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Adhesively Bonded Joint Analysis with Use of Acoustic Emission

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Abstract: Presented paper deals with analysis of adhesively bonded joint with urethane methacrylate-based adhesive, which was subjected to the effect of adhesive aging investigation. The testing procedure consists of compression test of the testing preparation with adhesively bonded joint and simultaneous measurement of acoustic emission activity at two places on testing sample. Obtained experimental results are discussed and compared with datasheet information. Detailed analysis of measured acoustic emission data will be also performed.

Keywords: Adhesively Bonded Joint; Acoustic Emission; Uniaxial Compression Test.

1 Introduction

Technology of joining structural parts with aim of various types of adhesives practically interferes wide part of industrial sectors, concretely automotive, aerospace or marine industry. Nowadays trend is to manufacture products with low production costs with associated demands on simple and, let's say, effective geometry. All these requirements correspond with use of adhesively bonded joints, which will help us to reduce costs for fasteners while reducing weight. Despite a significant expansion and progress on theoretical and technical field [1], the bonding technology still does not get above commonly used traditional technologies (screw joints, solder joints etc.).

Nowadays, acoustic emission testing [2] has become a recognized nondestructive method, used to detect and as well as locate defect caused by mechanical loading of structures. In contrast to other nondestructive methods like ultrasonic testing, magnetic powder testing or penetration method, acoustic emission method is applied before or after loading of the structure. Sometimes, acoustic emission method is being called "passive" nondestructive method, because the defects can be detected only during their formation. Hence, the disadvantage is in the inability to repeat particular test. On the other hand, acoustic emission method is able to detect the failure in the very early stage.

The main aim of proposed paper is to provide comparison between two samples of the same type of adhesive, differing in the manufacture date (2015 vs. 2005 – original package stored in the dark at temperature of 20 degrees) in terms of declared value of compressive shear strength and the overall behavior of adhesively bonded joint, exposed to loading. Acoustic emission [3] has been used to map out what's happening inside adhesive during the compression test.

2 Experimental Procedure

The authors have realized four compression tests altogether, two with new adhesive and two with old one. All tests were performed on multiaxial testing device INOVA 100 kN. The loading speed was equal to 1 mm/min. The adhesively bonded joint test apparatus consists of mortise housing and tenon, on which has been machined groove to the depth of 0.1 mm (see Fig. 1). Following solution ensures us constant adhesive thickness of 0.1 mm. Six channel acoustic emission measuring system supplied by Soundwel Technology Company has been used.

For current measurement, authors have used only two channels, which have been equipped by SR150 series resonant sensors with two separate 40 dB amplifiers. Initial calibration of the AE system has been made by Pen test [4] (Hsu-Nielsen source). The threshold was set to 40 dB in order to avoid the specific noise. A simultaneous recording of processed AE variables (AE Counts, RMS) and force as function of offset of hydraulic grips has been done.

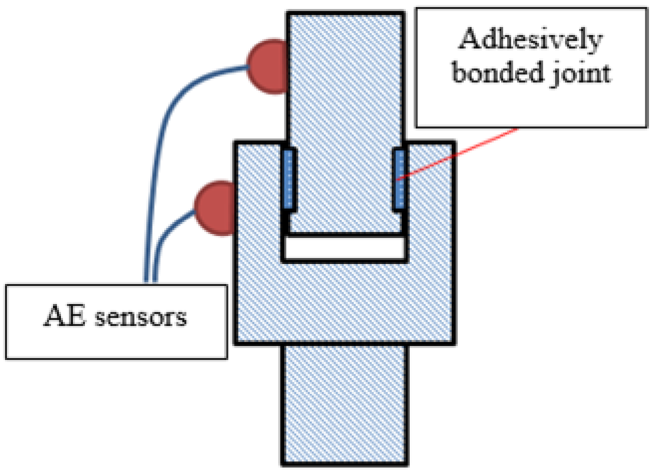

Fig. 1: Adhesively bonded joint test apparatus and placement of sensors.

3 Results

Following figures display us dependences of force, AE counts and RMS value as function of offset of hydraulic grips of INOVA 100 kN testing device and adhesive manufacture date. In both cases (adhesive of manufacture date 2015 and 2005), we have reached very good conformity in terms of results, therefore, the paper contains only one result set from each experimental adhesive set.

Fig. 2 and Fig. 3 show results of adhesive of 2015 year of manufacture. Generally speaking, the structure starts to exhibit AE activity when any discontinuity or defect will occur. The first signs of AE activity started to appear around the value of 0.25 mm of hydraulic grips offset, where we can also notice a certain change in force/offset dependence.

