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DETERMINATION OF MECHANICAL PROPERTIES OF COPPER ALLOYS, OBTAINED BY FSW PROCESS

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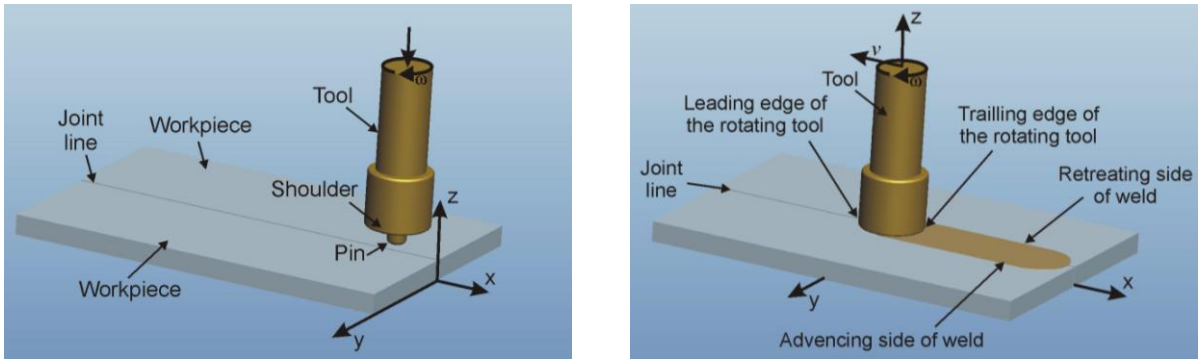
ABSTRACT
In this paper the experimental research were performed, in order to determine the mechanical parameters in the process of joining of materials using FSW process. The paper presents the joining of copper alloy, with thickness of 7.8 mm. Experimental research have been made on the basis of the adopted experimental plan. Values varied in the experiment are: welding speed, rotation speed of tool, angle of pin slope, pin diameter and shoulder diameter. The experiment was carried out under laboratory conditions, which are similar to production.
Keywords: FSW - Friction Stir Welding, Shoulder, Pin, Tensile Strenght, Copper Alloy

1. INTRODUCTION
During the nineties of the last century a new method of joining similar and dissimilar materials in the solid state without melting of material, known as friction stir welding - FSW is developed. The process is patented by The Welding Institute - TWI in England in 1991, and invented by Wayne M. Thomas who has successfully joined plates of aluminum alloys [1, 2, 3, 4]. Method of friction stir welding has very quickly found its application in shipbuilding, aviation and space industry, railroad and other industries. It is primarily used to join plates of larger thickness. Tools that are used in the process of welding are cylindrical and consisted of two concentric parts (Figure 1.a), which are rotating at the great speed. A larger diameter part of the tool is called the shoulder, while the smaller diameter part is called the pin. Rotating tool slowly approaches the joint line and plunges into material, which creates heat. Due to that the temperature increases to the heat metal forming where mechanical mixing and joining of materials is performed, enabling the tool to move in the longitudinal direction or along the joint lines (Figure 1.b). After passing of the tool along the joint lines the solid phase of weld (joint) remains, where the upper plane remains smooth and flat thanks to the tool shoulder, while the lower plane of the work piece is formed from the basis on which the work piece is standing and it is also smooth and flat [5, 6, 7, 8, 9, 10].



(a) *(b)*

Figure 1. Tool and workpiece

2. EXPERIMENTAL RESEARCH

In order to determine the influence of geometric parameters of the tool on the mechanical properties of welded joint, the experimental research of welding of copper alloy, thickness of 7,8 mm was carried out. The family of tools where geometrical parameters were varied was adopted for welding of copper alloy sheet.

The multifactor orthogonal plan with varying of factors on two levels, and repetition in the central point of plan n_0=4 times is adopted. For input values, factors of the welding regime are adopted: welding speed (v = 50; 63; 80 mm/min), rotation speed of tool (ω = 800; 1000; 1250 rpm) and geometrical factors of tools: angle of pin slope (α^o = 3; 3.87; 5), diameter of the pin (d = 3.5; 3.97; 4.5 mm) and diameter of the shoulder (D = 20; 22.36; 25 mm).

