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MECHANICAL RESISTANCE ON COLD WELDING ACHIEVEMENT BETWEEN COGGED SURFACES

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ABSTRACT

Cold welding on cogged surfaces is a technology developed by researchers from Robotics and Welding Department, Dunarea de Jos University of Galati. Easily deformable samples, having plane surfaces, are pressed on cogged surfaces of harder samples. The paper presents several experimental results regarding mechanical resistance on cold welding achievement. Welded joints between aluminum and copper, brass, carbon steel, stainless steel have been obtained. The maximum mechanical strength is obtained at the deformation rates 20...30%, value obviously much lower that the one characterizing the usual cold welding (minimum 70%). While the tensile strength of the joint is low (around 10% of the tensile strength of the parent metal), the shearing strength is much relevant.

KEYWORDS: Mechanical Resistance, Cold Welding.

1. Introduction

Several theoretical aspects can justify our theory regarding the necessity of cogging the surface:

⇨ A welded sloped or tacking surface is greater than the plate's area (to be weld) normal section, as fig. 1a presents. That's why the strength total amount increases; even per square area strength is diminished due to the point like clinching of the materials or microscopic inclusions.

⇨ As other researchers confirm that the normal and tangential stresses existence makes the clinching and welding processes easier, improving joint strength and diminishing the material deformation rate for weld achievement.

⇨ It is known that in the joining area, reciprocal materials displacement with small velocity are produced, making possible the rapid slip-out of the oxide layer and the materials stick cold welding.

Our theory regarding cold welding between cogged surfaces is based on the small material displacements when low pressure is applied, to the exterior cogged surfaces lengthwise [2].

Our intention was to cold weld an aluminum plate normally pressed with another one, with cogged surface, made from a different material with increased hardness.

Due to the normal pressing force applying, we expect the cold welding achievement at a lower material deformation degree, meaning that even the process necessary pressing force will be reduced.

Applying this method, small bimetallic objects, made from dissimilar metals can be obtained, at a single up-set of usually equipment [5].

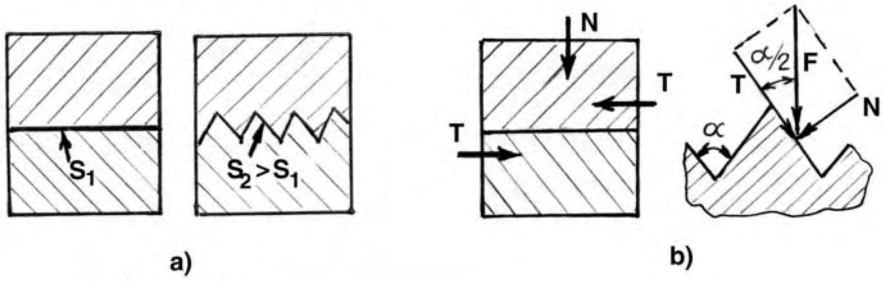

Fig. 1. *Cogging advantages: a – increasing welding surface; b – easy achievement of the normal and tangential stresses [2].*

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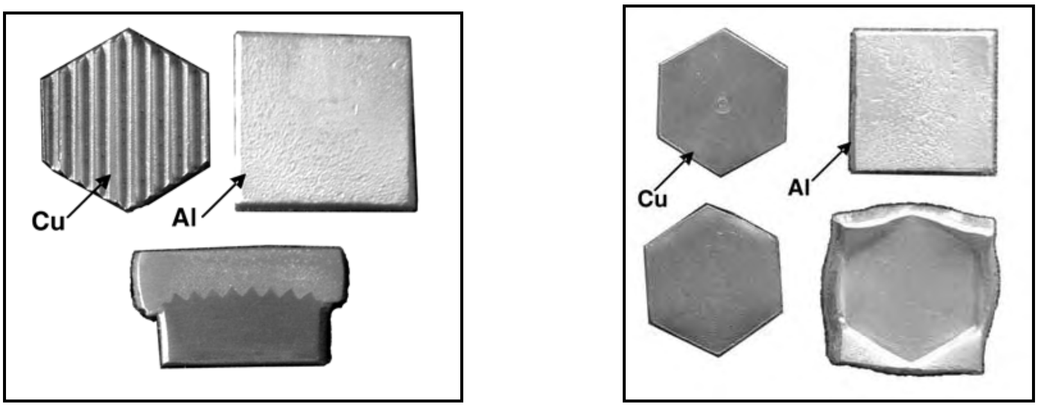