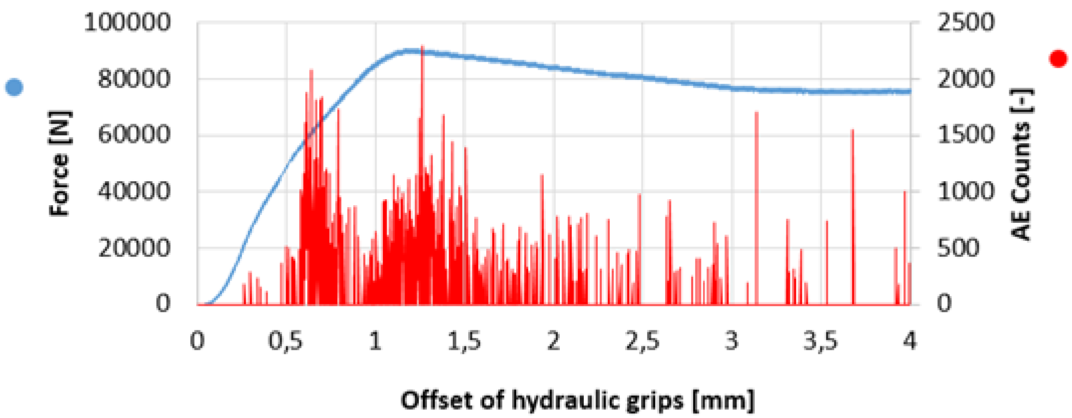

Fig. 2: Force and AE counts as the function of offset of hydraulic grips – Adhesive with 2015 year of manufacture.

After the value of 0.5 mm of hydraulic grips offset, there are present two significant regions with AE activity. The first culminates at value of 0.7 mm supplemented with relatively high values of RMS – Fig. 3 (signal energy). It is quite clear, that at this point, the adhesively bonded joint was partially breached with simultaneous ability to still transfer the loading. After failure of the adhesively bonded joint, the AE activity was emitted by mutual friction of bond surfaces.

Fig. 4 and Fig. 5 present us results from test of the same adhesive, but with the 2005 year of manufacture. It is evident, that the force/offset, AE Counts/offset and RMS/offset dependencies are different. Especially the AE Counts/offset dependence exhibits only one significant peak. The RMS/offset dependence has, however, revealed us AE activity about the value of 0.7-0.8 mm of offset.

If we focus on the values of AE counts and RMS in both experiments, can we notice, that the adhesive with 2005 year of manufacture has approximately ten time larger value of AE counts compared to adhesive with

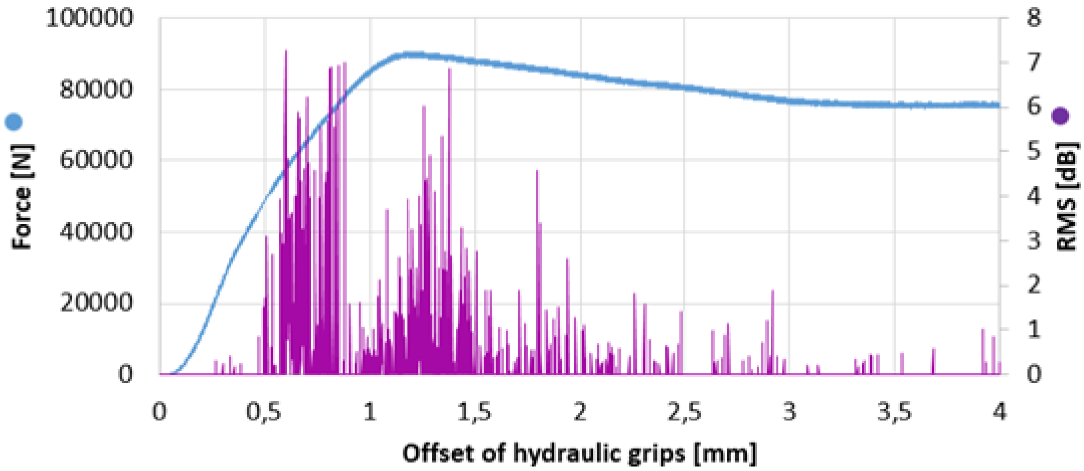

Fig. 3: Force and RMS values as the function of offset of hydraulic grips – Adhesive with 2015 year of manufacture.

2015 year of manufacture. RMS value of the signal are however greater in the case of adhesive with 2015 year of manufacture.

