GH. AMZA, D. DOBROTĂ, V. PETRESCU, Z. APOSTOLESCU, R.G. ALBULESCU

ISSN 0543-5846
METABK 54(3) 523-526 (2015)
UDC – UDK 621-41:621.791.052:534-8:620.17=111

INFLUENCE OF USE OF ULTRASOUND ON METALLOGRAPHIC STRUCTURE OF PLATED PIECES BY WELDING IN ULTRASONIC FIELD

Received – Primljeno: 2014-08-08
Accepted – Prihvaćeno: 2015-01-10
Preliminary Note – Prethodno priopćenje

To optimize the plating process is necessary to know the behavior of surfaces plated during the exploitation and in particular susceptibility to cracking, the formation of cracks from the inside to outside or reverse, embrittlement in the heat affected zone. Research has been realized considering several samples plated by welding without ultrasonic activation and with ultrasonic activation, and these samples were made of AISI 4130 steel, and as filler material was used Inconel 625 Fe developed as electrode wire ø 1,2 / mm. The plating process was realized by a WIG welding process in Ar100 /% environment with non-consumable tungsten electrode, in two versions, respectively with and without the use of ultrasonic energy. Four pieces played by welding there were analyzed the metallographies structure in the base material, the deposited material and the material from the heat affected zone.

Key words: plating by welding, ultrasonic energy, metallographic structure, porosity

INTRODUCTION

Using a complex system of plating by welding with ultrasonic activation, the pieces can be plated with a uniform layer in comparison with a conventional system of plating by welding [1]. There are several techniques for plating pieces, but plating by welding in ultrasonic field is expected to replace other techniques with very good results. This should be taken into consideration the relationship between energy density and the ultrasonic energy input mode [2]. Plating is realized in optimal conditions if the material deposited by welding with the base material forms a couple with a far better behavior in exploitation than if the piece would be made of only the base material or only the filler material which is usually very expensive, and the pieces must entirely correspond to the functional role they belong. To explain and optimize the plating by welding process is necessary to know the behavior of plated surface during exploitation, behavior given by tensile strength, yield strength, resistance to dynamic loads, susceptible to cracking, the formation of cracks from the inside to outside or inverse, embrittlement in the heat affected zone [3].

When plating by welding of the pieces it should be considered the fact that heat cycle, which is obey to the base material and the filler material (heating - melting - cooling - solidification) cause changes in chemical composition due to the phenomenon of dilution and changes in functional and technological properties, due to changes of structure in three distinct areas around the boundary (base material, heat affected zone and filler material) [4].

Plating pieces by welding in ultrasonic field involves the following process steps: initial control of plated piece, produced by forging, casting or welding; surface preparation on which is not deposited filler material; surface preparation on which is plated by welding; marking and / or protecting the surface on which is not deposited filler material; preheating surfaces; plating itself; checking the characteristics of the layer / layers deposited; processing to final dimensions required by the functional role; thermal treatment post welding and final control. A quality palting by welding is characterized by: high resistance to corrosion and / or wear, low roughness, high adhesion between the deposited and base material, low porosity [5].

MATERIALS

Plating the surfaces with a layer of filler material to provide high resistance to corrosion and / or wear, should be realized so that the thickness of a plating layer does not exceed the thickness of 3 – 4,2 / mm. In order to determine the optimum technological plating there were plated pieces using different parameters for the plating process presented in Table 1 or Table 2. Plated was performed using a couple of the base material, namely AISI 4130 steel and filler material Inconel 625 Fe developed as electrode wire ø 1,2 / mm.

Gh. Amza, Z. Apostolescu, Faculty of Engineering and Management of Technological, Polytehnic University of Bucharest, Romania
D. Dobrotă, Engineering Faculty, "Constantin Brâncuşi" University of Târgu-Jiu, Romania
V. Petrescu, Engineering Faculty, Lucian Blaga University of Sibiu, Romania
R.G. Albulescu, The Oil Company, Ploiesti, Romania

Table 1 **The values of parameters of welding regime in Ar 100 / % environment by deposition a single layer without ultrasonic activation**

