPOSITION FOR THREE OF THE MATERIALS USED

Material / Elastomer composition	BrBR	BP/SP	BC/SP2
Chloroprene	-	-	9-12
Butadiene rubber	-	-	0.8-1
Chlorobutyl rubber	-	-	50-55
Butyl rubber	12-22	65-71	18-20
Polyethylene	8-13	29-35	10-15
Bromobutyl rubber	70-75	-	-

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The tests were performed using standard apparatus and standardized methods in order to avoid any difference resulted from the method or testing equipment used.

Determination of the mechanical strength

A James H. Heal dynamometer, model TITAN 710, coupled with a Genius Fini compressor of 8 bars, was used for the tests. The apparatus works under the following parameters: 3000 N ± 1% maximum tensile strength, and operation system between +5 ÷ +45 °C [9-10].

Determination of tensile strength and elongation of the textile materials

Two sets of samples were taken from each material, one on the warp direction and the other on the weft direction. No sample taken on the warp direction should contain the same longitudinal threads and no sample taken on the weft direction should contain the same threads. Every set contains five samples of 50 mm 0.5 mm width and a length enough to allow a distance between the clamps of 200 mm ± 1 mm, accordingly to [11].

The samples were set and pretensioned with 5 N for materials with weight between 200 and 500 g/m^2 and 10 N for materials with weight > 500 g/m^2. The clamp movement was set to a constant rate of 100 mm/min ± 10 mm/min.

The tests results where the samples slide asymmetrically or over 2 mm along the fixing line were excluded.

Maximum break force and elongation at break were recorded and the mean value on each direction for the five samples was calculated. The values obtained were rounded to 1 N or 1 %.

The mean values of the elongation at maximum break force and elongation at break were calculated. The values obtained are rounded as following: 0.2% for elongations 8%; 0.5% for elongations between 8 and 50%; 1% for elongations > 50%.

