Cages for Bearings with Plated Pocket's - Resistance Tests. An Exploratory Research

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Abstract
The development of new, innovative, cage-based solutions composed of a base material in which the walls of the pockets are coated with antifriction material which implies the need to carry out tensile tests, shock tests, and peel strength testing so that experimental product research focuses on potentially optimal features. The aim of the current exploratory research presented in this study is the testing of new composite specimens and the obtainment of dimensioning confirmation because the current standards indicate constructive solutions just for simple, monoblock specimens. In some cases, the redesign of specimens can be determined by a number of disturbing factors. The use of a universal machine to perform traction tests has determined the need for redesigning of the specimens due to deficiencies in the gripping system, which is implicitly designed for simple specimens. Even in cases where specimens need to be redesigned, the costs involved in carrying out the tests are reduced and the results obtained provide clear, future research directions.

1. Introduction

The constant requirement at global level to increase the efficiency of products and production processes within industry, constantly accentuated by technological developments, requires redesigning products and development of new, superior to existing ones. Confirmation of the features of newly designed or redesigned products is done in some cases by tests on small-scale models or on specimens.

Optimizing or developing new products in the heavy roller bearing industry is a challenge because it is unlikely that the kinetic energy of the bearings will be reduced by altering the inner or outer ring design. Reducing the kinetic energy of the bearing by reducing the kinetic energy of the cage can be accomplished if the cage is made of a base body which consists of usual materials with low density, preferably inexpensive, in which the pockets that guide the roller bodies are plated with an antifriction material, a formula that is a genuine new solution for heavy bearings cages [1, 2].

Interlocking between the base material and the cladding elements (plating elements /material) can be achieved by soldering, for example with industrial adhesives, or by brazing [3, 4]. The novelty of cage designed solutions requires verification of the strength of both the intermediate layer between the base body and the cladding element as well as the entire assembly which composes the multilayer material consisting of base body, adhesive and cladding element. The main loads to which a cage is subject are stretching - compression and crushing. The presence of the adhesive as an intermediate layer between the base body and the cladding elements can cause the destruction of the integrity of the assembly and through the peeling of the adhesive layer (adhesive layer exfoliation).

Taking into account the above-mentioned, appropriate compound tests multilayer specimens were designed in order to be subjected to tensile test, shock test and peel strength testing respecting as much as possible existing standards [5, 6].

This paper address only the study of behavior of compound tensile specimens specially designed to perform test on multilayer materials used in the present case in the constructive structure of new, innovative, cages.

2. Test Specimens

Since the newly designed original cages are made up of a base material (base body) which has the pockets plated with some cladding elements made from an antifriction material, adhesively secured with the base material, determines the need for the test specimens to have a similar multilayer structure. The specimens will be composed of an element 1, similar to the base cage material, a cladding element 2 similar to the plating material, and a layer of adhesive that solidifies them (see Figure 1). For testing it is not imperative that the elements 1 and 2 are of different materials and have different thicknesses, but it is imposed to know the tensile strength for each layer (material) which composes the multilayer test specimen. The compound specimens designed in order to determine the characteristics of the multilayer material are made up of two identical elements which are placed in parallel and interlocked with the adhesive.

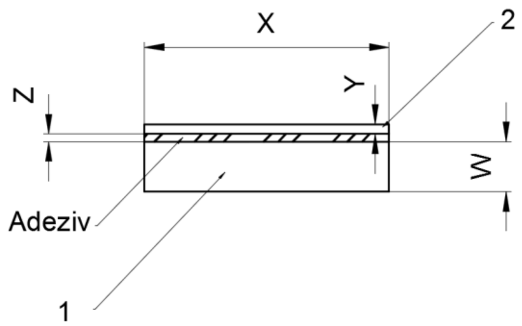


Fig. 1. Multilayer material

In order to determine the tensile strength of the lateral components of the compound specimen we have used simple types of dumbbells specimens (Figure 2) whose geometrical characteristics complies whit the current standards [7].