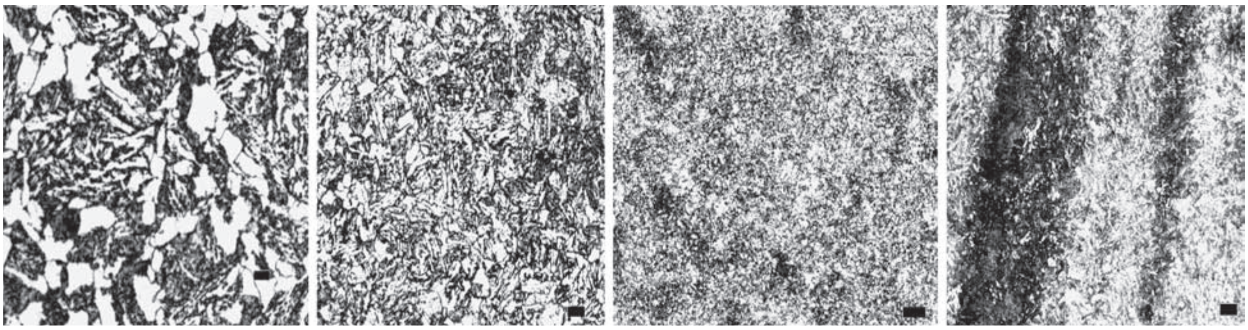
No.	Sample	Parameters of welding regime					
		U_a / V	I_s / A	$V_{s\,/}$ cm/min	E_l/ KJ/cm	Wire type	Gas values / l/min
1	Sample 1	11,9	320	52,3	7,30	Cold wire Ø 1,2 mm	15
		13,1	280	52	7,40		14,5
		12,5	270	46,5	6,45		14,9
2	Sample 2	14,3	229	48,2	6,79	Cold wire Ø 1,2 mm	15,5
		15,6	246	50,6	7,58		14,8
		16,4	285	53,5	8,73		15,0
3	Sample 3	15,4	252	45,2	8,58	Cold wire Ø 1.2 mm	15,0
		16,8	272	47,8	9,55		14,9
		17,2	310	49,6	10,75		14,8
4	Sample 4	20,1	180	38,5	9,39	Cold wire Ø 1,2 mm	14,6
		21,6	210	42,3	10,72		14,5
		22,3	240	45,7	11,71		15,0

Table 2 **The values of parameters of welding regime adn ultrasonic activation at plating by WIG welding in Ar 100 / % environment by deposition of a single layer with ultrasonic activation**

No.	Sample	Parameters of welding regime				Parameters of ultrasonic field				
		U_a / V	I_s / A	V_s / cm/min	E_l / J/cm	I_a / W/cm^2	F / kHz	A_l / mm	Wave type	a_r / µm
1	Sample 1u	11,9	320	52,3	7,30	7,8	15	38,9	longitudinal and radial	17,6
		13,1	280	52	7,40	9,6	14,5	57,5		23,2
		12,5	270	46,5	6,45	12,3	14,9	58,8		24,5
2	Sample 2u	14,3	229	48,2	6,79	6,5	15,5	53,2	longitudinal and radial	25,6
		15,6	246	50,6	7,58	8,9	14,8	62,7		25,2
		16,4	285	53,5	8,73	11,7	15,0	52,5		54,8
3	Sample 3u	15,4	252	45,2	8,58	10,9	15,0	35,7	longitudinal and radial	21,1
		16,8	272	47,8	9,55	13,7	14,9	39,9		22,2
		17,2	310	49,6	10,75	15,8	14,8	38,2		23,5
4	Sample 4u	20,1	180	38,5	9,39	9,6	14,6	46,8	longitudinal and radial	28,9
		21,6	210	42,3	10,72	14,8	14,5	69,7		30,2
		22,3	240	45,7	11,71	16,3	15,0	70,5		32,7

