BONDING OF NON-METALLIC MATERIALS USING THERMOPLASTIC ADHESIVES

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Abstract. The paper presents the strength tests results of joints made by use of different fusible adhesives on ethylenevinylacetate (EVA) basis. Four non-metallic materials were bonded, namely plywood of two different thicknesses and spruce, and pine wood. From plywood sheet the test specimens of dimensions 25x100 mm were cut out under the angles of 0˚, 45˚ and 90˚ related to the plate length. The specimen pairs were bonded with the overlap of 20 mm using the fusing gun. All these assemblies were loaded using the universal tensile strength testing machine up to their destruction. The destructive force and the destruction type (failure of the bond, of the bonded material) were registered. From the results of the carried out tests evaluation it unambiguously follows that the angle of the acting force is of the maximum influence on the joint resultant strength. But the sort of used adhesive is of expressive influence, too. The bonded surface roughness is of minor influence.

Keywords: adhesive bonding; fusible adhesives; bonded joints testing.

Introduction

Bonding is taken for the modern and perspective method of undetectable jointing of metallic and non-metallic materials. With regard to its properties the bonding technology complements the used methods assortment, e.g. soldering, welding or riveting.

One of evolving methods of easy and fast bonding above all of non-metallic materials is the use of contact fusible adhesives. They contain no solvents, they are hygienic and sanitary unexceptionable. Using them it is possible to join practically all non-metallic materials, e.g. wood, paper, textile, plastics, tiles, ceramics, and metallic materials, too. Manufacturers deliver them in various forms, most often as sticks, granulate, cushions and blocks. The simplicity of the adhesive application is the greatest advantage. This is advantageous for hobby, too. Rather lower bonded joints strength is the disadvantage.

Materials and methods

The bonding was carried out under the conditions recommended by manufacturers of fusing guns and fusible adhesives. Two adhesives on ethylenevinylacetate (EVA) basis were tested, namely TERMIK 150 and TERMIK 251. Their basic properties are presented in Table 1. The chosen non-metallic materials were bonded, namely plywood and wood from spruce and pine.

Table 1

Properties of adhesives TERMIK

Adhesive type	**TERMIK 150**	**TERMIK 251**
adhesive colour	white	yellow
stick diameter and length	11.2 – 200.0 or 300.0 mm	11.2 – 200.0 mm
working temperature	120 – 190 ˚C	170 – 190 ˚C
workability time	15 – 20 s	30 – 35 s
solidification time	5 – 8 s	2 – 4 s
by manufacturer recommended application	for bonding of metals, fibers, wood, plastics, ceramics, paper, excellent waterproof	for bonding of metals, plastics, textile, ceramics, wood, toys and decorations
1 kg sticks price (without VAT)	179.40 CZK (7.05 €)	499.20 CZK (19.61 €)

The test specimens of dimensions 25 x 100 mm from plywood sheets, spruce and pine boards were cut out in different directions – in the direction of the longer semi-product size (angle 0˚), in the direction of the smaller semi-product size (angle 90˚) and in the beveled direction (angle 45˚).

For the strength testing of joints made using the manually operated fusing gun and the contact fusible adhesive the modified test according to the standard CSN EN 1465 (66 8510) was used. The shape and dimensions of the test specimens before and after bonding are evident from Figure 1. Besides of the 4 mm plywood thickness the plywood of 8 mm thickness was tested, too. The specimens from spruce and pine wood were of 6 mm thickness. The other dimensions are the same as it is presented in Fig. 1. For loading the universal tensile strength the testing machine was used. The test was finished at the joint destruction.

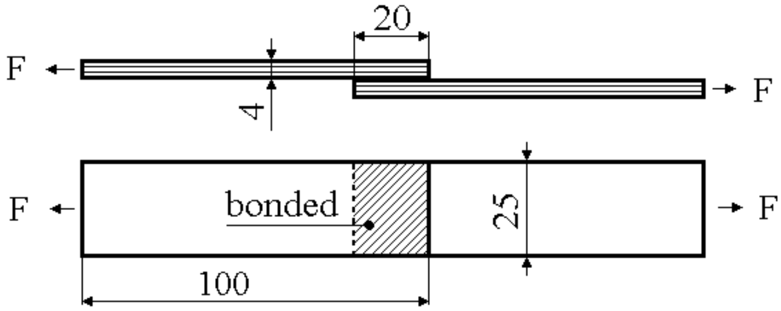

Fig. 1. **Test specimens shape and dimensions**

The aim of carried out tests was to evaluate the influence of:

- load direction (0˚, 45˚, 90˚),
- bonded surface roughness (S – smooth – surface of plywood, surface of planed boards, R – rough – surface of sawn wood),
- sort of used fusible adhesive (TERMIK 150, TERMIK 251).