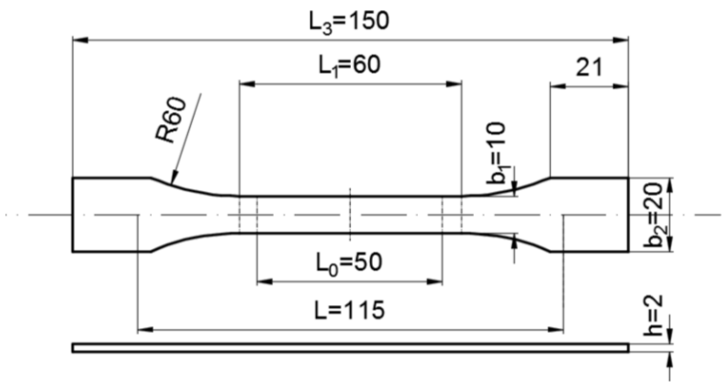


Fig. 2. Standard type dumbbell (Type 1B)

Three variants of compound dumbbell specimens (multilayer material) were designed, variant A (Figure 3), B (Figure 4) and C (Figure 5). The specimen A presented in Figure 3 is composed of two simple type dumbbell specimens, but asymmetric with respect to the probable tear test section L_0 (initial length / specimen neck area). Figure 3 captures all the geometric and dimensional characteristics of the composite specimen A.

Specimen B presented in Figure 4 is different from variant A through the known radius of the probable tear test section L_0. As in case of specimen A, Figure 4 highlights all the geometric and dimensional characteristics of the components and the compound specimen in its entirety.

Specimen C presented in Figure 5 is in accordance whit the geometry indicated by the standard for a simple dumbbell type specimen, differing mainly by the much reduced length of the areas between the ends. The cumulative area b1 of the probable tear test section L_0 of the compound test specimens is smaller than the areas of the gripping heads of the two lateral components which making up the specimens.

It has been assumed that the tensile strength of the adhesive in its bonding plane with the lateral parts of the compound specimen is dependent on the adhesion area. In order to check this, a compound (multilayer) specimen was designed, an idea based on an existing standard [8], consisting of two identical rectangular blades (Figure 6), overlapping with a length L_0 of different values (L_0 = 10; 20; 30; 40; 50 mm), thus providing different values of the adhesion area.

It was proposed to use a speed of 2 mm/min for the tests of the compound specimens, speed which it's in accordance with the standards for simple specimens.

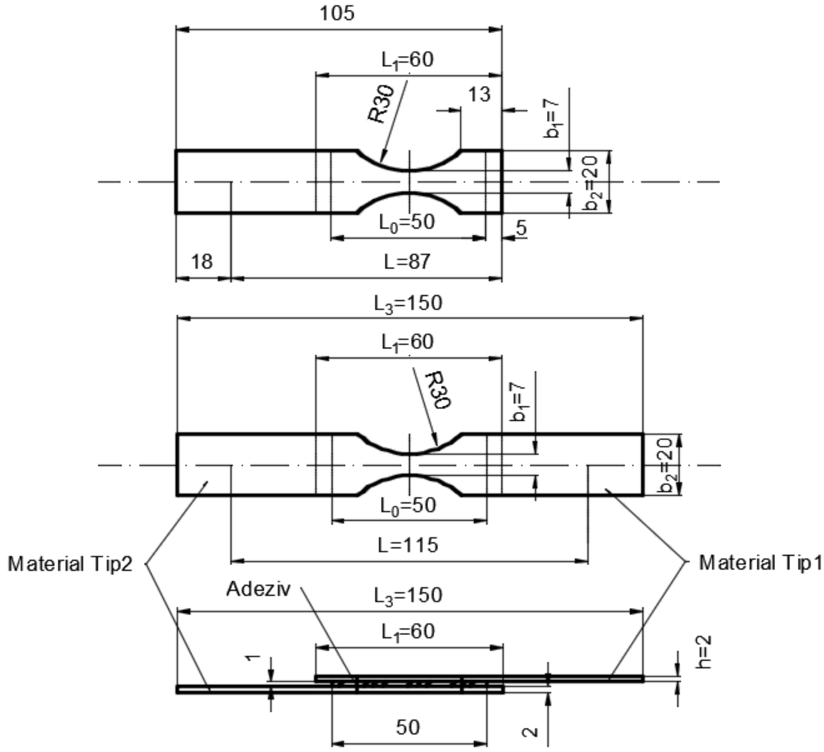


Fig. 3. Compound dumbbell specimen (Version A)