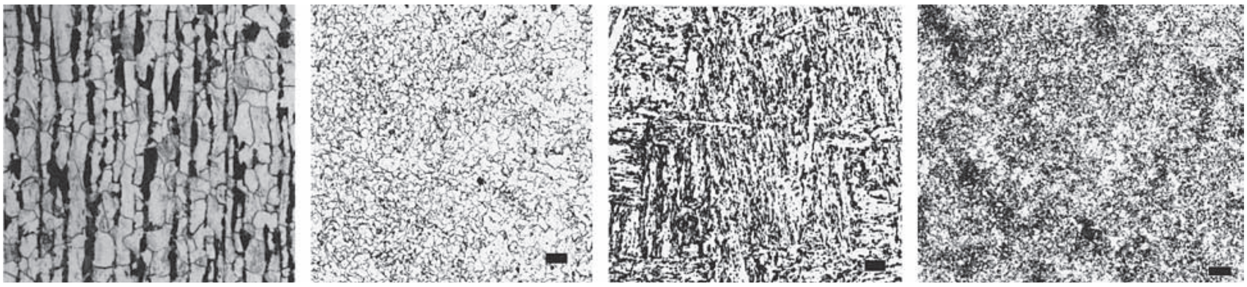
RESULTS AND DISCUSSIONS

To highlight these properties of plated pieces it was released a metallographies analysis of samples processed in all eight samples plated without ultrasonic activation in ultrasonic field. Figure 1 shows the basic structure of the base material at plating by welding with ultrasonic activation (Figure 1, a) and playing in an ultrasonic field (Figure 1, b) for sample 1u (amplitude 38,9 µm, frequency 33 867 / Hz) sample 2u (Figure 1, c) conditions: amplitude 62,7 / µm and frequency 38 204 / Hz and 4u sample (Figure 1, d) conditions: amplitude 70,5 / µm and frequency 35 797 / Hz. It is found that as the amplitude increases, the crumbling of structure is becoming more pronounced, the grains become smaller. Figure 2 shows the structure of the filler material at plating by welding without ultrasonic activation (Figure 2, a) and playing in an ultrasonic field 1u sample (Figure 2, b) conditions: amplitude 38,9 / µm and frequency 33 867 / Hz, 2u sample (Figure 2 c), under



a b c d

Figure 1 Structure of base material (AISI 4130): a – in case of plating by welding without ultrasonic activation; b – in case of plating by welding in ultrasonic field, in conditions: f = 33 867 / Hz, A=38,9 / µm, I_s=320 / A, v_s=52,3 / cm/min; c - in case of plating in ultrasonic field, in conditions: f = 38 204 / Hz, A=62,7 / µm, I_s=240 / A, v_s=50,6 / cm/min; d – in case of plating in ultrasonic field, in conditions: f = 35 797 / Hz, A=70,5 µm, I_s=240 / A, v_s=45,7 / cm/min; zoom 200x



a b c d

Figure 2 Structure of filler material (Inconel 625 Fe): a – in case of plating by welding without ultrasonic activation; b – - in case of plating in ultrasonic field, in conditions: f = 33 867 / Hz, A=38,9 / µm, I_s=320 / A, v_s=52,3 / cm/min; c - in case of plating in ultrasonic field, in conditions: f = 38204 / Hz, A=62,7 / µm, I_s=240 / A, v_s=50,6 / cm/min; d – - in case of plating in ultrasonic field, in conditions: f = 35 797 / Hz, A=70,5 / µm, I_s=240 / A, v_s=45,7 / cm/min; zoom 200x; attach 5ml H_2SO_4 + 3mlHNO_3 + 92ml HCl

the conditions: 62,7 amplitude / µm and frequency 38 204 / Hz and 4u sample (Figure 2 d) in the following conditions: amplitude 70,5 / µm and frequency 35 797 / Hz. Similarly, it is found that the amplitude increases and it works in resonance system, the fragmentation of the structure is becoming more and more pronounced and it is obtained a fine grain structure with equidistant grains with great technological and functional properties. Most spectacular results are obtained in the heat affected zone (Figure 3) where we can see the action of ultrasonic waves during the solidification process, having an essential contribution in obtaining a structure with equiaxed grains for more than 80 / % and the remaining 20 / % are small grains but disorderly placed depending on how the solidification front goes ahead.

In case of plating by welding without ultrasonic activation, carbides occur between grain boundary and, especially in the martensite matrix, in the case of ultrasonic activation where the possibility of occurrence of rough carbides in the heat affected zone is getting smaller and there are situations when they were finely dispersed in the two materials of the couple along the demarcation line (Figure 3 d). It is found that the best results are obtained when operating under a resonance regime, maximum amplitude and vibration mode is closest to the resonance frequency, for it has been calculated the ultrasonic system. Fine grain structure ob-