a) **b)**

Fig. 2. *Al-Cu pressed samples at the same deformation rate:*
a) weld on cogged surface; b) un-weld samples on plane surfaces [7].

2. Preliminary Tests

Tests on the above theoretical assumptions were performed on small samples made from aluminum and different metals as stainless steel, brass or copper. Triangular shape cogs, 3 mm metric module pitch, at a 60^0 angle, were machined on the hardest samples surface.

Plates joining areas were mechanically cleaned with a rotating wire-brush. After that, the plates were up-set without limiting the pressing machine stroke. A shearing resistant cold-welded joint was obtained. Although the coupled materials resultant deformation is smaller than usual, the joint was achieved due to the aluminum component. The plate’s total deformation rates calculated as the ratio between the materials displacements and the initial thickness was about 20% [8]. The practical advantage of the cold welding on cogged surfaces is due to the fact that the joint is obtained only by deforming the easily deformable sample, at lower deformation rates than in the case of classical cold welding [7]. 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.

From the welded plates cross section image it can be noticed that aluminum fills completely the space between the cogs.

3. Specimens for Mechanical Tests

The specimens were used to determine the minimum deformation rate of the materials when the cold welding process on cogged surfaces starts, respectively its influence on the joint tensile strength. To determine the moment when partial mechanical links between the two materials are initiating, the welded samples were used as tensile test specimens [1]. As fig. 3 shows, the cylindrical components have a M12 threaded hole to mount a double-ended bold before up-setting. After pressing, the cold welded joints were tensile tested, using two intermediary clamping nuts assembled on the bolts free ends. The direct clamping in the tensile testing machine’s devices is avoided, because it may introduce supplementary stresses in the joint area.

The specimens’ components were made from different materials as aluminum, brass, copper, steel and stainless steel. The aluminum parts had a smooth contact surface, while the others were cogged by cutting.