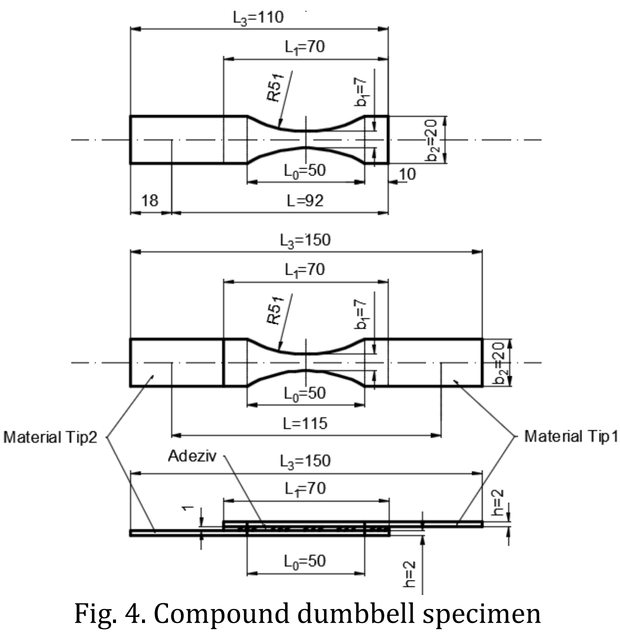


Fig. 4. Compound dumbbell specimen (Version B)

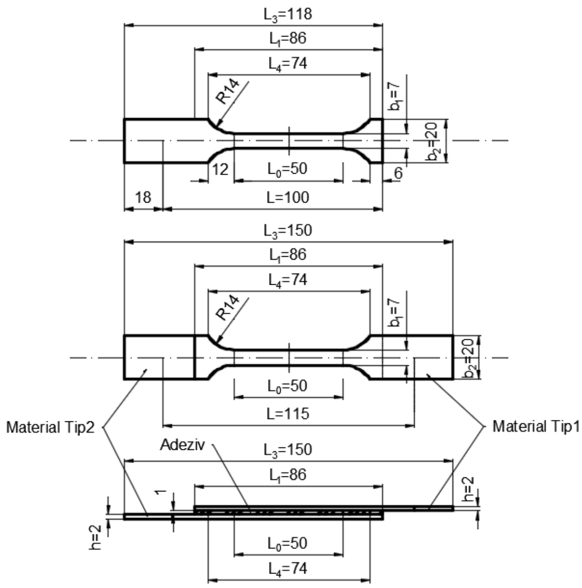


Fig. 5. Compound dumbbell specimen (Version C)

3. Preparation of Specimens

The specimens were made of steel S185 [9] which is equivalent to OL32, according to the standards in force, their component parts (component blades) having in all cases the thickness h = 2 mm. The thickness of the specimen blades was obtained by rectifying them (Figure 7).

The thickness of the adhesive layer was in all cases h ≅ 1 mm. In order to obtain the necessary thickness of the adhesive for all compound test specimens these specimens were "assembled" using a grip vice and a spacer with a thickness of h = 1 mm (Figure 8). The process in which the specimen adhesion area is marked and the mode of adhesive application for the components of a compound specimens is shown in Figure 9, a simple process that requires no specials tools or complex devices at all. The excess adhesive resulting around the specimens was removed after partial curing of the adhesive (Figure 10).

To ensure the maximum adhesive strength, the specimens were left 24 hours to cure.