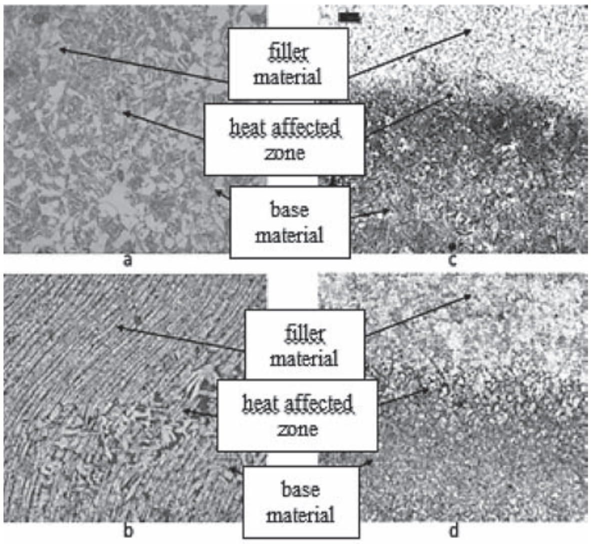
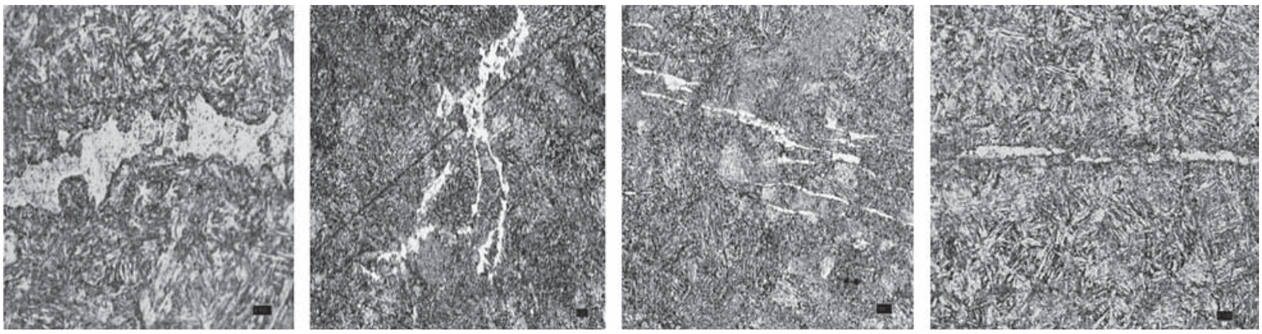


Figure 3 Structure of materials in heat affected area: a – at plating by welding without ultrasonic activation; b – at plating by welding in ultrasonic field, in conditions: f = 33 867 / Hz; A=38,9 / µm; I_s=320 / A; v_s=52,3 / cm/min; c - at plating by welding in ultrasonic field, in conditions: f = 38 204 / Hz; A=62,7 / µm; I_s=240 / A; v_s=50,6 / cm/min; d – at plating by welding in ultrasonic field, in conditions: f = 35 797 / Hz; A=70,5 / µm; I_s=240 / A; v_s=45,7 / cm/min; zoom 200x; attach 5ml H_2SO_4 + 3mlHNO_3 + 92ml HCl



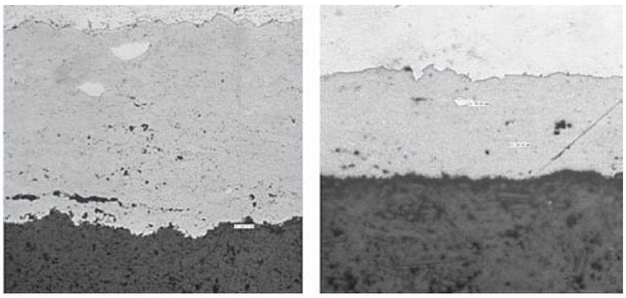
a b c d

Figure 4 The formation of carbides: a - at plating by welding without ultrasonic action; b - at plating by welding in the ultrasonic field in conditions: f = 33 867 / Hz, A = 38,9 / µm; Is = 320 / A v_s = 52,3 / cm / min; c - in the case of plating in the ultrasonic field in conditions: f = 38 204 / Hz, A = 62,7 / µm; Is = 240 / A; v_s = 50,6 / cm / min; d - in case of plating in ultrasonic field, in conditions: f = 35 797 / Hz, A = 70,5 / µm; Is = 240 / A; v_s = 45,7 / cm / min; zoom 200x; attach Nital 2 / %

tained in the heat-affected zone under the action of ultrasound explain the properties of the area which means less hardness, good tenacity, no embrittlement and absence of cracking tendency.

