CONTRIBUTIONS OF THE POSSIBILITY OF USING ULTRASOUND IN PLATING PROCESS PARTS

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Abstract. *The efficiency of the plating process in the ultrasonic field is primarily dependent on the mode of introducing the ultrasonic energy into the welding bath. The research undertaken has revealed that the propagation of ultrasound in the liquid metal bath has a significant influence on the transfer process filler material through the electric arc and on the process of crystallization. All these influences are attributed to the two basic phenomena due to the propagation of ultrasound in liquid enviroments and ultrasonic cavitation and the acceleration of diffusion process.*

Key words: ultrasound, plating, welding, heat affected zone

1. INTRODUCTION

The plating of the surfaces has the role to modify the technical, functional and economic properties of them along with the modification of their geometric characteristics in accordance with the functional role. In the majority of technical applications, plating presume the deposition of a layer or multiple layers of filler material, most often with high resistance to corrosion and / or wear and corrosion on substrates, made of a different material, in most cases a material between the cheapest. The technological process through which make this deposition is different, depending on the chosen process, but the most commonly used method is plating by welding.

Depending on the geometry configuration of the surface, dimensions of gauge of the surface, the nature of the base material, the nature of the filler material, number of units, production volume, physical, chemical, mechanical and geometrical properties of the deposited layer, are used multiple welding processes for plating, the most common being: manual welding with electric arc and wrapped electrodes, welding in protective gas environment, automatic welding under flux layer with band electrode, welding with oxyacetylene flame and special welding processes (with plasma, electron beam, beam photons etc.). Whatever the chosen welding process for plating, it must be designed and realised the technological process so that the deposition layer or layers of filler material to make without any deviation from continuity, shape, size, appearance, structure, physical, chemical, mechanical and geometric properties, mean flawless .

The most common imperfections which should be avoided in the plating are:

- pores, which occur due to the existing oxides on the plating surfac or at a high cooling rate, when the electric arc is too long or when the filler material is wet;

- **non-metallic or metallic inclusions**, which occur when the welding bath temperature is lower or welding intensity is chosen improperly, when the plating is done in several layers and cleaning after deposition of each layer was not done properly;

- **cracks**, which occur due to: the incompatibility between the filler material and base material; the absence of the preheating; improper welding order; improper heat treatment after welding and cooling rate too high;

- **lack of melting**, which occurs when the welding speed is too high, the linear energy is too low, the electrode-wire diameter is too large and the filler material is chosen poorly;

- **lack of penetration**, which occurs when the electric arc power is too low, or welding intensity is too low, when the geometry of the **joint** is inappropriate or the height of the joint is too high;

- **marginal trench or notch**, when welding current intensity is too high, the filing of an insufficient number of layers or the wrong inclination of the electrode-wire;

- **excessive penetration**, occurs when the intensity of the welding current is too high, the electrode-wire diameter is too small or, the joint has opening too large.

Also, any of the welding processes used to achieve plating pieces or products it should be well known the phenomenon of dilution of both base and filler materials, because dilution has the following effects :

- reduction of the corrosion resistance;
- reducing the wear resistance and reducing the hardness;
- reduction in tensile strength;
- reduction of fatigue strength;
- increasing or decreasing the sensitivity to cracking.

Dilution is defined as the ratio between the penetration depth p and the total thickness of the deposited layer ht (Figure 1) :

$$\text{Dilution} = \frac{\textit{penetration depth}}{\textit{total thickness of the deposited layer}} \times 100[\%] \qquad (1)$$