Presented results indicate, that in case of adhesive with 2005 year of manufacture, the breach was brittle with formation of large number of microcracks, which resulted in large amount of AE counts with lower amplitudes. Lower values of AE signal amplitudes are reflected in lower values of RMS.

On the other hand, adhesive with 2015 year of manufacture exhibits, as mentioned earlier, ten times smaller values of AE counts, but with higher rate of RMS. These results point to more ductile failure compared to older adhesive.

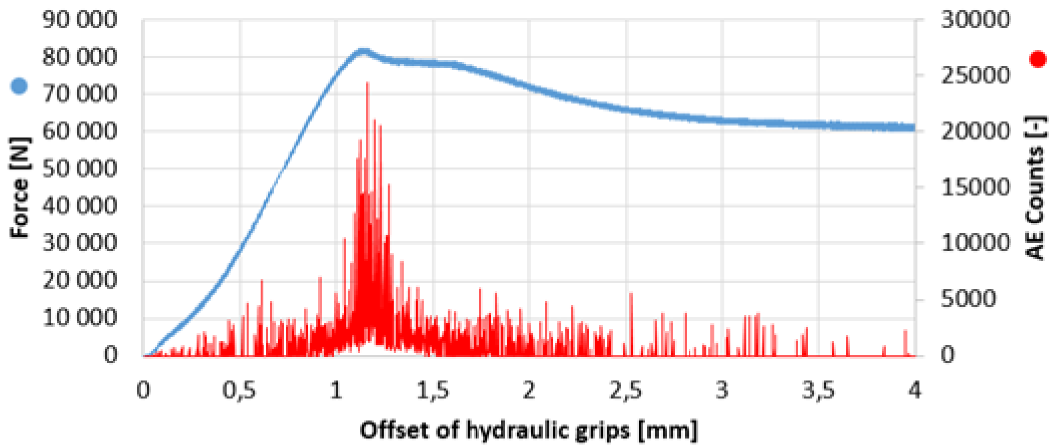

Fig. 4: Force and AE counts as the function of offset of hydraulic grips – Adhesive with 2005 year of manufacture.

4 Conclusion

Comparison between two samples of urethane methacrylate-based adhesive with different year of manufacture has been performed in order to assess the behavior and quality of the adhesive in regard to the effect of aging. Acoustic emission method has been used to map out what's happening inside the adhesively bonded joint during the compression test.

Experimental results showed, that the proper storage of intact package, even stored for ten years, doesn't have marginal effect on shear strength. In addition, both adhesives fulfilled declared values of shear strength. The difference has been found in the failure mechanism.

The older adhesive (2005 year of production) showed in its results brittle breach, which resulted in large amount of AE counts with lower amplitudes. The result of newer adhesive showed us significantly lower values

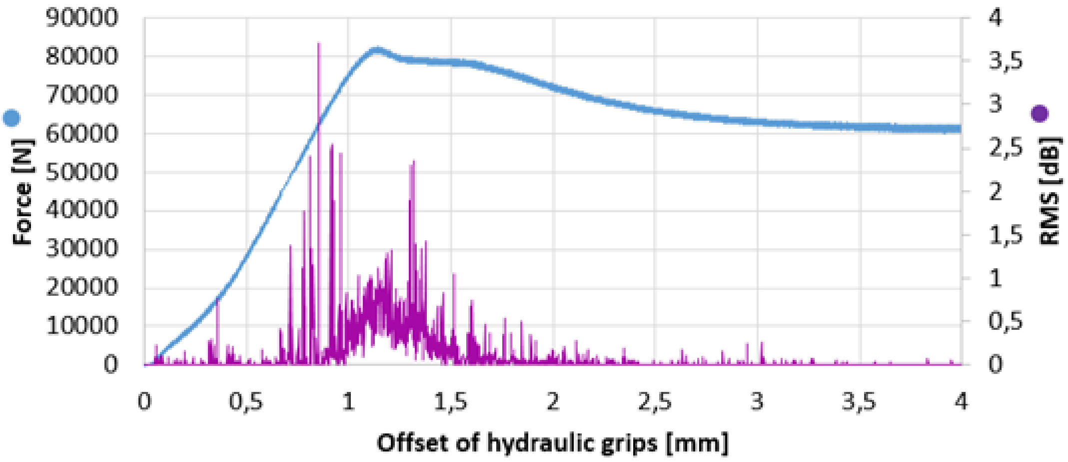

Fig. 5: Force and AE counts as the function of offset of hydraulic grips – Adhesive with 2005 year of manufacture.

of AE counts, but with higher amplitudes of AE signal, which indicates us more ductile failure compared to older adhesive.

Acknowledgement

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