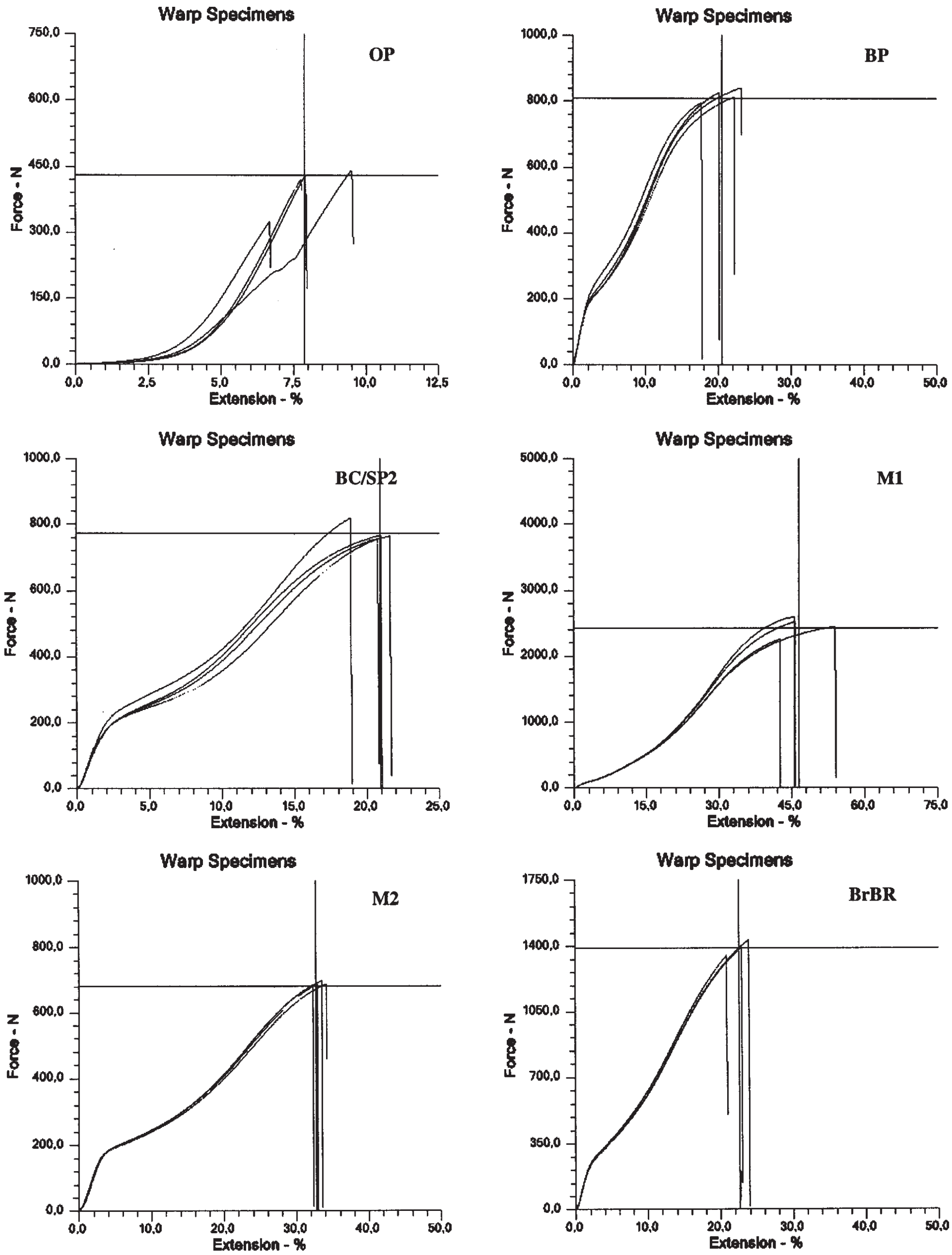

Fig. 1. Warp tensile strength and elongation at break

Determination of tear force – trouser-shaped test specimen

Two sample sets of five samples were taken, one on the warp direction and the other one on the weft direction. Any two samples should not contain the same longitudinal or transverse threads and should not be cut from less than 150 mm of the material edge [12-13].

The sampling length of the apparatus is set at 100 mm, and the elongation rate at 100 mm/min.

The following parameters were marked: the tear force - in Newtons, the tear trajectory, perpendicular or not on the stress direction, whether the threads slide, instead of breaking.

Results and discussions

Tensile strength and elongation at break

The elongation at break and tensile strength values are given in figures 1-4.

