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INFLUENCE OF USE OF ULTRASOUND ON THE MECHANICAL PROPERTIES OF PLATED PIECES BY WELDING IN ULTRASONIC FIELD

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Preliminary Note – Prethodno priopćenje

Plating by welding in an ultrasonic field represents a technological solution to increase resistance to corrosion and / or wear of pieces of the machinery industry. Research has been carried out for two types of parts, namely a piece of flange end type and bonnet type made of AISI 4130 steel, and as filler material for plating was used Inconel 625 Fe developed as electrode wire with a diameter of ø 1.2 / mm. The plating was done by depositing a single layer by welding in ultrasonic field, welding process in Ar 100/ % environment non-consumable tungsten electrode, WIG process, and when using ultrasonic activation it was used a longitudinal and a transverse wave with a frequency of 15 / kHz. For pieces plated by welding there have been made attempts of the hardness and tensile and bend shock

Key words: plated, welding, ultrasonic energy, mechanical properties

INTRODUCTION

The plating process in an ultrasonic field of the pieces is optimal if the realized piece has achieved outstanding reliability, greater efficiency and minimal cost of processing. To have outstanding reliability, surfaces plated with anticorrosive alloy have corrosion and / or anti-worn out should have features that confer high resistance to corrosion and / or a high resistance to wear, in conditions during operation demands [1, 2]. This is done if the material deposited by welding, with the base material forms a couple with a behavior far better in exploitation than if the piece would be made of only the base material or only a filler material, which is usually very expensive. In following the plating, resulted pieces should have a high resistance to corrosion and / or wear and entirely correspond to the functional role in the assembly they belong, in following the process of plating [3].

It is important to highlight the behavior, in exploitation, of the pieces plated by welding and to determine the optimal plating technology by welding in ultrasonic field to achieve a large number of experiments, on surfaces of different geometric configuration and different overall dimensions, using couples of different materials, which will be then subjected to various tests to determine the resistance to wear and/or corrosion resistance, crack resistance, toughness and brittleness, the behavior to the mechanical demands and structural changes which occur in the base material, in the filler material and in heat affected zone. To explain and optimize the plating process of welding is necessary to know the behavior of plated surface during operation, reaction given by breaking strength, yield strength, resistance to dynamic demands, susceptible to cracking, the formation of cracks from inside to outside, embrittlement in the heat affected zone [4-6].

Enabling with ultrasonic of plating process by welding influences the behavior in exploitation of pieces due to factors related to the propagation of ultrasound through welding bath and deposited layer, namely: ultrasound intensity - has great influence on the process of diffusion and solidification; ultrasound frequency - is a very important parameter in calculating the components of ultrasonic system in the sense that it is working in regime of resonance; amplitude of particle velocity (amplitude of ultrasonic oscillations) - directly influences the crystallization and solidification process which amplifies when the amplitude increases; type of ultrasonic waves - in the welding bath or in the deposited layer are generally transmitted longitudinal waves, but according to the ratio wave length / thickness of the deposited layer, can occur radial waves, transverse or surface waves, which accelerates the diffusion [7-8].

MATERIALS

Plating the surface with a layer of additional material to provide resistance to high corrosion and / or wear, should be such that the thickness of the plating layer does not exceed the thickness of 3 – 4,2 / mm. To determine the optimum technological process, were carried

