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QUALITY ANALYSIS OF Al-Cu JOINT REALIZED BY FRICTION WELDING

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Original scientific paper

This paper outlines the bases of the friction welding process, especially when it comes to friction welding of different materials. This was illustrated on an example of friction welding of aluminum and copper, which is often applied in electrical engineering. The analysis of influential parameters was conducted based on the data obtained by an experiment, since the data on this topic are very seldom in the available literature.

Keywords: *friction welding, base metal, aluminum, copper, friction time, friction pressure, compression pressure*

Analiza kvalitete Al-Cu spoja ostvarenog zavarivanjem trenjem

Izvorni znanstveni članak

Ovaj članak daje osnove procesa zavarivanja trenjem, naročito kada je u pitanju zavarivanje trenjem različitih materijala. To je ilustrirano na primjeru zavarivanja trenjem aluminija i bakra, koji se često primjenjuje u elektrotehnici. Analiza utjecajnih parametara provedena je na temelju podataka dobivenih eksperimentom, jer su podaci o ovoj temi vrlo rijetko u dostupnoj literaturi.

Ključne riječi: *zavarivanje trenjem, osnovni metal, aluminij, bakar, vrijeme trenja, tlak trenja, tlak kompresije*

1 Introduction
Uvod

In modern industrial practice there is often the need for joining two completely different metals. Copper and aluminum are metals of high electrical and thermal conductivity, thus they have common application as cables, elements of cooling and heating engineering, civil engineering accessories. That is why it is necessary to join together Al and Cu very often. This is for example joining of copper and aluminum conductors or cable ends. There are several ways to join aluminum and copper: with addition of material (soft and hard solders) and without addition of material (electricity resistance-, cold-, friction-, explosion-, ultrasonic welding).

This paper outlines the friction welding procedure of copper and aluminum parts. Experimental part refers to the quality assessment of realized bimetal joint based on mechanical and micro structural tests.

2 Basic principles of the friction welding process
Temeljni principi procesa zavarivanja trenjem

Friction welding is the procedure of joining metals in solid state, because the welded joint is formed at the temperature that is lower than the melting temperature of the base metal that melts more easily. The essence of the process is transformation of mechanical energy into the heat, which gets released as the result of friction at the joint i.e., in the contact zone. The thin layer of the zone next to the contact line heats up and turns into a plastic state, with action of a pressure force, thus one actually gets the forge welding. The heat developed on the contact surface of the welded parts depends on the compressive force and the friction coefficient of the rotating parts.

The basic advantage of the friction welding is that it can be applied to mutual joining of metals with different mechanical and thermo-physical properties. In addition, it is very often the only possible way of joining some metals, which during welding by other methods form the inter-metallic brittle phases. The process itself and joint formation mechanism in solid state are very complex. There are several hypotheses that describe the process, starting from different assumptions, but none of them can give the full explanation for numerous phenomena that accompany this process. Essentially, all researchers agree that the process of joining in solid state is based on formation of metal bond (solid solutions) between components of the base metals. Such a bond occurs during closing of metal clear surfaces to the distance of the order of magnitude of crystal lattice parameters. Since metal surfaces of real metal pieces are not ideally smooth, the contact at the start of welding will be realized only on the peaks of wavy surfaces. The increase in the surface of the contact can be achieved by plastic deformation of coupled peaks. When the peaks are fully compressed, the boundary surfaces approach to the order of magnitude of crystal lattice parameters, so bonds that enable formation of mutual crystal lattices occur.

Technological time sequences during friction welding of Al and Cu are shown in Figure 1.

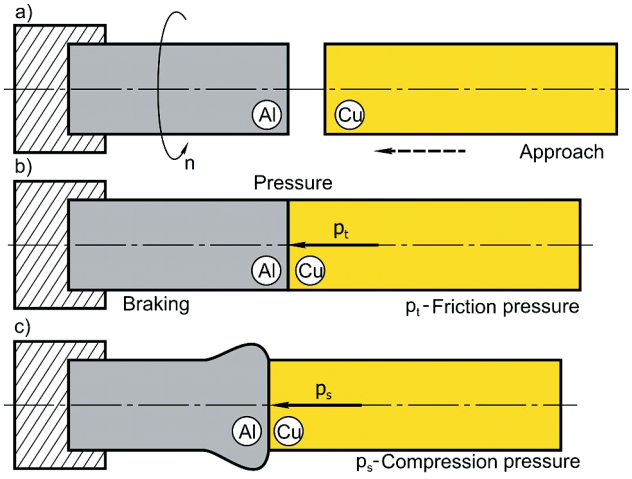

Figure 1 *Technological time sequences during friction welding of Al and Cu* [3]
Slika 1. *Tehnološki slijed tijekom zavarivanja trenjem Al i Cu* [3]

In the course of the friction welding process, the aluminum working object was rotating, and the copper