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NEW WELDING TECHOLOGY – THE COLD WELDING ON COGGED SURFACES

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ABSTRACT

Welding by cold pressing on cogged surfaces, produces the joint of a component made from an easy deformable metal by pressing on the cogged surface of a harder metal component. Different welds between aluminium (the easy deformable component) and copper, brass, steel, stainless steel (harder component, cogged on the contact surface) can be obtained. The weld is obtained only by deforming the aluminium component at a deformation rate of 20…30%. The weld tensile strength is up to 10% of aluminium ultimate tensile strength, better results being obtained for the shearing strength. The weld contact electric resistance is negligible, recommending the process for producing dissimilar elements used in electrotechnics.

KEYWORDS: Cold Pressure Welding, Aluminum Joints.

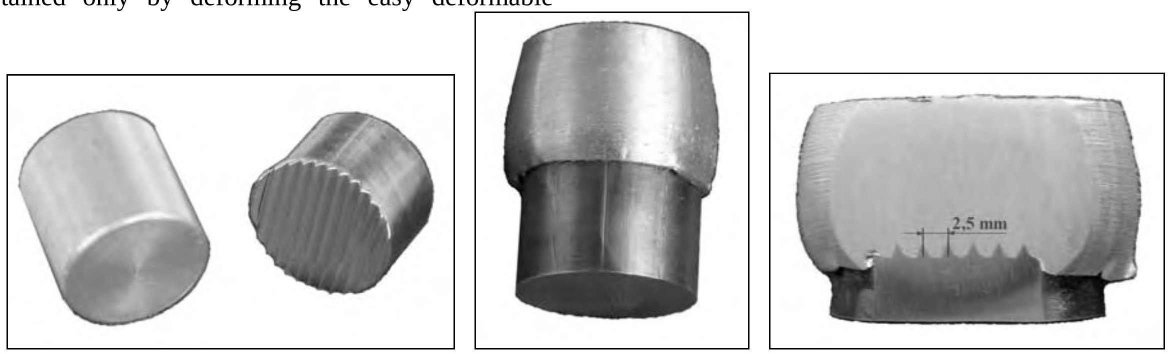
1. Introduction

Cold welding on cogged surfaces is a technology developed by researchers from Robotics and Welding Department, Dunarea de Jos University of Galati [1]. Easy deformable samples, having plane surfaces, are pressed on cogged surfaces of harder samples (Fig. 1). Of importance for joint achievement is the deformation rate of the easy deformable material.

The practical advantage of the cold welding on cogged surfaces is due to the fact that the joint is obtained only by deforming the easy deformable sample, at lower deformation rates than in the case of classical cold welding. This aspect is illustrated in Fig. 2. At the same deformation rate, the weld was achieved only in case of pressed samples on cogged surfaces, the pressed plane samples couldn’t be joined [2].

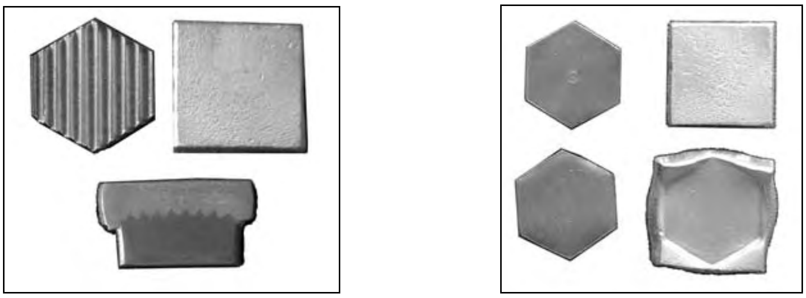
Cold welding on cogged surfaces can be achieved in the following variants:

- ⇨ direct, between two samples with different plasticity;
- ⇨ indirect, between two samples with the same plasticity, using an intermediate easy deformable material.



a) b) c)

Fig. 1. *Specimens’ components: a) before up-setting; b) welded specimen; c) the brass cogs imprint the aluminum.*



a) b)

Fig. 2. *Al-Cu pressed samples at the same deformation rate: a) weld on cogged surface; b) un-weld samples on plane surfaces.*