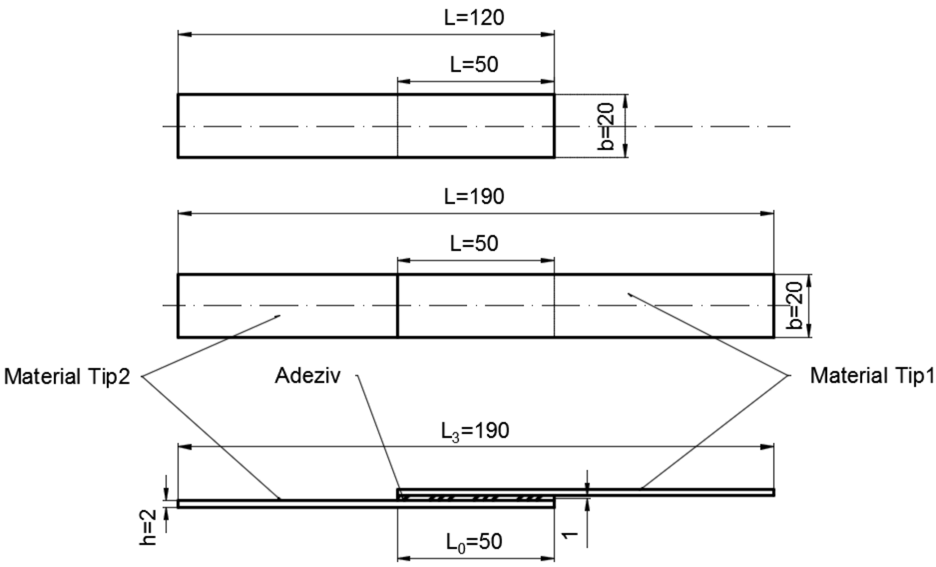
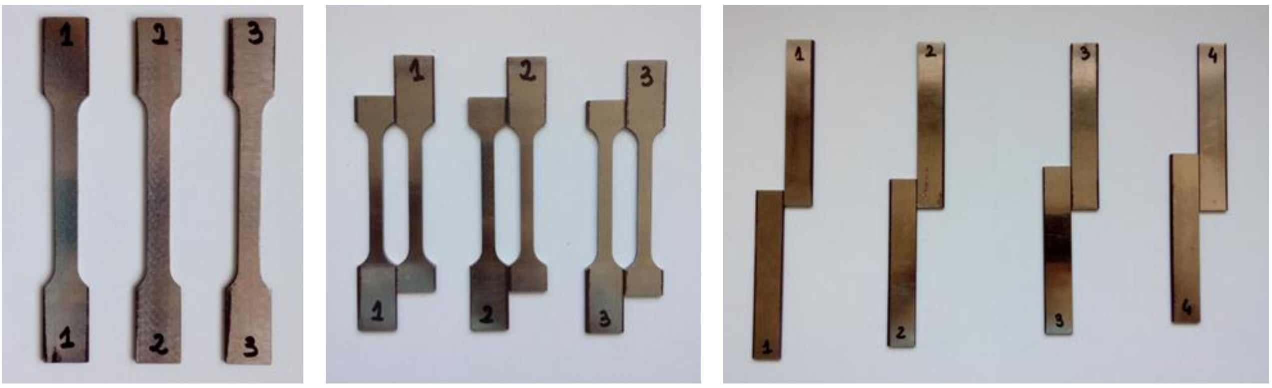


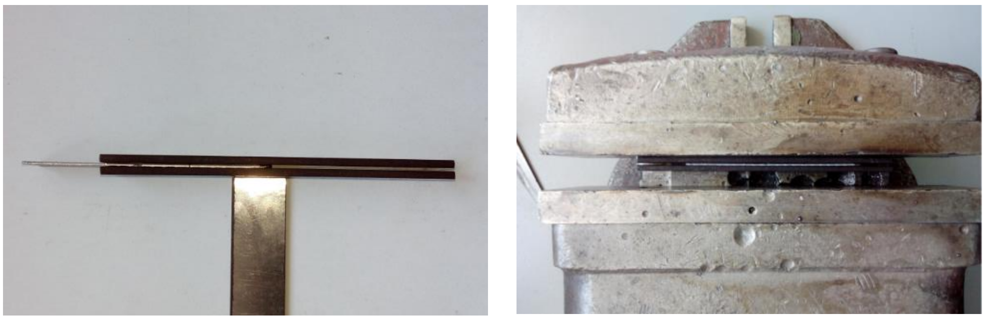
Fig. 6. Test specimen made to determine the shear properties in the bonding (soldering) plane by tensile testing



A B C

Fig. 7. Manufactured tensile test specimens

(A - standard dumbbell specimen; B - compound dumbbell specimen version C; C - Test specimen made to determine the shear properties in the bonding plane by tensile testing)