Results and discussion

The test results of the specimens from plywood of 4 mm and 8 mm thickness are presented in Figure 2, of the specimens from spruce wood in Figure 3 and of the specimens from pine wood in Figure 4.

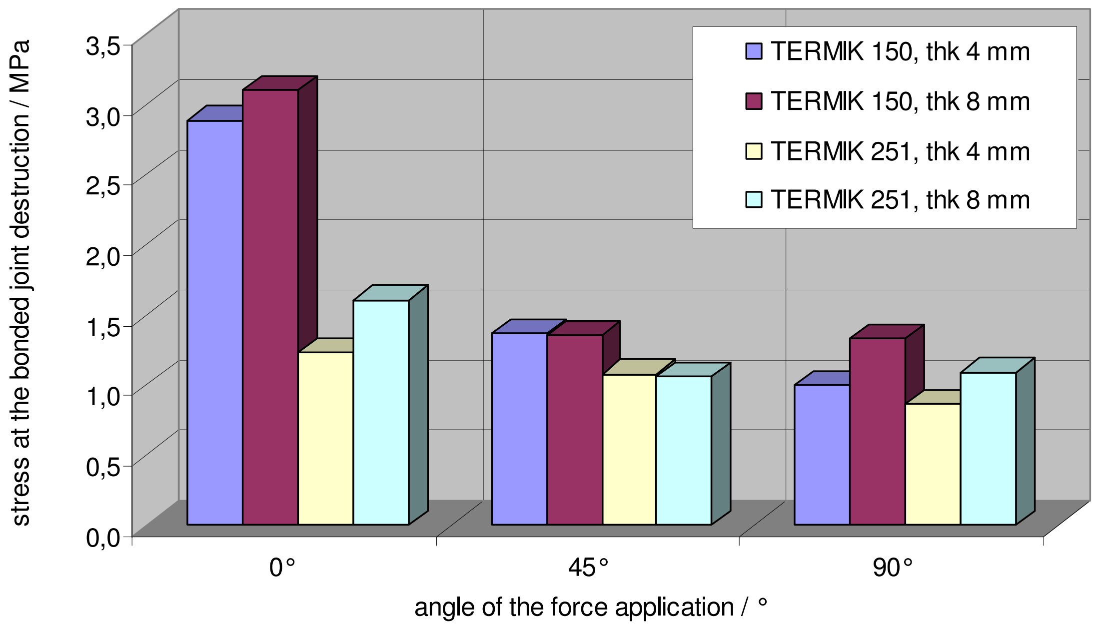

Fig. 2. **Test results of the specimens from plywood**

From the test results of the specimens from plywood it is evident that the load direction is on the joint strength of the maximum influence. In the longitudinal direction (0˚) the joint destruction in the adhesive layer occurs, because the material (plywood) is of higher strength than the joint. On the contrary, in the next two directions (45˚ and 90˚) the plywood is of lower strength than the bonded joint and it is the weakest place of the construction.