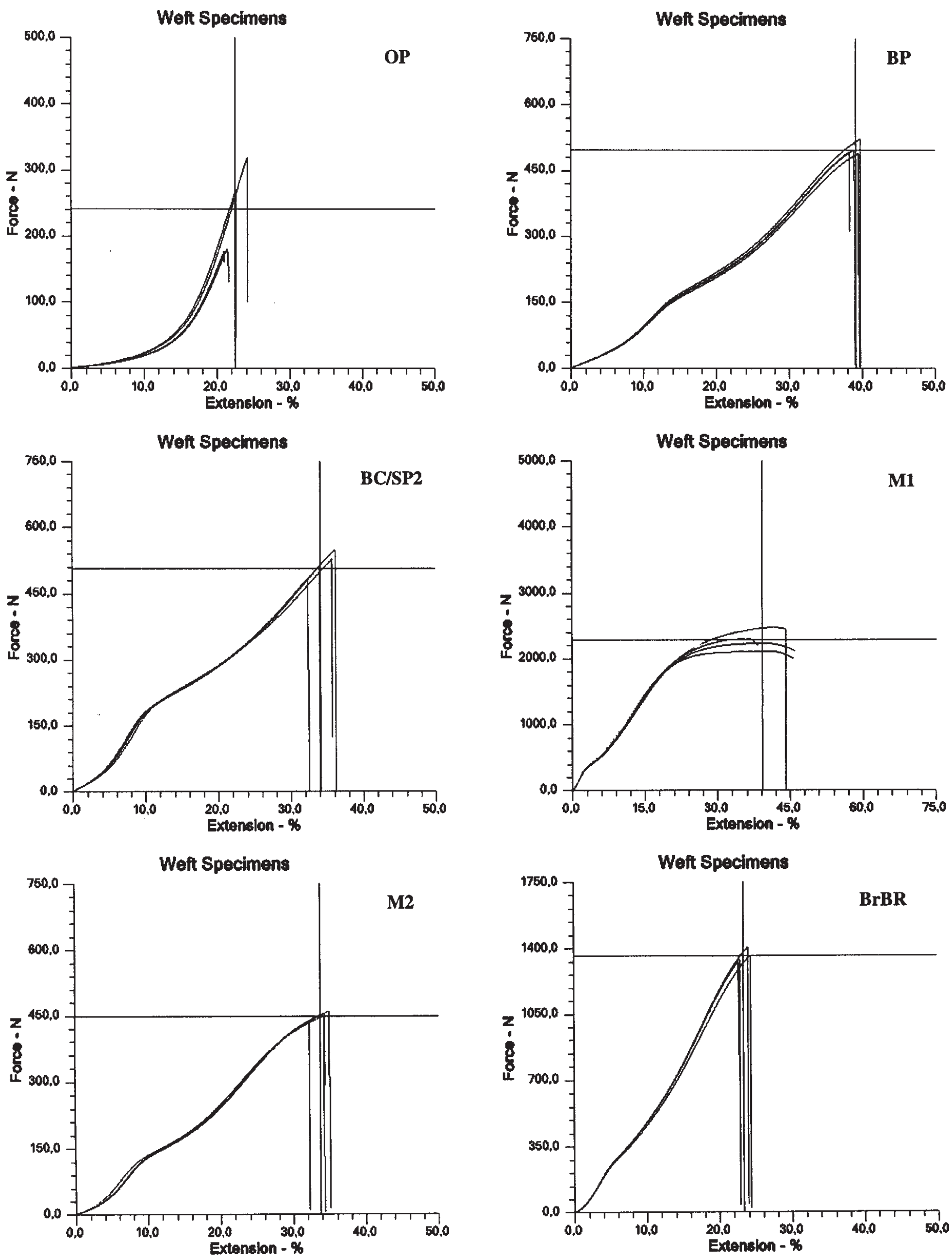

Fig. 2. Weft tensile strength and elongation at break

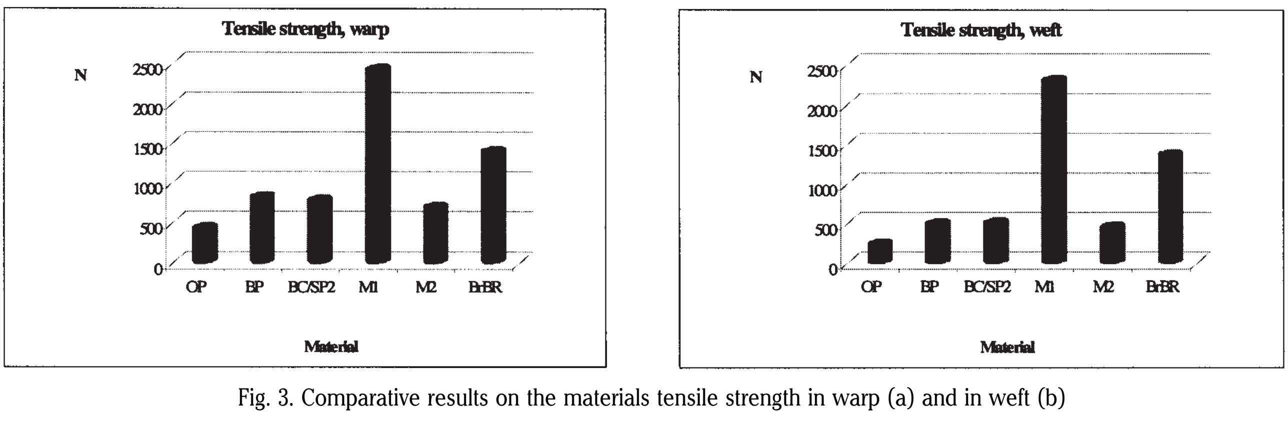

Fig. 3. Comparative results on the materials tensile strength in warp (a) and in weft (b)