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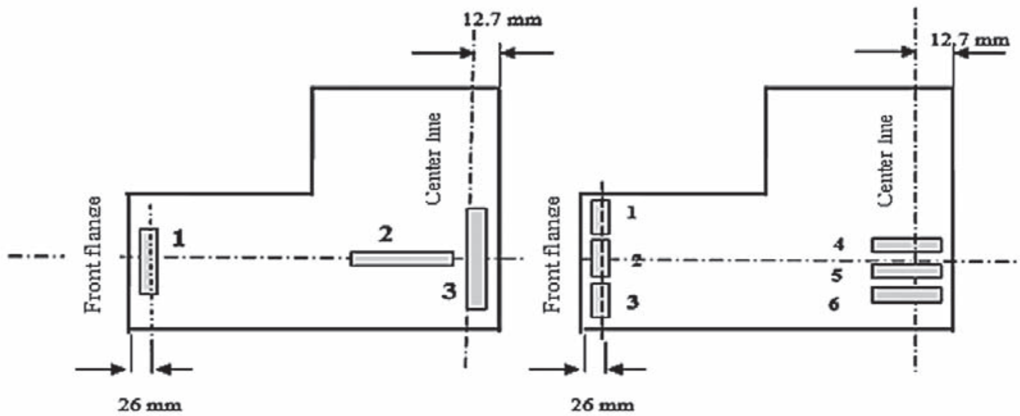
the plating of various pieces, namely for a piece of flange end type and for a bonnet type. The plating was done using a couple of material which consists of basic material: AISI 4130 steel and the filler material Inconel 625Fe developed as electrode wire with a diameter of 1,2 / mm. The technological process of plating by welding was done both in the case of ultrasonic activation and in the absence of activation using the welding process in Ar 100 / % environment with non-consumable tungsten electrode, WIG process, and when using ultrasonic activation it was used a longitudinal and a transversal wave with a frequency of 15 / kHz.

RESULTS AND DISCUSSIONS

To determine the optimal plating technology by the loading by welding in an ultrasonic field of some used pieces in machine building, it was established a way of working and a set of experiments that allow an analysis between samples plated by welding without ultrasonic activation and samples plated by welding in ultrasonic field. In the three distinct areas of a piece plated by welding there take place a number of changes, particularly structural, which lead to the change of properties in these areas : basic material - heat affected zone - filler material. Therefore, in the experimental researches was carried out several attempts in these areas, on various types of pieces to highlight the influence of various parameters of the plating process by welding on the functional and technological properties of the obtained couple.

Attempts were made to determine the hardness obtained after plating by welding (hardness HB) and mechanical properties of the base material, filler material and heat affected zone. The first type of piece subject to reconditioning process was a piece of flange end type whose shape, but also the places of sampling for tensile test and the bending shock test are presented in Figure 1. Brinell hardness test for a piece of flange type was made in the areas of Figure 2 , under the conditions shown in the figure, for plating by welding without ultrasonic activation (Figure 2, a) and plating by welding in an ultrasonic field (Figure 2, b).



a b

Figure 1 The places of sampling for the piece of flange end type: a - tensile testing; b - bending shock test