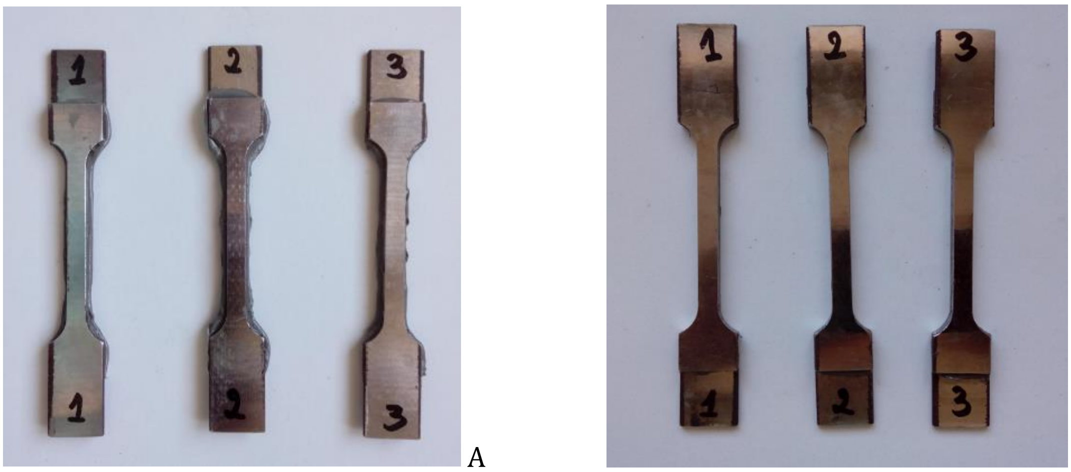
A B

Fig. 8. Method to provide a layer of adhesive of 1 mm

(A-device created; B - usage mode)

A B C

Fig. 9. Compound dumbbell specimen - version C
(A - marking of the bonding area, B - adhesive application on the bonding area, C - assembled specimen)



A B

Fig. 10. Compound assembled dumbbell specimens - version C
(A - with excess adhesive, B - with excess adhesive removed)

4. Testing of Specimens and Results

A Universal Testing Machine type LFV-50HM presented in Figure 11, hydraulically operated, was used to perform the tensile tests on the specimens, available at Transilvania University of Brasov (Material Resistance Laboratory).

Some of its features are:

- static load capacity ± 63 kN;
- dynamic load capacity ± 50 kN;
- piston stroke 100 mm;
- distance between connection adapters up to 1200 mm.

The fastening of the heads of the specimens is done in the two identical ends of the machine by means of two jaws translatable in the inclined plane. This particularity determines the axial tension of the specimen during tightening (stress compression).

The research was carried out as follows:

- In the first step, the standard dumbbell (Type 1B) specimens (Figure 12) were tested in order to obtain the confirmation of the strength characteristics of the material (S185 steel) from which the composite specimens were made.

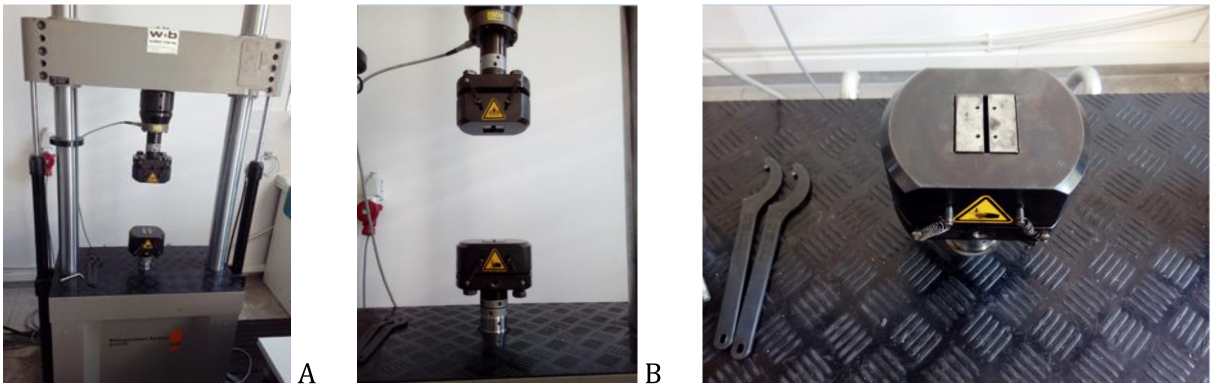


Fig. 11. Universal Testing Machine Type LFV-50HM
(A - view of the cell test, B and C - view of the clamping system)