Method of forming of carbides in the martensite matrix of the grain boundary shown in Figure 4, where it can be seen very well their arrangement at the limit of grains under the action of ultrasonic waves. Compression action - extent at propagation of ultrasonic waves in the solidification leads to fragmentation and dispersal carbide grains, depending on the ultrasonic frequency and amplitude of vibration and the nature of ultrasonic waves introduced into welding bath.

An important problem that has been pursued was that of possible defects that may occur in plating by the welding process. As shown in Figure 5 a, the plating by welding without ultrasonic activation may occur a lot of porosities, in particular in the heat affected zone and in the filler material, which may be dangerous because they can become areas which accumulates hydrogen atomic leading to the appearance of microcracks and even cracks, or which accumulate sulfide hydrogen leading to a decrease in the corrosion resistance. When planting in an ultrasonic field (Figure 5, b) porosities disappear almost completely and from the heat affected zone and deposited layer and this is possible because



a b

Figure 5 Appearance of porosities in case of plating by welding: a – at welding without ultrasonic activation; b – at welding in ultrasonic field, in conditions: f = 35 797 / Hz; A = 70,5 / µm; I_s = 240 / A; v_s=45,7 / cm/min; zoom 100x, attach Nital 2%

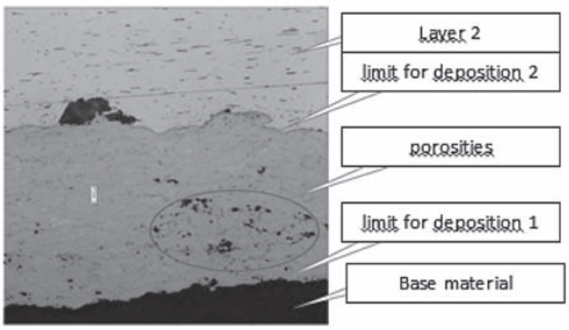


Figure 6 Appearance of porosities at plating by welding without ultrasonic activation and deposition of two layers

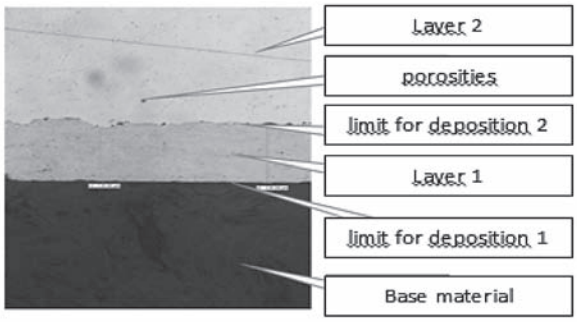


Figure 7 Appearance of porosities in a piece plated by welding in ultrasonic field, in conditions: f = 35 797 / Hz; A = 70,5 / µm; I_s = 240 / A; v_s = 45,7 / cm/min

the extensive phenomenon appears - compression that is subject the welding bath under the action of ultrasound, allowing the removal of porosities to the surface of the deposited layer.

In Figure 6 we see a large number of porosities, and in case of depositing the second layer of filler material, especially in the first layer in contrast with the plating by welding in the ultrasonic field (Figure 7) where the porosities almost completely disappear near the demarcation line between base material - layer 1 of filler material and some porosities remain attached to the demarcation line between layer 1 - layer 2, probably due to improper cleaning after deposition of layer 1 of filler material.

CONCLUSIONS

– the action of ultrasounds at a tension -compression in the solidification process leads to fragmentation of the carbide grains and their dissipation according to ultrasound frequency and vibration amplitude but also according to the nature of ultrasonic waves introduced into welding bath;
– at plating in ultrasonic field, defects of porosity type disappeared completely and the cracking tendencies are no longer manifest in the demarcation line between filler material - base material.

REFRENCES

[1] Gh. Amza, D. Dobrotă, Metalurgija, 52 (2013) 1, 83-86.
[2] D. Dobrotă, Gh. Amza, Metalurgija, 52 (2013) 1, 87-89.
[3] R. Kažys, A. Voleišis, B. Voleišienė, Ultragarsas (Ultrasound), 63 (2008) 2, 7-17.
[4] A. Siddiq, E. Ghassemieh, Mechanics of Materials, 40 (2008) 12, 982-1000.
[5] Shin-ichi Matsuoka, Hisashi Imai, Journal of Materials Processing Technology, 209 (2009) 2, 954-960.

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