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FRICTION STIR WELDING OF COPPER ALLOYS

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ABSTRACT
This paper presents the research of welding copper alloys using the Friction Stir Welding process. The paper includes experimental researches performed on the basis of the adopted experimental plan. The paper describes the used experimental equipment and tools. This paper analyzes the influence of input parameters on the performance of welding processes.
Keywords: FSW - Friction Stir Welding, Copper Alloy, Tool

1. INTRODUCTION
Method of FSW (Friction Stir Welding) was invented TWI (The Welding Institute) of the England in 1991 as a solid-state joining technique and was initially applied to aluminum alloys [1, 2, 3, 4, 5, 6].
Shortly thereafter, the FSW welding method is applied to other alloys of copper, magnesium, steel, etc.. as well as the welding of dissimilar materials, such as aluminum and copper, steel and aluminum and so on. Method of FSW has very quickly found its application in shipbuilding, aviation, space and car industry [4, 5, 6, 7, 8]. Tools used in the FSW process are cylindrical and consisted of two concentric parts, which rotate at high speed. Part of the tool with larger diameter is called the shoulder, while the part with smaller diameter is called the pin [4, 5, 6, 7, 8, 9]. Tool and workpieces that are welded are shown in Figure 1.

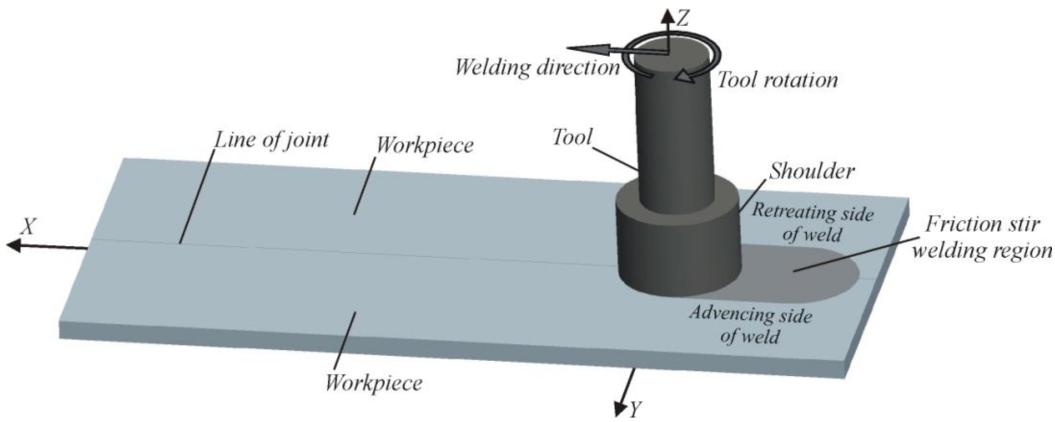


Figure 1. Presentation of friction stir welding method.

Tool shoulders are designed to produce heat to the surface and subsurface regions of the workpiece. Friction stirring pins produce deformational and frictional heating to the joint surfaces [4, 6]. The pin is designed to disrupt the faying, or contacting, surfaces of the workpiece, shear material in front of the tool, and move material behind the tool [4, 6].

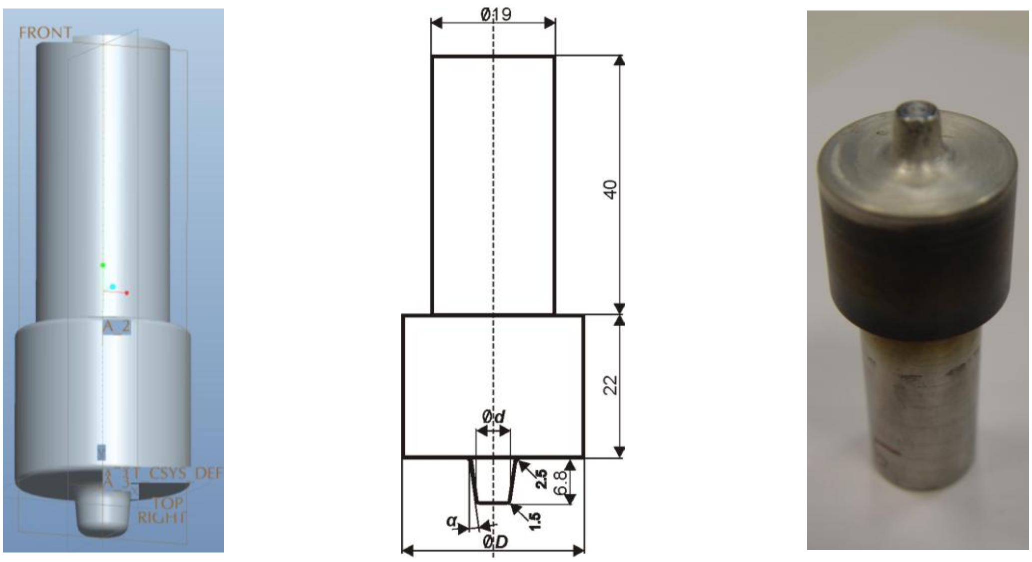
2. EXPERIMENTAL RESEARCH

Experimental research were carried out in laboratory conditions that are similar to production. For experimental research vertical milling machine was used. The material used in this experiment is a copper alloy sheet. Workpieces of dimensions 200 x 50 mm, are obtained by cutting the plate with the thickness of 7.8 mm.

Material of welding tool was 1.2343 steel according to the standard EN 10027-2. The tool was designed in Creo, using a program for parametric modelling (Figure 2.a).

For welding of sheet of copper alloy the family of tools is adopted where the geometrical parameters are varied. The tool is axisymmetrical and consisted of the workpiece and body of the tool. The body of the tool is adjusted to the jaws of the machines used in the experiment. The general appearance of the family of tools for FSW process is given in Figure 2.b.

Based on preliminary researches, 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: $X_1=v$ mm/min (welding speed), $X_2=\omega$ rpm (rotation speed of tool) and geometrical factors of tools: $X_3=\alpha$ ^{o} (angle of pin slope), $X_4=d$ mm (diameter of the pin) and $X_5=D$ mm (diameter of the shoulder). Levels of variation of input factors are adopted and given in Table 1. Presentation of tools in a central point of the plan is given in Figure 2.c.



a) b) c)

Figure 2. Tools of welding process.

Table 1. Levels of variation of input factors.

Input factors	Lower level:	Basic level:	Upper level:
X_1	50	63	80
X_2	800	1000	1250
X_3	3	3.87	5
X_4	3.5	3.97	4.5
X_5	20	22.36	25

Macrostructure of the copper alloy is shown in Figure 3, while Figure 4 shows the complete process of friction stir welding with basic tools and materials with supporting equipment.

Figure 3. Macrostructure of copper alloy.

Figure 4. Vertical milling machine used in FSW method.

Figure 5 presents the welded workpieces on the upper side or the side from which the welding is performed.

Figure 5.The appearance of the welded joint with the upper side of the welded workpieces

3. CONCLUSION

The experimental research successfully completed the joining of copper alloy using friction stir welding method (FSW). Experimental research has established that the dimensions of tools (shoulder diameter, pin diameter and angle of pin slope) have large effect on the quality of weld as well as regimes of welding (welding speed and rotation speed). This experimental research FSW process are part of a broader study that also include quality testing of welded joints through the determination of mechanical properties and microstructure.

4. REFERENCES

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