2. Direct welding

Through direct welding by cold pressing on cogged surfaces an easy deformable material is joined with the cogged surfaces of a harder metal. Were used cylindrical samples with 30 mm diameter and highs of 20...40 mm. The contact surfaces were firstly mechanically cleaned with a rotating steel-wire brush, at a rotating speed of 2800 rot/min. Immediate after the samples’ cleaning, a hydraulic press was used for samples up-setting [3]. Different welded joints were achieved between aluminum (easy deformable sample) and copper, brass, steel and stainless steel (harder, cogged sample). Based on the mechanical test results, several conclusions about the characteristics of the cold welded on cogged surfaces joints were drawn.

Deformation rate. The weld was achieved only by deforming the aluminum sample, at a deformation rate of 20-30%. Higher deformation rates aren’t recommended [4]. Insufficient pressings with reduced degrees of deformation have resulted in an incomplete filling of the space between the cogs, and consequently, in a reduced mechanical resistance. This inconvenience may easily be eye-noticed. The smaller discrete unfilled spaces may be seen with the microscope or by means of penetrating liquids. Moreover, exaggerated pressings result in the deformation of cogs or in cracks. The practice has proved that the peripheral cog frequently modifies its position towards the exterior as a result of the influence of the deformed aluminum on it. Exaggerated pressing is signaled by the flaring of the components.

The cogs geometry must be correlated with the dimensions of the welding samples. In small samples case, the cog angle must be up to 45^{0} for a pitch over 2.5 mm (Fig. 3 and 4). The double cogged joints resisted better of the simple cogged joints (Fig. 5).

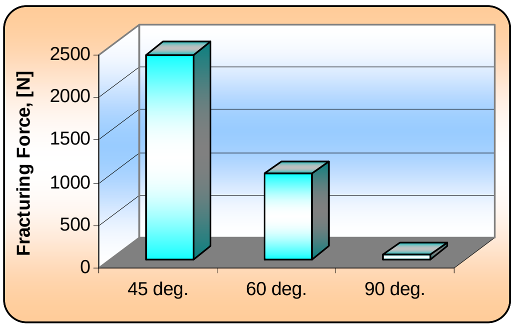


Fig. 3. *The ultimate strength by the stretching of cogs with different angles.*

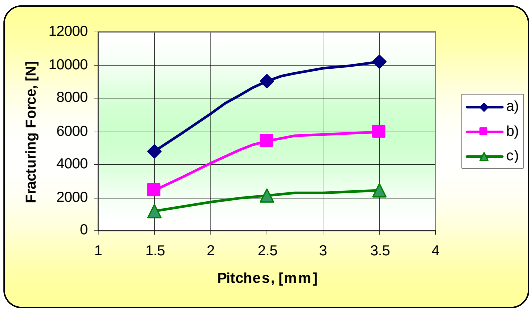


Fig. 4. *The ultimate strength at different pitches: a) by cross shearing; b) by longitudinal shearing; c) by stretching.*