(a)

(b)

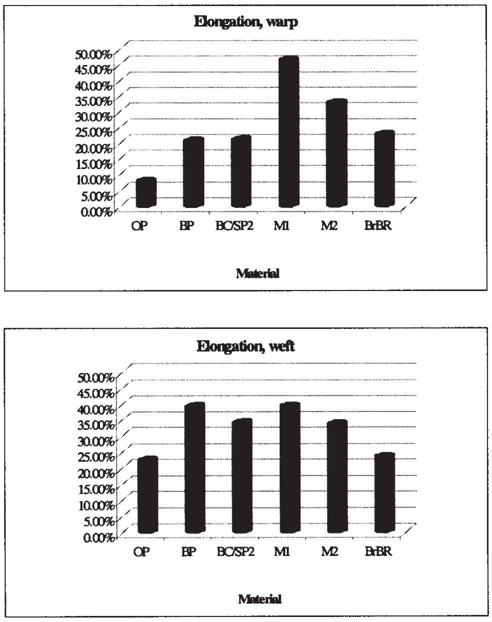

Fig. 4. Comparative results on the materials elongation at break in warp (a) and in weft (b)

(a)

(b)

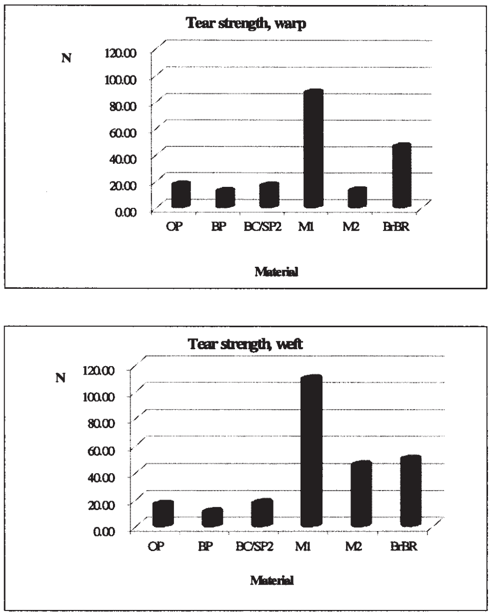

Fig. 5. Comparative results on the materials tear strength in warp (a) and in weft (b)