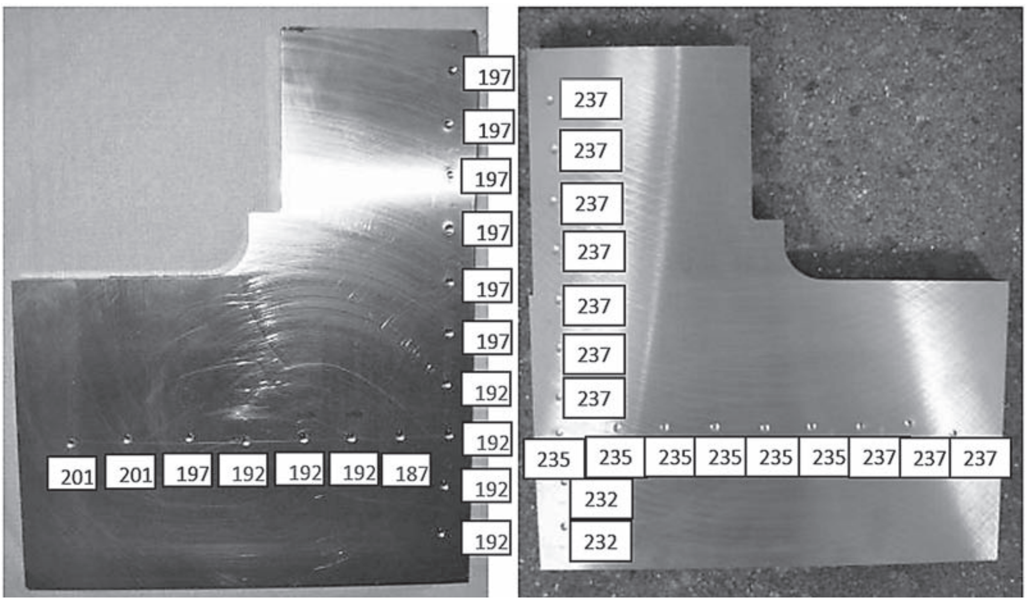


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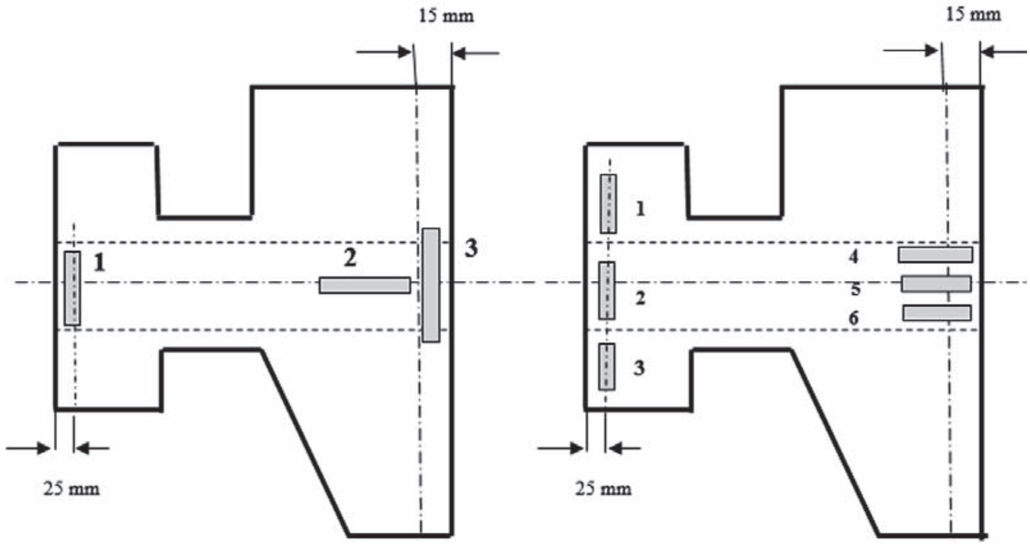
Figure 2 Determination of Brinell hardness for the piece of flange end type : a - sample plated by welding without ultrasonic activation; b - sample plated by welding in ultrasonic field.



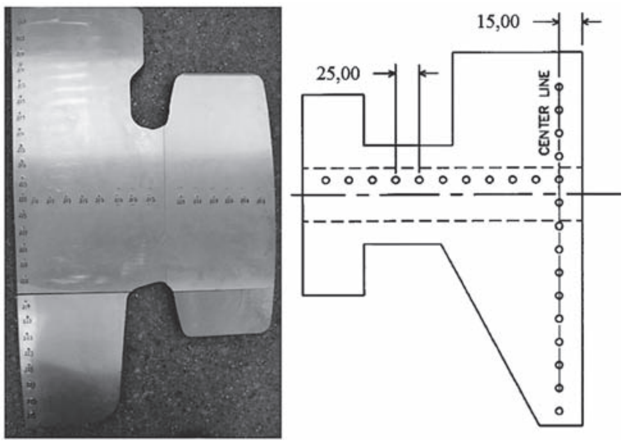
a b

Figure 3 The places of sampling of piece of bonnet type: a - for tensile testing; b - the bending shock test

Piece of a bonnet type whose form, and places of sampling for tensile test and bending, shock test are shown in Figure 3. Brinell hardness test for the piece of bonnet type was made in the areas of Figure 4 under the conditions shown in the figure, for plating by welding without ultrasonic activation (Figure 4, a) and plating by welding in an ultrasonic field (Figure 4, b).

The experimental results for testing the hardness and tensile and bending, shock tests are shown in Table 1 for the piece of flange end type and in Table 2 for the piece of bonnet type.