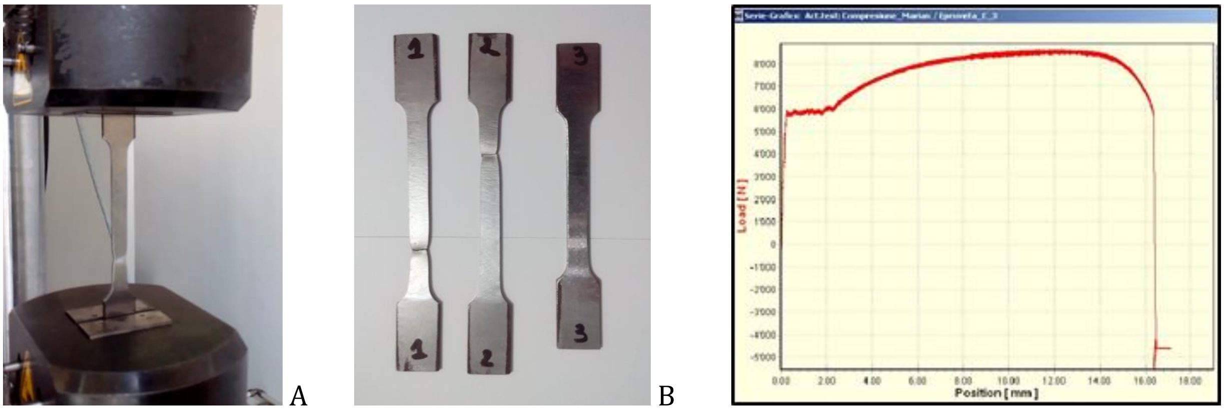


Fig. 12. Testing standard dumbbells
(A - test, B - specimens after test, C - graphic representation of the test result)

- In the second step the compound specimen's - version C were tested (see Figure 5). When the first specimen was tested, due to the axial load that occurred when the specimen was fastened, this was subjected to compression (buckling) and the destruction of the specimen occurred through separation of the adhesion plan (see Figure 13). The phenomenon was identified and when the second test was performed the entire thickness of the specimen was gripped between the jaws, the effect being also this time the detachment of specimen components in the adhesion plan. It has been concluded that this type of specimens needs to be redesigned so that the effect of the jaw translation that occurs when the specimens are caught will not affect their integrity.

