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ULTRASOUND INFLUENCE ON MATERIALS STRUCTURE IN PARTS RECONDITIONED BY WELDING WITH ULTRASONIC FIELD

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Preliminary Note – Prethodno priopćenje

Research presented in the paper refers to the structural analysis of materials that are thermally influenced for loading by welding of pieces in the classical variant of manual coated electric arc welding and the version that in which the welding bath is activated by ultrasounds. The structural analysis made refer to: the size of the grains of the structure obtained under certain loading conditions through welding, grain size variation on the submission of a single layer in the ultrasonic field, the mode of solidification and fragmentation of grains when loaded in welding in a ultrasonic field, acceleration of the diffusion process for ultrasonic activation, the appearance of hard carbides between grains.

Key words: structural analysis, loading by welding, manual welding, ultrasonic activation

INTRODUCTION

Modification of technological and functional properties under the action of ultrasound was first highlighted in single crystals and metallic materials developed in laboratory and then the research was extended to a wide and varied industrial metals and alloys [1]. The influence of ultrasound on metals and alloys in the solid state generally is reduced to the following important effects, namely: the effect of "acoustic softening", the effect of "acoustic hardening" and thermal effect and the effect of contact friction reducing [2].

Reconditioning by welding of the pieces involves lodging a filler material over a substrate in order to obtain the desired characteristics and dimensions (high resistance to fatigue and wear of erosion and /or corrosion). The efficiency of the technological process of reconstruction depends primarily on the behavior of the base layer - filler layer torque and how it connects marginal homogeneity between atoms of the two materials in the contact area and near the contact area [3].

Homogeneous bond formation is the result of technological steps for the submission of the filler material over support material [4].

To highlight the operational behavior of the reconditioned part and especially to determine the optimal technology for reconditioning by ultrasonic field welding is necessary to analyze the structural changes occurring in the thermally influenced area [5].

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MATERIALS

To accomplish an analysis of the structural changes in the thermally influenced area several types of tests were made for both classical without ultrasounds method and the version where the welding is activated with ultrasonic process (Table 1).

The most difficult problem was linked to the introduction of ultrasonic energy in the liquid metal bath and the design of the ultraacustic system and in the test the ultrasounds were introduced directly in the direct welding bath [6].

Table 1 **Type of test pieces used for structural analysis**

No.	Test no.	Support Material
1	1C	OL 42
2	1U	OL 42
3	2C	OL 42
4	2U	OL 42
5	3C	OL 42
6	3U	OL 42
7	4U	OL 42
8	5U	OL 42

Legend: C - classic loading without ultrasonic welding; U - loading by welding in ultrasonic field with characteristics f= 22 KHz; A= 45 μm; ultrasound activation time t_A= 5 min; 1 - one layer submission; 2 - two layers submission; 3 - three layers submission; 4 - one layer submission in an ultrasonic field with the characteristics f= 20 KHz; A= 30 μm; t_A= 3 min; 5 - one layer submission in an ultrasonic field with the characteristics: f= 22 KHz; A= 62 μm; t_A= 8 min

RESULTS AND DISCUSSION

To determine susceptibility to cracking and behavior of the reconditioned piece to cracks forming from the outside or inside or to the stop of a crack we proceeded to metallographic analysis of OL 42 samples obtained by weding with a layer deposited in a classic welding or through ultrasonic activation.

There were followed those effects of ultrasound propagation in welding and during bath application which influences the functional and technological properties of the deposited layer and obtained ansamble, in the different conditions of deposition of the layer of filler material. Crystal structure analysis was done on microscope ZEISS AXIOVERT40 MDT.

By sectioning across the deposits made and their metallographic analysis there were found:

A substantial change in the grain structure, respectively in size and uniformity of the grains (Figure 1) where the grain size change is evident (Figure 1, the base material) layer deposited without ultrasounds (Figure 1, b) and layer deposited in ultrasonic field with the conditions: frequency f= 22 KHz; oscillation amplitude A= 45 µm; time t_A= 5 min (Figure 1, c), submission of two layers (Figure 1, d), in the conditions f= 22 KHz; A= 45 µm; t_A= 5 min, submission of three layers (Figure 1, e), in the conditions: f= 22 KHz; A= 45 µm; t_A= 5 min. and submission of one layer (Figure 1, f) in the conditions: f= 22 KHz; A= 62 µm; t_A= 8 min.

It is also noted that as the activation time increases, the ultrasound frequency increases and the vibration amplitude increases, grain the decreases and smoothes.