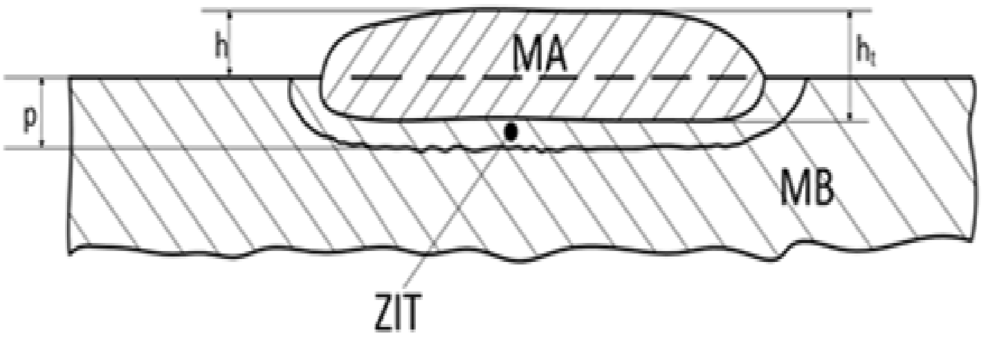

Fig 1. *The elements of defining of the dilution:*
MA - filler material ; MB- base material ; HAZ - heat affected zone ;
h - thickness of the deposited layer ; ht - total thickness of the deposited state ; p – penetration

Knowing the dilution phenomenon and its proper management can lead to the obtaining of particular functional and technological properties for the layer or layers of deposited material and special functional features for the surface plated by welding.

Therefore, in order to avoid imperfections described above and to lead the appropriate dilution in order to achieve the desired plating process has been proposed the realization of a plating process by welding in ultrasonic field.

In order to establish an optimal plating technological process by welding in ultrasonic field is required a systematic analysis of ultrasonic field with elements that define its properties and its usability, considering that the base material and the filler material undergoes a thermal cycle of heating type until melting and cooling to solidification at ambient temperature .

2. POSSIBILITIES OF USE OF ULTRASOUND IN THE PLATING OF SURFACE.

The efficiency of the plating process in the ultrasonic field is primarily dependent on the mode of introducing the ultrasonic energy into the bath of welding. The research undertaken has revealed that the propagation of ultrasound in the liquid metal bath has a significant influence on the transfer process of the filler material with electric arc and on the process of crystallization. All these influences are attributed to the two basic phenomena due to the propagation of ultrasound in liquid environments and ultrasonic, namely the ultraacoustic cavitation and the acceleration of diffusion process.

The most difficult problem that arises is related to the method of introduction of ultrasonic energy in the liquid metal bath.

In the paper has been tried many variations, the best results were obtained by the following methods:

- inntroducing the ultrasonics directly into the wleding bath (Figure 2);
- introduction of ultrasound directly in plated piece by loading by welding (Figure 3 and Figure 4);
- introduction of ultrasound through the electrode, which depends on the chosen welding process (Figure 5).

In the case of directly introducing ultrasonic in welding bath are obtained the following advantages: it substantially improves the transfer process of filler metal added to the weldin bath; increases of the electric arc's stability; accelerates the process of ionization of the elctric arc's space.

The disadvantages of these varints are related to direct contact between the welding bath and the active part of ultrasonic energy concentrator and method of controlling the deposition process. At the introduction of ultrasound directly in the plated piece, when depositing filler material on the base material (Figure 3 and Figure 4) are obtained the following advantages: it provides a nearly perfect cleaning of the plated surface due to cavitation process; accelerating the diffusion process; the cavitation process occurs in welding bath, which increases the cooling rate, which influence the solidification process; it is obtained a fine grain structure due to the periodic action of the ultrasonic waves; dilution phenomenon can be more easily controlled; the precipitation at the limit between grains disappear, near the interface base material - filler material; the internal tensions disappear and is no more required the heat treatment after weldin; to improve the functional properties of the structure.

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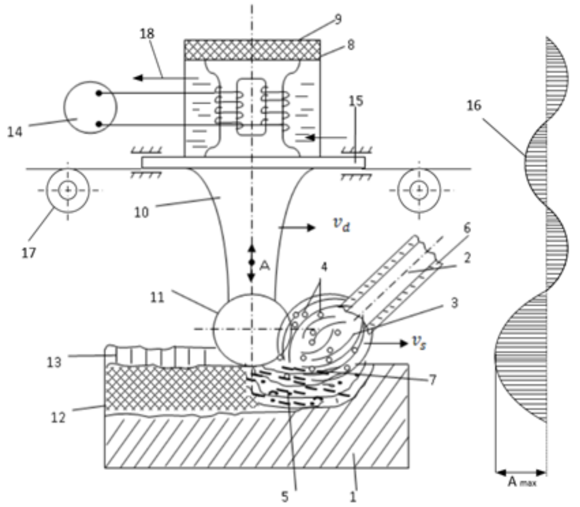