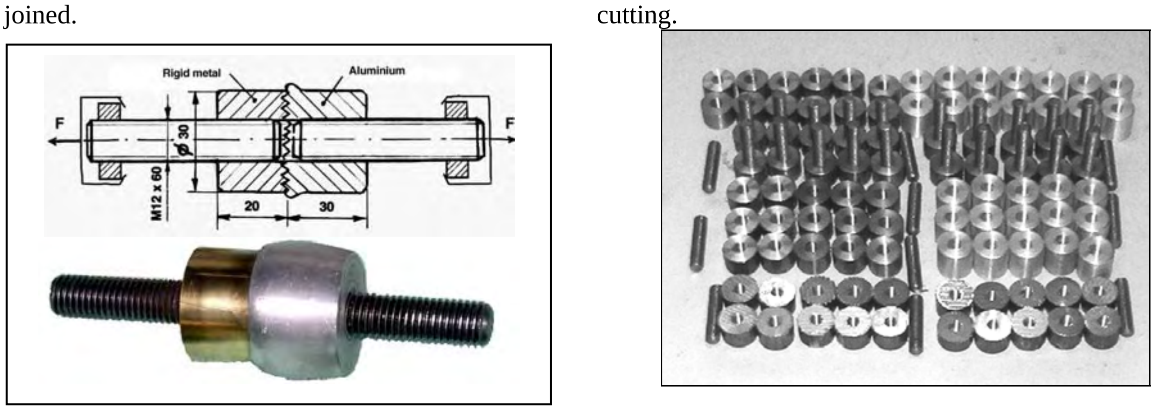


Fig.3. *Specimens’ components [3].*

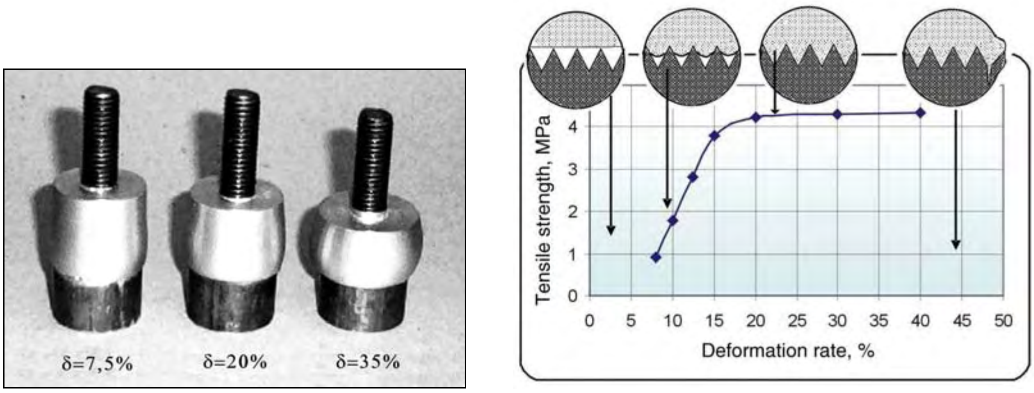


Fig.4. *Tensile strength versus material deformation rate for aluminum-brass couple [4].*

4. Stretching Resistance

We want to determine the minimum deformation degree, which makes possible cold welding achievement, and its influence on joint resistance.

To understand the starting moment of the materials atomic interaction was used as a tension test specimen a cold welded sample, presented in fig. 3. After cold welding achievement, the cylindrical sample with a threaded double-ended bolt was stretched.

The results obtained for aluminum-brass couple are presented in fig. 4. We notice that the cold welding process starts at small material deformation degrees (computed only for the deformation of the aluminum component). The maximum joint resistance is obtained for a material deformation rate δ = 15…20% [4].

The reason for this small value can be the cold welding achievement only in isolated contact points of the coupled materials, due to aluminum small displacement and sticking on harder material cogs.

Figure 5 presents the tensile strength - deformation rate dependency in case of cold welding on cogged surfaces of the aluminum with different materials. Analyzing these curves plotted in case of pressing the aluminum component on copper, steel, respectively stainless steel, small differences regarding the joint resistance can be noticed, which allow grouping these materials in two categories [3]:

⇨ 1st group: copper and brass; the joint maximum resistance is obtained at 20% deformation rate (computed only for the aluminum component);

⇨ 2nd group: steel and stainless steel; the joint maximum resistance is lower than in copper and brass case and is registered at 30% deformation rate (computed only for the aluminum component).

In classical butt cold pressure welding case both materials are deformed. This joint’s strength depends on the number of the cold welded points (of the contact surface) initiated as a result of the material flowing at deformation rates over 70%. In the case of the contact on cogged surface only the aluminum component is plastically deformed by up-setting.