A change of grain size on the depth of the deposited layers (Figure 2) ascertaining a mixture of fine grains and uniform grain base layer in the transition zone between the base layer and deposited layer (Figure 2, b) and granular structure consists of equidistant fine grain layer deposited (Figure 2, c). From the analysis of grain size we note an increase in cooling rate caused by the action of ultrasonic waves and it is found that as the amplitude increases so does the frequency of the fragmentation process, the last one is accelerating and widening. The action of ultrasonic waves causes acceleration of diffusion, a phenomenon that leads to the formation of intermetallic better links to a larger diffusion, to the avoidance of defects in the transition area and to better functional and technological features (Figure 3). It is found that as frequency increases, the amplitude increases and the activation time increases, the diffusion process is accelerated more avoiding any appearance defects such as porosity, as in the deposit without ultrasound (Figure 3, a). Also, due to ultraacustic cavitation, which produces powerful shock waves you can easily make a dispersion of one metal into another resulting in mixtures of metals that can not be obtained routinely (analog to producing emulsions of two liquids that normally are immiscible). This increase in solubility to obtain the combinations Fe-W, W-Ni, Al-Cr, Fe-Pb and others (depends on hard alloy for loading).

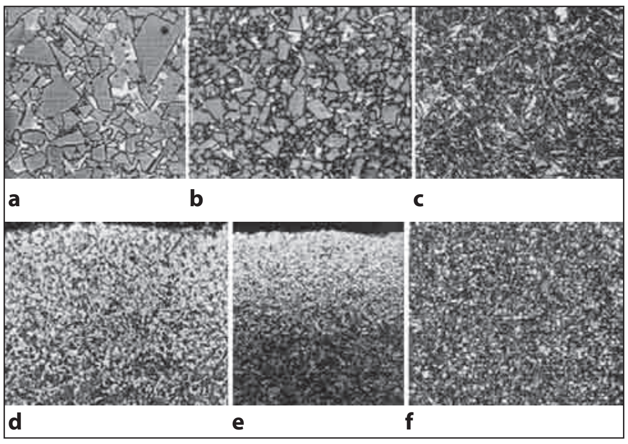

Figure 1 Grain size structure under certain loading conditions obtained by welding: a - in the basic layer structure; b - deposit a single layer without ultrasound; c - deposit a single layer in an unltrasonic field with the characteristics: f= 22 KHz; A= 45 µm, t_A= 5 min; - depositing two layers in an ultrasonic field with the characteristics f= 22 KHz; A= 45 µm, t_A= 5 min; e - depositing three layers in an ultrasonic field with the characteristics f= 22 KHz; A= 45 µm, t_A= 5 min; f - depositing one layer in an ultrasonic field with the characteristics f= 24 KHz; A= 62 µm, t_A= 8 min.

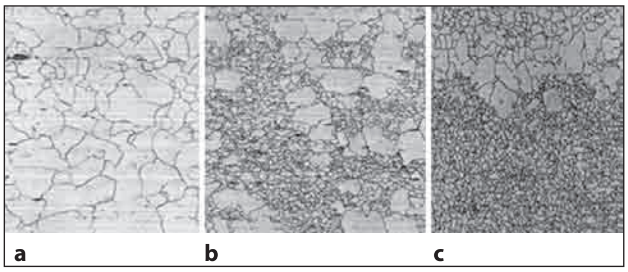

Figure 2 Variation of grain size at the submission of a single layer in ultrasonic field: a - base layer; b - interlayer; c - layer deposited in the conditions: f= 22 KHz; A= 45 µm, t_A= 5 min

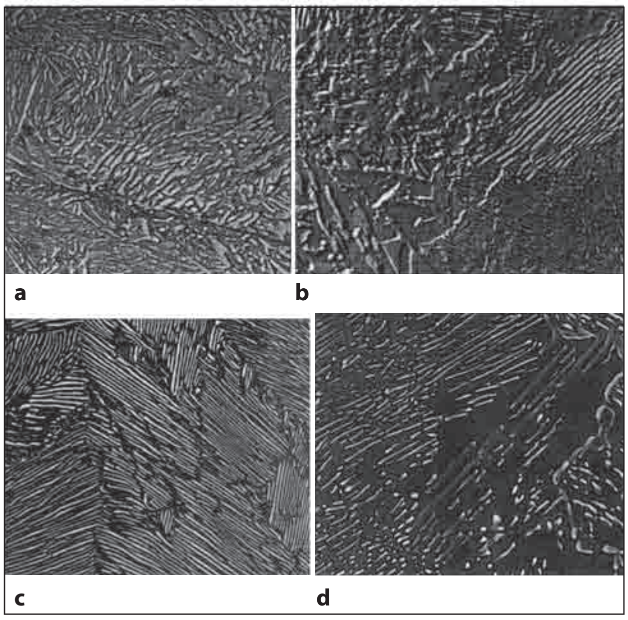

Figure 3 Mode of solidification and fragmentation of grains from field ultrasonic welding load: a - in the conditions: f= 20 KHz; A= 30 µm, tA= 3 min; b - in the conditions: f= 22 KHz; A= 45 µm, t_A= 5 min; c - in the conditions: f= 24 KHz; A= 62 µm, t_A= 8 min; d - in the conditions: f= 26 KHz; A= 35 µm, t_A= 10 min

