Studies and research on the crack testing for brazed aluminium alloys specimens

A Dimitescu\textsuperscript{1*}, C Babiş\textsuperscript{1}, D F Niţoi\textsuperscript{1} and C Radu\textsuperscript{1}

\textsuperscript{1}Univ. Politehnica of Bucharest, Splaiul Independenței no. 313, sect 6. Bucharest, Romania

E-mail: andrei_dimitescu@yahoo.com

Abstract. The scope of this paper is the identification of an optimum technological solution for brazing aluminum alloys using crack tested specimens. To obtain conclusive results, these tests are conducted on two sets of different specimens. Thus, we get two sets of data which we will compare. These tests are part of the standardized series of tests required by the ASME standards. These are called exfoliation tests. They are used to determine where the crack occurs: in the base material or in the filler material. Thus, we can determine whether the cracking is cohesive or adhesive.

1. Introduction

One of the materials used in all industrial branches is aluminum and its alloys. In order to obtain an unmistakable joining of one or more components of this material, we can use various technologies such as welding, brazing, bonding, riveting, etc. As in all cases, the technologies used have advantages and disadvantages that we can only highlight with destructive and non-destructive testing [3]. Considering that the brazing operation is a welding-related process, at the boundary between welding and bonding operations, the peeling tests are part of the standardized series of tests.

In order to determine the values at which breaking of the aluminum specimens occurs, two types of specimens will be presented in detail in the paper. To put in execution this destructive test procedure, I used the Universal Fatigue testing Machine INSTRON 8801 shown in Figure 1 in accordance with the effective standards; the loading speed was 1mm/min, the acting force of the grips represents 10\% of the force applied on the specimens.

Figure 1. Universal Fatigue Testing Machine INSTRON 8801: 1.testing device; 2.control system of pressure and temperature; 3.electric motor; 4.software; 5.transforming data system; 6.P.C. for working [6].
For the registration of the local deformations, it was used an extensometer with 50mm measuring base and was applied on the specimens until the specific deformation reached 3%.

![Figure 2. Wedge Grips serial number 3520 [1].](image)

For fastening the specimens has been used a clamping system series 3520, with its characteristics described by the manufacturer. The device is shown in Figure 2.

2. Experimental Data
To determine the values of the forces setting it is necessary to calibrate test instrument on a set of samples from the same batch.

![Figure 3. Specimen 1 to 13.](image)

Thus 13 samples were randomly selected and cut at the same size. Due to tests results several graphs. Mediating these interim results we can determine the value range that should set de device.

The results are presented in Figure 3 and in table 1.

The crack testing of the experimental specimens in case of aluminum brazed alloys were executed on two units of specimens named onwards „folded specimens” and „experimental specimens”. [4]
Table 1. The values maximum tensile stress – load specimen 1÷13.

|                | Modulus (Segment 0.01 % - 0.2 %) (MPa) | Tensile stress at Tensile Strength (MPa) |
|----------------|----------------------------------------|-----------------------------------------|
| 1              | 72716.45078                            | 255.48909                               |
| 2              | 50256.33160                            | 260.20387                               |
| 3              | 42099.28267                            | 249.67543                               |
| 4              | 65535.27963                            | 175.02436                               |
| 5              | 5074.20228                             | 69.76217                                |
| 6              | 2864.79769                             | 59.65678                                |
| 7              | 7226.47623                             | 88.93281                                |
| 8              | 4203.56999                             | 76.53837                                |
| 9              | 3306.87539                             | 70.30969                                |
| 10             | 5087.66295                             | 76.06730                                |
| 11             | 4091.69669                             | 72.79232                                |
| 12             | 4549.95272                             | 77.19921                                |
| 13             | 17262.75607                            | 121.54138                               |
| Median         | 5087.66295                             | 77.19921                                |
| Coefficient of | 119.10653                              | 62.02752                                |
| Variation      |                                        |                                         |
| Standard       | 26045.42731                            | 78.87958                                |
| Deviation      |                                        |                                         |

The first unit consists on 6 specimens that were brazed using an optimum technology: pickling with Aloclene 100 solution, applying the filler material on both sides of the base material, using spectral acetylene and a neutral flame.

It is mentioned that during the entire period of assembling the specimens it was used one single operator to avoid the human errors. “The folded specimens”, figure 4, were retrieved from the same material as the “experimental specimens”.

The specimens were brazed head to head by folding the ends 5mm long under the terms of SR EN 12797 [2] referring to the specimens used for the crack testing (peeling test). It is to be mentioned that the brazing area is constant on all the specimens.

The brazing technology used for "folded specimens" 3 and 6 is the following: pickling the aluminum alloy in Aloclene 100 solution, depositing the filler material on both sides of the base material, using spectral acetylene and neutral flame. [5]

![Figure 4. Unit of tests on „folded specimens”.](image-url)
Figure 5. The results of the crack testing on „folded specimens”.

The tests performed on the test machine shown in Figure 1 resulted in a set of values for the folded specimens breaking forces. These are presented graphically in Figure 5. The correlation between maximum tension and maximum breaking force is shown in Table 2.

Table 2. The values maximum tensile stress - load on „folded specimens”.

| Specimen # | Tensile strain at Maximum stress (%) | Tensile stress (N) | Load at Maximum Tensile stress (N) |
|------------|--------------------------------------|--------------------|-----------------------------------|
| 1          | 2.18890                              | 1547.28889         |                                   |
| 2          | 3.25160                              | 2211.85684         |                                   |
| 3          | 4.31722                              | 4127.02560         |                                   |
| 4          | 2.95765                              | 3716.95757         |                                   |
| 5          | 2.85615                              | 3547.50156         |                                   |
| 6          | 5.91125                              | 4267.31110         |                                   |

The second unit of specimens used for the crack testing is part of the “experimental specimens”. This are presented in Figure 6. Representative technologies were considered those that had very good results on nondestructive examination.

Figure 6. Unit of representative „experimental specimens”.
Figure 7 shows the three graphs corresponding to the 3 "experimental specimens". It should be noted that these specimens were brazed by the brazing technology through which "folded specimens" 3 and 6 were also executed.

It can be seen that the values of the breaking forces are similar to those shown for "folded specimens" 3 and 6.
3. Conclusion
Standardized peeling tests only refer to samples of the folded specimens. These are difficult to achieve due to the bending of the edge on a relatively small area. At the same time, it is possible, in the case of a quick bending, that the aluminum alloy will change its properties by deformation in the bending zone and thus cause a false breaking at the action of the loads.

Experimentally, we demonstrated that using a set of "experimental specimens" the results are similar to the following: all samples should be taken from the same batch of material, all samples should be brazed using the same technology and most importantly use the same technician in order not to enter other values of human error.

In the case of the folded and the experimental specimens, the crack appears in the base material, not in the brazed joint.

In the case of both specimen units, the results dispersal validates the experiments. The technology that consists on pickling with Aloclene 100 solution, applying the filler metal on both sides of the base material, using spectral acetylene and neutral flame can be considered the optimum way because in consequence of the crack testing (peeling testing) could be obtained a maximum resistance in the brazing joint.

4. References
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