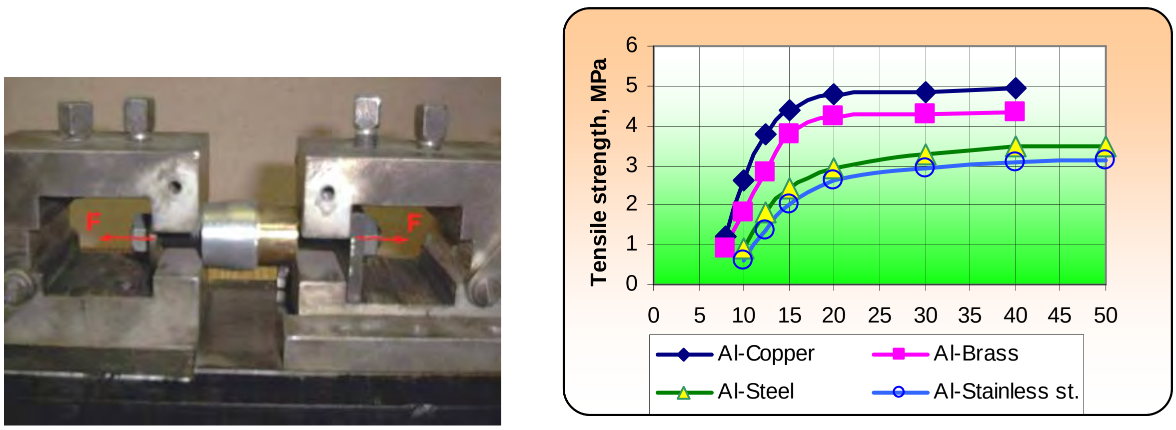
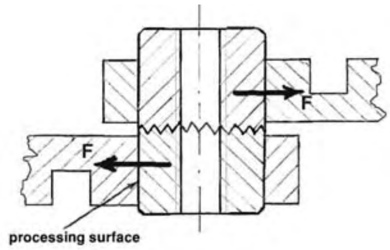


Fig.5. *The tensile strength-deformation rate dependency in case of cold welding on cogged surfaces of the aluminum with different materials [3].*



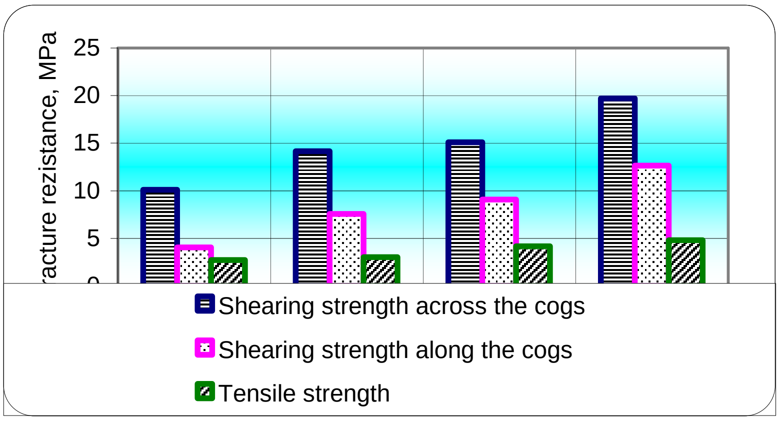


Fig.6. *The fracture resistance for different cold-welded samples on cogged surfaces [6].*

The increase of the aluminum deformation rate over 20-30% doesn't improve the joint strength. When pressing, the aluminum component slips and fills-in the gaps between the cogs. The harder component's cogs stop the aluminum flowing on the contact surface.

The increase of the deformation rate moves the material plastic deformation to a weaker, milder area, situated on the middle of the aluminum component, without any influence on improving the dissimilar joint's strength. This explanation was theoretically and practically confirmed by FEA, respectively by the metallographic analysis [4].

5. Shearing Resistance

Several tests on cold welding were performed. The values obtained for shearing stress are around 10…20 MPa, being greater than the values obtained for tensile strength (fig. 6).

On cogs normal direction, due to a supplementary anchoring of the pressed materials, the shearing stress values are bigger. This anisotropy can be reduced by double cogging (at 90^0) the harder material surface [6].

6. Conclusions

Due to its characteristics, we consider that, for this joining method, the term of cold welding is a little bit too much. In our opinion, appropriate terms would be bonding or adhesion.

The joint is achieved after cleaning and pressing the samples, due to atomic interaction in solid state, without forming common grains.

The stretched samples, pressed again in the same relative position are presenting the same resistance.

Cold welding achievement on cogged surfaces – with or without an intermediate layer – of dissimilar materials gives the possibility of obtaining small bi-metallic or multi-layer samples. The joint is the result of the aluminum 15…20% deformation rate. The joint tensile strength is 10% of aluminum resistance. The joint surface dimension at a single pressing stroke depends on the pressing equipment performance and can be extended, using multiple pressing, along the cogs. Resistance pieces can't be obtained using this method.

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