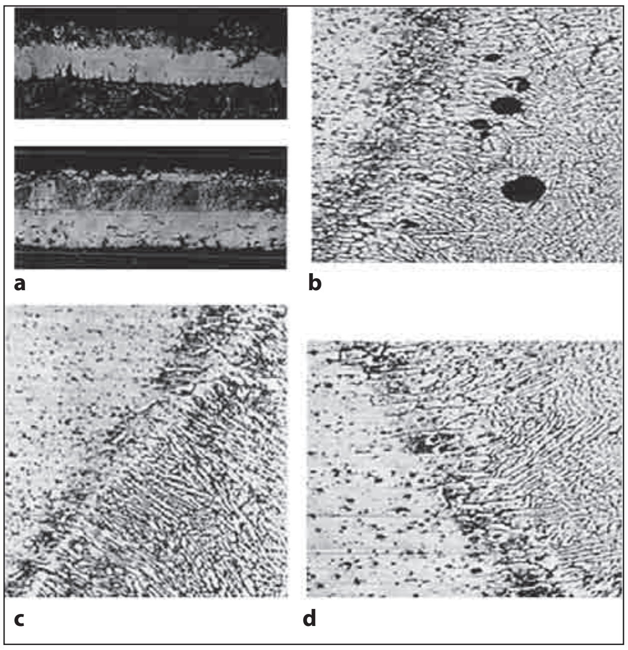

Figure 4 Accelerating the diffusion process: a - deposit a layer without ultrasound; b - deposit a layer under the ultrasonic field: f= 20 KHz; A= 30 μm, t_A= 3 min; c - deposit a layer under the ultrasonic field: f= 22 KHz; A= 42 μm, t_A= 5 min; d - deposit a layer under the ultrasonic field: f= 24 KHz; A= 62 μm, t_A= 10 min

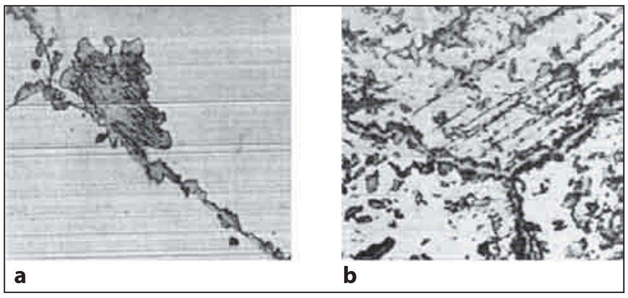

Figure 5 Occurrence of hard carbide between grains: a - submission of a layer without ultrasounds; b - the submission of a layer with ultrasonic field

By accelerating the diffusion process under the action of ultrasonic waves a phenomenon id produced that leads to the formation of better intermetallic links to a larger diffusion, to the avoidance of defects in the transition area and to better functional and technological features (Figure 4);

It is found that as frequency increases, the amplitude increases and the activation time increases, the diffusion process is accelerated more avoiding any appearance defects such as porosity, as in the deposit without ultrasound (Figure 4, a).

By applying ultrasounds in the welding process you produce uniform deposits of hard carbides at the boundary between crystalline graines (Figure 5) and eliminate the possible oxides, a phenomenon that is explained by the action of ultrasounds, preferential absorption of ultrasonic energy at the boundary between the grains and especially the occurrence of ultraacustic cavitation.

CONCLUSIONS

It is observed in the filler material a primary crystallization structure formed by a very fine ledeburit grown in a predominant martensite matrix;

In the melting area there is a dilution of the filler material in the base material, depending on how dilution occurs the amount of ledeburite varies;

In the melting area there is a dilution of the filler material in the base material, depending on how dilution occurs the amount of ledeburite varies;

There was observed a substantial change in the grain structure, resectively a change in grain size and uniformity depending on the technological and acoustic parameters (frequency of oscillation, the particle velocity amplitude, activation duration and ultraacoustic intensity);

Accelerating the diffusion process under the action of ultrasonic waves leads to the formation of intermetallic better links at a lower dilution, the avoidance of defects in the transition and the best functional and technological features;

Because of the ultrasonic waves activation during the solidification process uniformization of hard carbide occurs betewwn grains and the eventual elimination of existing oxides on the surface;

The occurrence of cracks due to high thermal conductivity difference between the deposited layer and the base layer can be avoided by choosing the appropriate technological and acoustic parameters.

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Note: The responsible translator for English language is S.C. Purtrad S.R.L., Targu Jiu, Romania