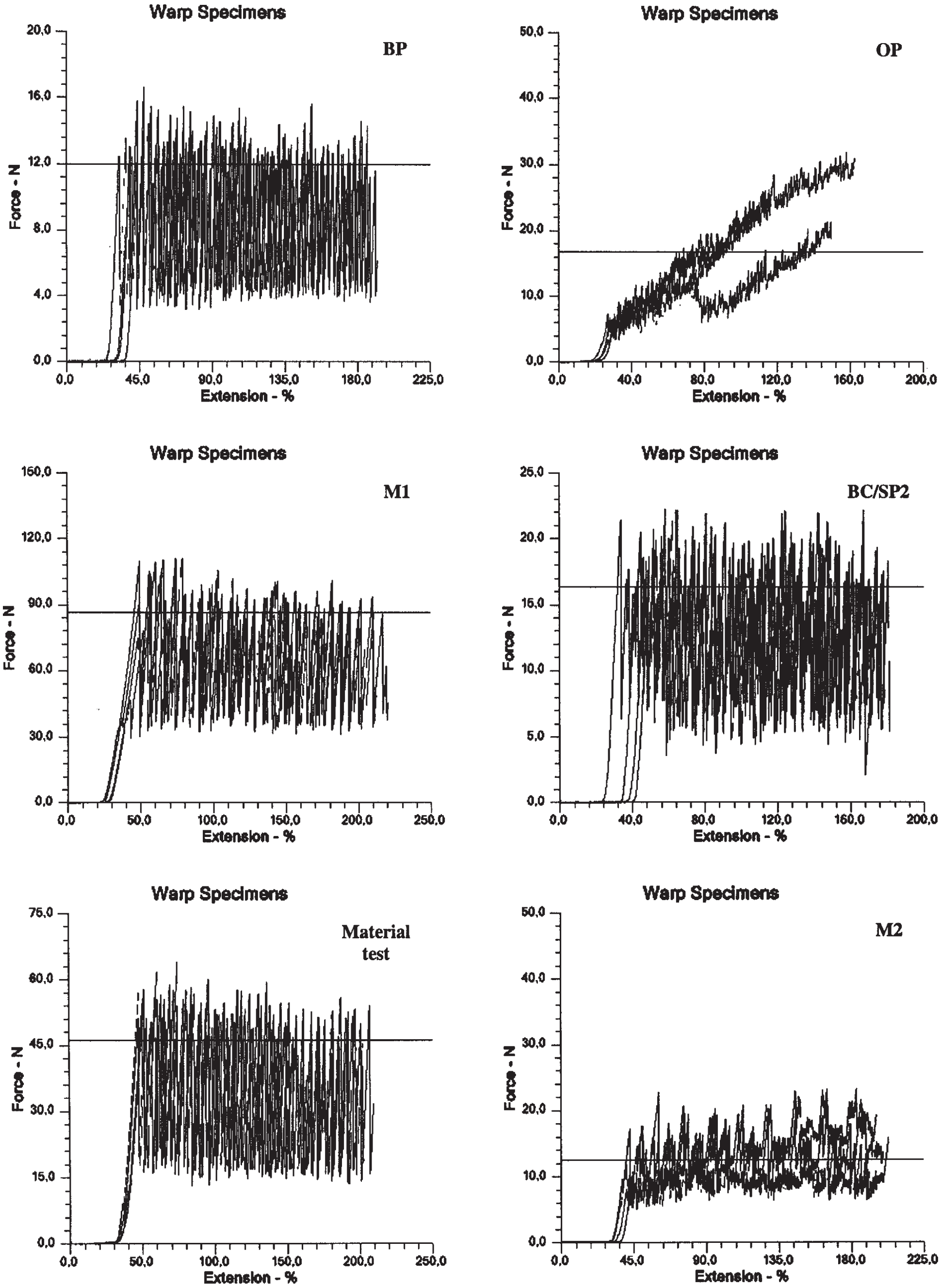

Fig. 6. Warp tear strength

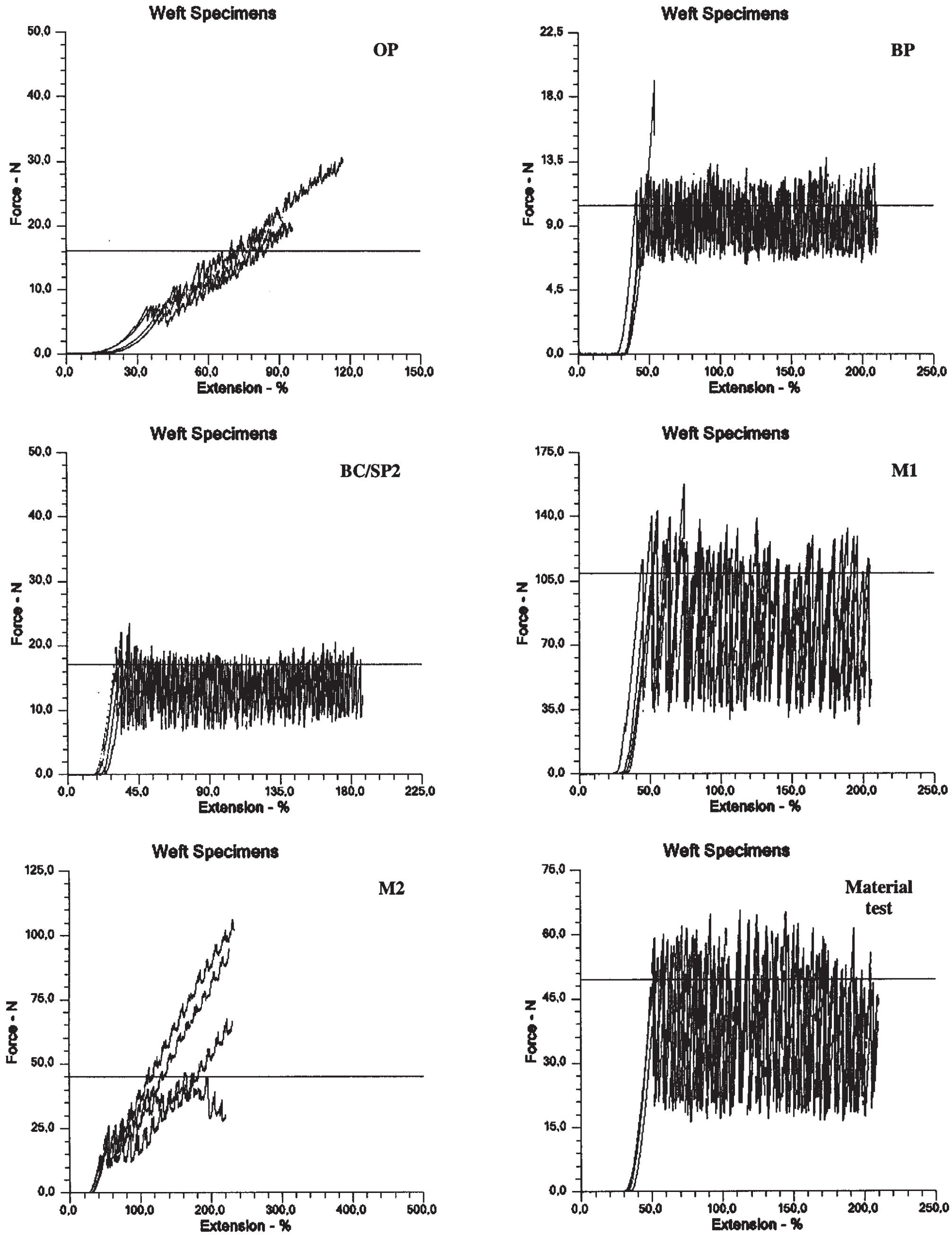

Fig. 7. Weft tear strength

From the data obtained it can be noticed a real improvement of the break parameters of BrBR, both in warp (1390.34 N), and in weft (1364 N), versus the performances of Romanian materials in use (429.37, 810.24, and 772.73 in warp, and 241.63, 497.77, and 506.27 in weft).

Also, versus the foreign materials, the material obtained is basically between the French material (681.96 N and 449.51 N) and the German one (2424.39 and 2294.27 N).

As regarding the elongation at break, it cannot be observed a significant improvement of this parameter. In the condition of a good mechanical resistance, this is a less significant operational parameter.

Tear force

The values obtained during tests using trouser-shaped method are presented in figures 5-7.

From the results obtained it can be noticed that BrBR offers a three time improvement in tear strength (46.20 and 49.57, respectively) versus Romanian materials in use (16.87, 11.98 and 16.34 N; and 16.18, 10.39 and 17.07 N, respectively).

In comparison with the foreign materials, the composite obtained is similar to the French material (12.45, and 45.08 N, respectively), but strictly inferior to the German material (86.70, and 109.27 N, respectively).

Conclusions

Mechanical properties of the new bromobutyl rubber-based composite (BrBR) were evaluated in comparison with similar NBC protection materials, used either in Romanian Army or in other NATO armies: mechanical strength, tensile strength and elongation, and the tear force – trouser-shaped test specimen.

A real improvement of the break and tear strength parameters of BrBR, both in warp and in weft, versus the performances of Romanian materials in use was noticed. Also, versus the foreign materials, the material obtained presents properties basically between the French material and the German one. No improvement was noticed, though, regarding the elongation at break.

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