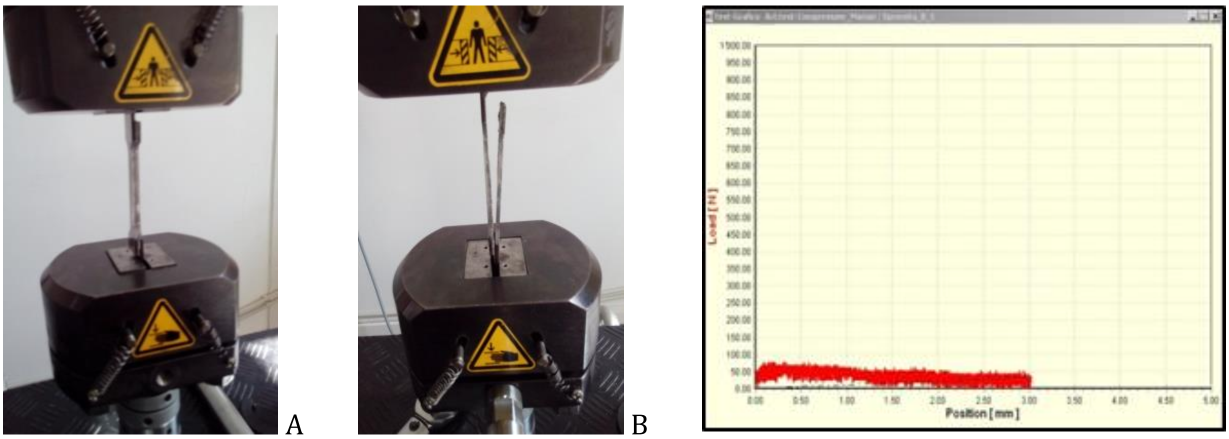
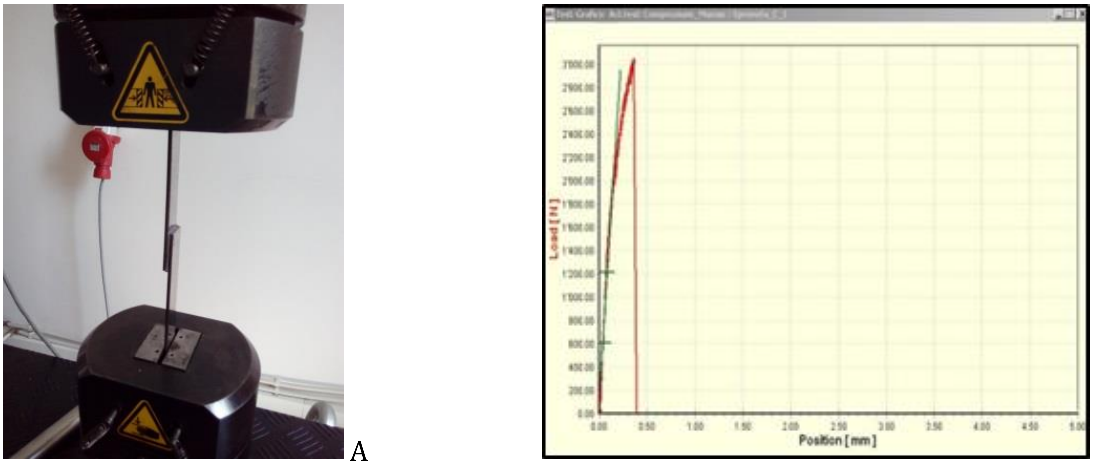


Fig. 13. Testing of compound dumbbell specimen - version C
(A - test, B - specimens after test, C - graphic representation of the test result)

- Finally the specimens made to determine the shear properties in the bonding (soldering) plane by tensile testing, which is preselected in Figure 14. The first specimen was gripped in the jaw of the machine with compensation for the jaw translation. Two attempts have been successful. It is necessary to mention that the gripping heads of the specimens made to determine the shear properties in the bonding (soldering) plane by tensile testing are not in the same plane and as a result bending stresses appear. As the overall length of the composite specimen decreases (in those with increased adhesion surfaces), the bending stresses of the adhesion area increases and therefore decay (unsoldering) occurs due to the bending stresses exercised and not due to the traction stress to which the specimen is subjected. This phenomenon was highlighted in the third and fourth attempts, which led to the conclusion that these specimens should be redesigned as well.



A B

Fig. 14. Tensile testing of specimen made to determine the shear properties in the bonding (soldering) plane

5. Conclusions

Standards in force indicate constructive solutions only for simple specimen's types, monomaterial specimens. For compound specimens, appropriate specimens for the study should be designed.

Testing compound specimens on dedicated machines that are made to test simple specimen's types may be accompanied by disturbing factors, fact highlighted in the presented research. These factors can be eliminated by proper design of the specimens tested.

When testing specimens of types other than those indicated in the existing standards, exploratory research in order to identify disturbing factors and validate the constructive solutions of the specimens, it is necessary.

Testing of compound specimens made to determine the shear properties in the bonding (soldering) plane by tensile testing revealed that, apart from the two main variable factors, adhesion area and the thickness of the adhesive that directly influenced the strength of the adhesive, the variance of the roughness parameter was not talked into consideration for the current test. Roughness in the current case where the specimen's parts are bonded together can significantly contribute to the increase or improvement the strength and the behavior of the assembled elements. Thus for future tests it is recommended to use various roughness's for the adhesion area of the compound specimens.

In the case of cages which have the pockets plated with antifriction materials, cages which are especially dedicated to be used in heavy bearings, the study of different characteristics using proper designed specimens implies low costs and offers a highly advantage for any research on the product because this types of test ensures focus on potentially optimal features.

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