From the results shown in Table 3 there is an increase of about 8-15 / % of the mechanical properties of the base material by 10 – 20 / % of filler material and 5-10 / % in heat-affected zone (with the exception of hardness, which decreases), in comparison with the plating by welding without activation in ultrasonic field.



a b

Figure 4 Areas where is determined Brinell hardness of piece of bonnet type: a - general view in section; b - schematic diagram

Table 1 **The main functional properties of the piece of flange type, plated by welding with and without ultrasonic activation**

The tested area	Plating by welding	$R_{p0,2}$ / MPa	R_m / MPa	*A* / %	*Z* / %	Hardness/ HB	*KV* - 46 Longitudinal / J	*KV* - 46 Transversal / J
Base material AISI 4130	Without ultrasonic activation	543	723	25,2	50,6	192	68,9	60,6
	In ultrasonic field	573	756	30,1	59,8	227	75,3	69,4
Filler material Inconel 625 Fe	Without ultrasonic activation	652	890	32,4	41,8	207	61,6	58,7
	In ultrasonic field	694	932	36,7	47,2	247	70,3	65,8
Heat affected area	Without ultrasonic activation	478	640	23,5	39,6	197	51,2	47,2
	In ultrasonic field	496	688	26,5	45,3	186	58,7	51,6

Table 2 **The main functional properties of the piece of bonnet type, plated by welding with and without ultrasonic activation**

The tested area	Plating by welding	$R_{p0,2}$ / MPa	R_m / MPa	*A* / %	*Z* / %	Hardness/ HB	*KV* - 46 Longitudinal / J	*KV* - 46 Transversal / J
Base material AISI 4130	Without ultrasonic activation	523	703	26,5	60,3	218	58,0	68,5
	In ultrasonic field	565	780	31,7	75,1	242	66,5	78,9
Filler material Inconel 625 Fe	Without ultrasonic activation	632	899	30,2	39,4	227	61,2	60,3
	In ultrasonic field	680	967	40,1	47,6	235	68,7	68,7
Heat affected area	Without ultrasonic activation	468	648	22,5	38,2	215	49,7	57,2
	In ultrasonic field	508	709	32,6	44,3	208	57,2	67,8

From the results shown in Table 4 there is an improvement of the functional properties not only in the deposited layer of plating in the ultrasonic field, but also in the base material, especially in the heat affected areas. This increase can be explained by the action of ultrasound in the solidification process of the formation of crystallization seed and the itself crystallization, resulting in a fine grain structure, consisting of equiaxed grain with a smaller size than in the case of plating without activation in the ultrasonic field. It has a great importance the input mode of ultrasound in welding bath and their activation direction in relation to the direction of welding, the best results were obtained in the case of the introduction direction is parallel to the direction of ultrasonic welding.

In the case of the introduction of ultrasonic energy in the welding bath perpendicular to the welding direction, the influence of the ultrasound on the technological and functional properties of the base material, filler material and the heat affected areas are less than in the case of the introduction of ultrasound into the welding bath parallel to the direction of welding. Effects of propagation of ultrasonic wave through the welding booth during the solidification process leads not only to a change in hardness, but also other functional and technological properties change in both the filler material and the base material and in the heat affected areas.

CONCLUSIONS

- quality of plating by welding is characterized by: high resistance to corrosion and / or wear, low roughness, high adhesion between the deposited layer and base material, low porosity, low oxide content, high resistance to dynamic demands and fatigue;
- changing the functional properties of filler material, heat affected zone and the base material is explained by the action of ultrasound on the solidification process of the formation of crystallization seed and the itself crystallization, which results in a fine grain structure, consisting of equiaxed grains of much smaller size than the plating without ultrasonic activation;
- as the amplitude of longitudinal ultrasonic oscillation increases, hardness decreases because the fragmentation structure is more intense, and if the frequency increases, the hardness increases as the cooling of welding bath is faster and the structure has larger grains and in the heat affected zone may occur carbides at the boundary of grain;
- the action of tension ultrasound - compression in the solidification process leads to fragmentation of the grains of the carbide, spread them according to the ultrasound frequency and amplitude of vibration and depending on the nature of ultrasonic waves introduced into the welding bath.

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Note: The responsible translator for English language is
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