For mechanical testing of welded joints, tensile tests are used. The testing is performed with the standard testing machines and test pieces. For the tensile tests, MEST EN 10002-1:2008 standard was used [11], and testing is performed at a ambient temperature. Testing machine is used when testing with module of 200 kN. Samples which are cropped from welded workpieces were taken from y - directions (normal to the direction of welding - side direction).

In tensile test was adopted to the welded workpieces take four samples specimen. In excised specimens all zones that occur in the process of FSW are the length of the test specimen, so in this case we check the quality of welded joints. Arrange the specimens in a welded workpieces taken by the standards of the examination of welds. On this occasion, the cut-out and the test specimen Charpy toughness of the material, as well as to determine the microstructures in the paper will not be analyzed. All cropped specimen are precision machined to the dimensions and shapes that require standards [6, 11] using modern CNC machine for cutting (Wother Jet). In Figure 2 is shown in scheme excision of samples (specimens) for mentioned tests.

Figure 2. Showing excised samples of welded workpieces for copper alloys

Figure 3. provides a schematic view of test pieces, and Figure 4. provides the samples of the test piece in y - direction. Also the specimens are cropped from the base material as shown in Figure 5. Figure 6. shows the diagram of stretch in the central point of plan, test pieces from y - directions, with values of tensile strength Rm.

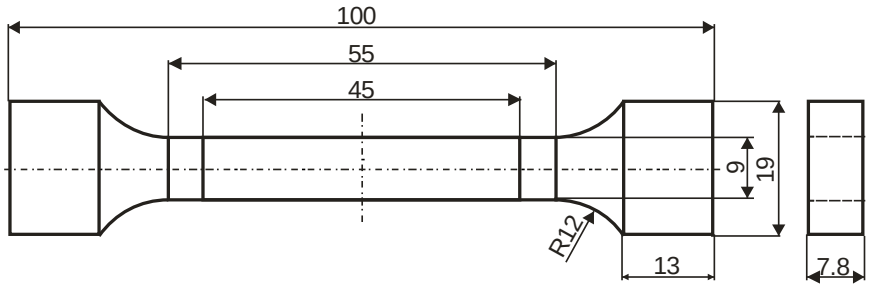
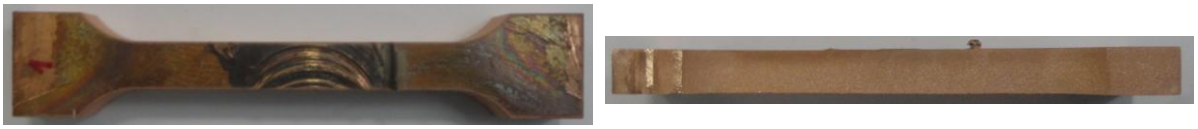


Figure 3. Specimen - Schematic view [4, 11].



(a) (b)

Figure 4. Specimen for tensile testing, y - direction normal to the welding direction; (a) on the upper side, (b) on the sides

Figure 5. Cropped in specimen of the base material

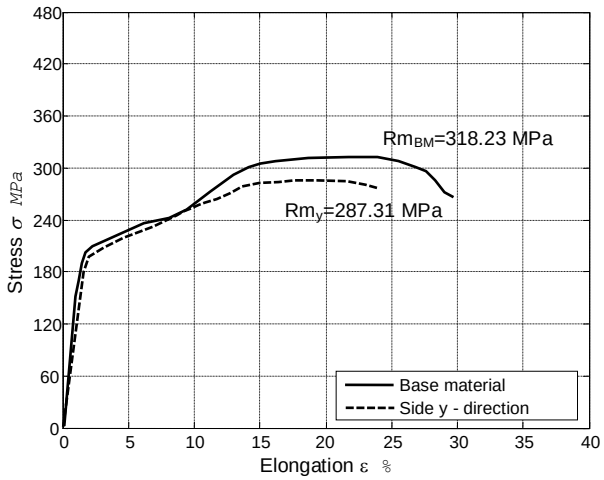


Figure 6. Diagram: Stress - Percentage Elongation.

3. CONCLUSION

The paper presents FSW process and mechanical tests were performed - determination of the tensile strength of welded joints. Based on the experimental results of FSW welding joints of copper alloy, it can be concluded that this procedure with the use of optimal parameters of welding, welded joints with good characteristics can be obtained. For further researches, good experimental conditions are made, and information base, which promise significant results in research that follows.

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