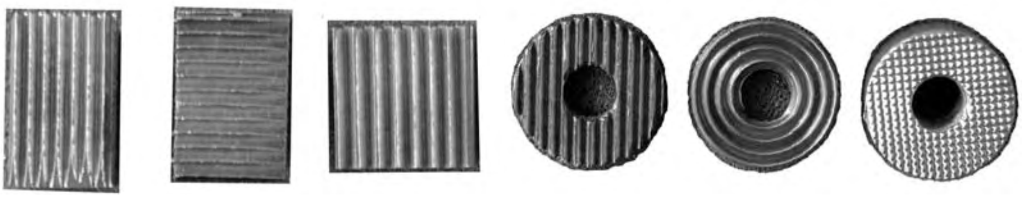


Fig. 5. *Different cogging.*

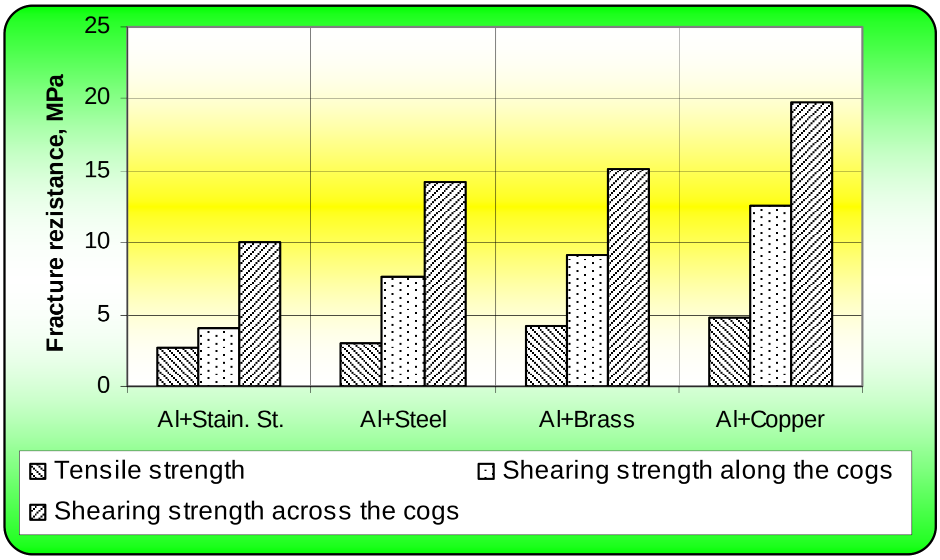


Fig. 6. *The fracture resistance for different cold-welded samples on cogged surfaces [5].*

The joint mechanical characteristics are: the tensile strength is up to 10% of aluminum ultimate tensile strength (50…80 MPa), double values were registered in case of the shearing strength (Fig. 6).

Thermal treatments. Components of aluminum and copper, on the one hand, and of aluminum and carbon steel, on the other, were welded by using a degree of deformation of 30 % applicable to the aluminum component only.

The lack of homogeneity in the joints (made up of materials with very different dilatation – contraction coefficients) may result in the shearing of the joint during the warming- cooling of the samples. In order to avoid such situations, a pre-compression device has been used (see Fig. 6). It is represented by a U 120 profile with plane-parallel processed internal facets and holes, which allow the free passing of the screws threaded in the samples.

The pre-compressing is obtained by means of the screwed nut. The dimensions of the support have been chosen so as to allow its placing in the thermal-treatment furnace. The heating was performed in an electrical laboratory furnace.

The mechanical characteristics can be improved through thermal treatments; up to a 3 times increase can be obtained by joints’ 30 minutes heating at 500 ^{0}C, at normal atmosphere [6].

The heating by favoring the diffusion processes lead to a constant increase in the traction resistance of the joints welded on cogged surfaces , as it may be seen in the graph under figure 8.

Fig. 7. *The compression device for the welded samples and the electrical furnace.*

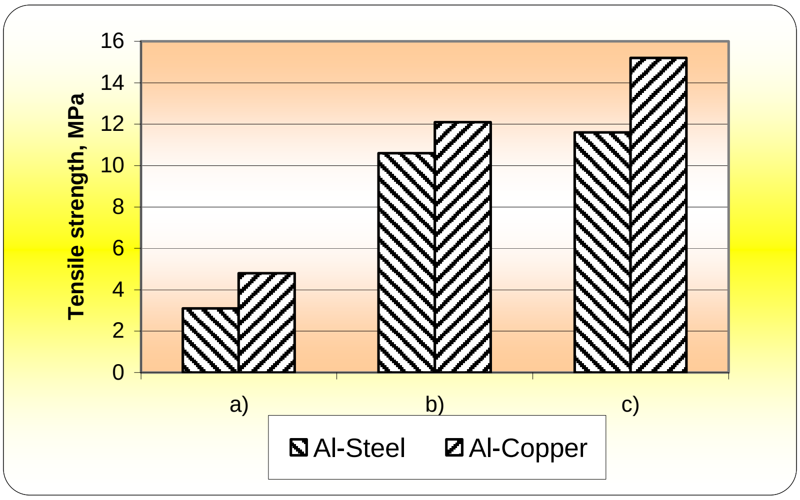


Fig. 8. *The influence of the thermal treatment on the resistance of the joint: a)-without thermal treatment; b)-with free thermal treatment; c)- with pre-compressed thermal treatment.*

The contact electric resistance measurements made with a CA 10 Microhmeter on the cold welded samples on cogged surfaces (Fig. 9) indicates negligible values: 1 μΩ for Al+Copper and 6 μΩ for Al+Steel. These values are constant for different pressing force.