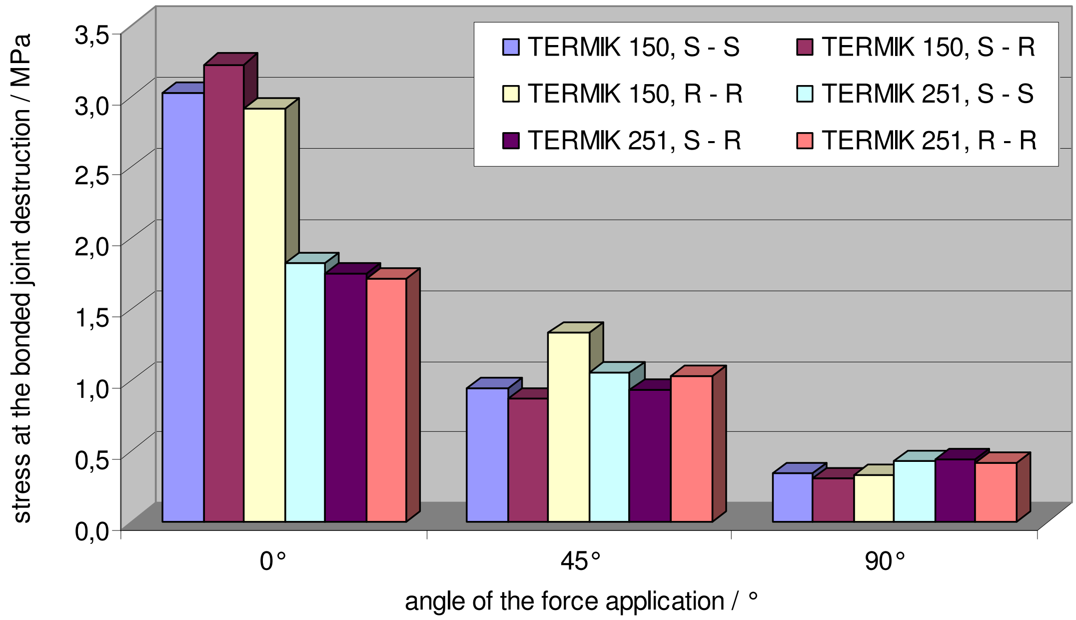

Fig. 3. **Test results of the specimens from spruce wood**

From the tests results of the specimens from spruce wood it is evident that in this case the load direction is of the maximum influence on the bonded joint strength, too. In the longitudinal direction (0˚) the bonded joint destruction always occurs because the bonded material (spruce wood) is of higher strength than the joint. In the contrary, in the next two directions (45˚ and 90˚) the wood is of lower strength than the bonded joint.

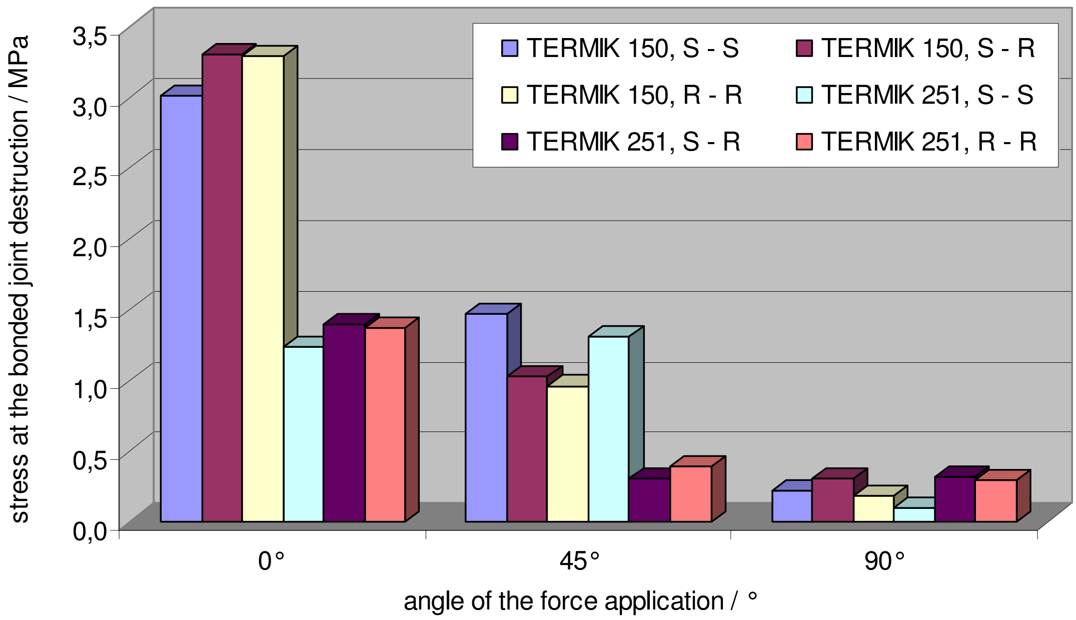

Fig. 4. **Test results of the specimens from pine wood**

From the tests results of the specimens from pine wood it is evident that also in this case the load direction is of maximum influence. In the longitudinal direction (0˚) the bonded joint destruction always occurs because the bonded material (pine wood) is of higher strength that the joint. In the contrary, in the next two directions (45˚ and 90˚) the wood is of lower strength than the bonded joint.

From the test results of all materials it is also evident that the strength of joints bonded using different adhesives is very different. By the use of the adhesive TERMIK 150 the joints strength of all bonded materials is expressively higher than by the use of the adhesive TERMIK 251, but its price is only of one third.

It is interesting that the surface roughness influence on the bonded joint strength is relatively low. From the tests results it follows that compared with the two above mentioned factors the surface roughness is practically of no influence.

Conclusion

1. The paper presents the results of the laboratory strength tests carried out according to the modified standard CSN EN 1465 (66 8510) using the specimens from plywood of 4 and 8 mm thickness and from wood of spruce and pine.
2. From the semi-products (plywood sheets and wooden boards) the specimens were cut out in the direction of the longer side (0°), in the direction of 45° and of 90° (crossly). The specimens were bonded using the manually operated fusing gun and two fusible adhesives (TERMIK 150 and TERMIK 251) on ethylenevinylacetate (EVA) basis. Then the joints were loaded using the universal tensile strength testing machine till destruction. The highest force was registered.
3. From the carried out tests results it follows that from the standpoint of the bonded joint load capacity the influences of the load direction and of the used adhesive are dominant. In all events the joint destruction occurs in the adhesive layer (loading direction 0°) or in the basic material (load directions 45° and 90°). Using the adhesive TERMIK 150 expressively better results were reached than using the adhesive TERMIK 251. The influence of the bonded surface roughness was practically insignificant.

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