Fig. 2. *The scheme of introducing ultrasonics directly in welding bath: 1 - base material; 2 - filler material; 3 - electric arc; 4 - drops of liquid metal; 5 - welding bath; 6 - wrapper; 7 - protective layer of melted wrap ; 8 - ultrasonic transducer; 9 - acoustic insolating; 10 - ultrasonic energy concentrator; 11 - the active part of ultrasonic concentrator (sonotroda); 12 - deposited layer; 13 - wear layer; 14 - ultrasonic generator; 15 - nodal flange; 16 - variation diagram of amplitude of particle velocity along the ultrasonic system 17 - running path; 18 - coolant liquid.*

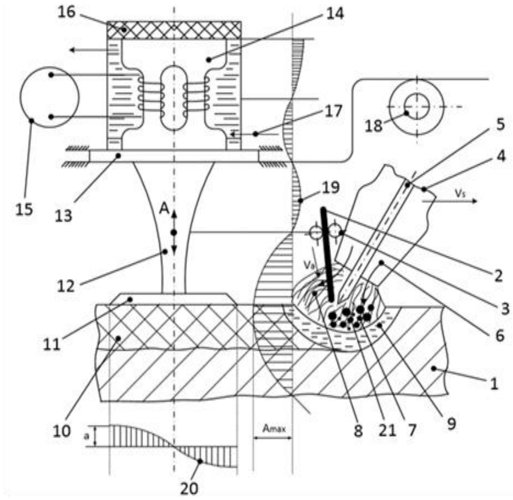

Fig. 3. *The scheme of introducing the ultrasonic in welding bath at right angles to the direction of welding: 1 - base material; 2 - filler material, 3 - training rollers; 4 - welding head; 5 - wolfram electrode; 6 - protective gas; 7 - electric arc; 8 - protective curtain of welding bath and electric arc; 9 - welding bath; 10 - deposited layer; 11 - the active part of ultrasonic concentrator; 12 - ultrasonic energy concentrator; 13 - nodal flange; 14 - ultrasonic transducer; 15 - ultrasonic generator; 16 - acoustic insolating; 17 - the coolant; 18 - guide rollers; 19 - variation diagram of amplitude of particle velocity longitudinally ; 20 - variation diagram of amplitude of particle transverse; 21 - drops of filler material; vs - welding direction; va - the advance direction of the wire-electrode.*

The main disadvantages arising from the correlation of ultrasonic system with the configuration of geometry and dimensions of gauge of the plated piece