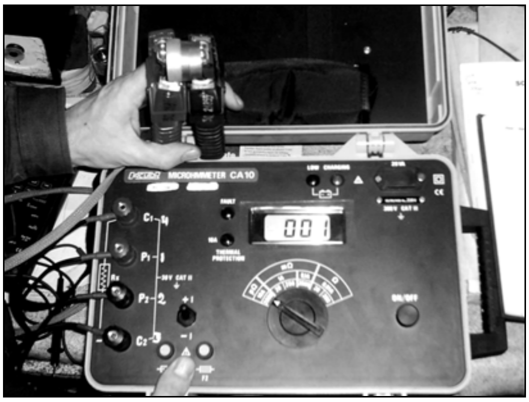


Fig. 9. *Contact electric resistance measurements.*

3. Indirect welding

At indirect welding, the intermediate metal must be weld with each sample, according to their plasticity. Depending on their plasticity, it can be discussed about:

- ⇨ cold welding on cogged surfaces with an intermediate easy deformable layer;
- ⇨ cold welding on cogged surfaces with an intermediate hard metal layer.

It must be underlined that the plasticity characteristic is relative, comparing with the steel, the copper is easy deformable and the steel is harder than the aluminum or lead [7].

Indirect welding with an intermediate easy deformable layer of aluminum or lead was used for dissimilar hard metals (having cogged contact surfaces) joints as copper+Al+stainless steel, brass-Al-steel etc. Figure 10 presents the brass+Al+brass joint and the copper+lead+copper joint.

Fig. 10. *Cold welding samples with Al and Pb intermediate layer.*

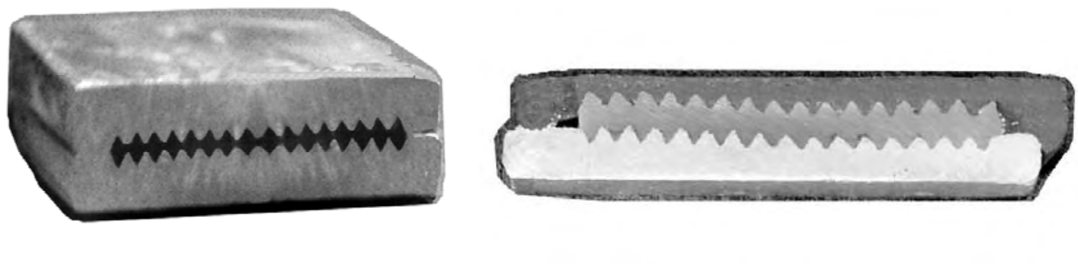


Fig. 11. *Cold welded samples with intermediate cogged layer.*

Indirect welding with hard metal intermediate layer. Easy deformable samples with plane contact surfaces ar welded through a cogged intermediate layer of a hard metal. The intermediate sample, adapted to the easy deformable samples shape, can be obtained by chipping, forming, drawing or bending. Figure 11 presents aluminum + copper + aluminum and lead + copper + aluminum cold welded samples.

4. Conclusions

- Cold pressed welding on cogged surfaces can be obtained at lower deformation rates of the aluminum component, up to 20… 30%.
- Bi-metallic or multi-layer components can be produced by cold welding on cogged surfaces between materials with different plasticity properties.
- The joints' tensile strength can be improved by thermal treatment, with or without pressing, stimulating the diffusion process of the peripheral atoms of the two materials.
- The contact electric resistance of the cold welded samples on cogged surfaces is negligible, recommending this type of joints for the electrical engineering applications.

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