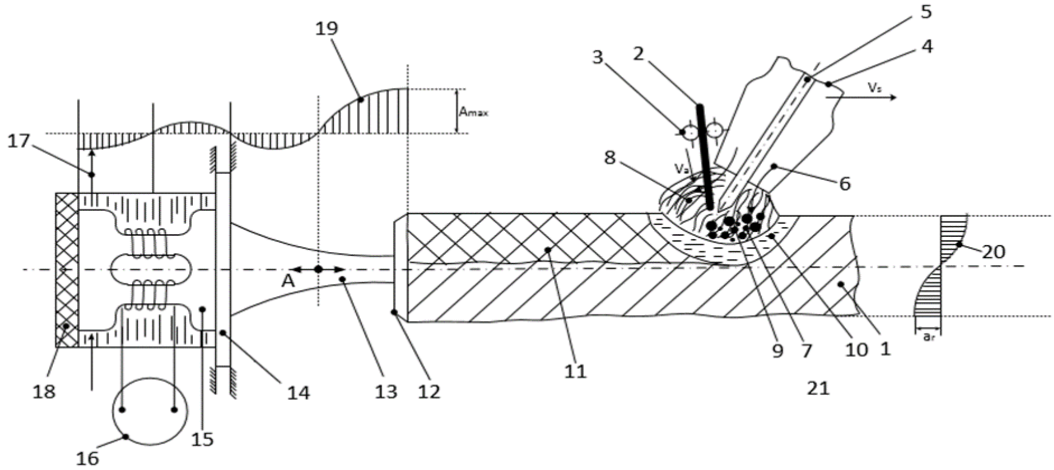

Fig. 4. *The scheme of the introduction of ultrasound in the welding bath parallel to the direction of welding: 1 - base material; 2 - filler material; 3 - training rollers; 4 - welding head; 5 - wolfram electrode; 6 - protective gas; 7 - electric arc; 8 - protective curtain; 9 - drops of filler metal; 10 - welding bath; 11 - deposited layer; 12 - the active part of ultrasonic energy concentrator; 13 - ultrasonic energy concentrator; 14 - nodal flange; 15 - ultrasonic transducer; 16 - ultrasonic generator; 17 - the coolant; 18 - acoustic insolating; 19 - variation diagram of amplitude of particle velocity longitudinally; 20 - variation diagram of the amplitude of particle velocity transverse*

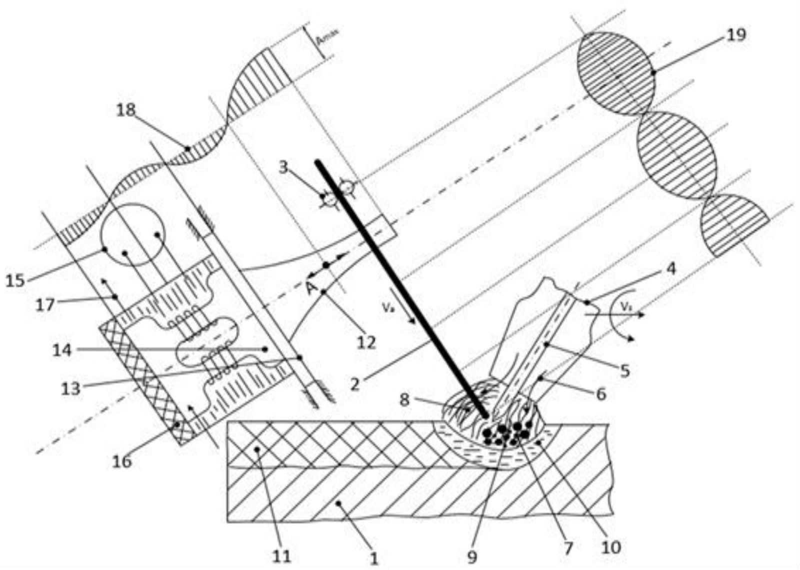

Fig. 5. *The scheme of introduction the ultrasound by operating wire-electrode:*
1 - base material; 2 - filler material; 3 - training rollers; 4 - welding head; 5 - wolfram electrode; 6 - protective gas; 7 - electric arc; 8 - protective curtain; 9 - drops of filler metal; 10 - welding bath; 11 - deposited layer; 12 - ultrasonic energy concentrator; 13 - nodal flange; 14 - ultrasonic transducer; 15 - ultrasonic generator; 16 - acoustic insolating; 17 - the coolant; 18 - variation diagram of amplitude of particle velocity longitudinally; 19 - variation diagram of the amplitude of particle velocity along the wire-electrode; va - the advance direction; vs - welding direction

The introduction of ultrasound using the electrode (Figure 5) are obtained the following advantages: substantially increase of the transfer of filler material on plated surface; increase the dynamic stability of the electric arc; accelerating the ionization process in the electric arc area; is obtained a fine grain structure due to the periodic action and alternating symmetrical to ultrasonic wave in welding bath; increasing the cooling rate and the degree of subcooling when the crystallization begin, due to cavitation phenomenon; it is created the possibility of disparition of fragile structures by Widmannstatten type; increased economic efficiency because the obtained structure is similar to that obtained after heat treatment of normalization.

The main disadvantages of this embodiment are given by weight of the correlation of calculation elements of ultrasonic system with the functional component of welding instalation that can be welded in the protective gas environment in the slag bath or under flux layer or others.

Plating processes by loading by welding can be classified according to the following criteria:

- after welding process used, differing as follows:
- acetylene flame;
- with electric arc (manual welding with wrapped electrodes, under flux layer, the protective gas environment, the slag bath, plasma); by pressure;
- depending on the degree of mechanization and automation, distinguished: manual; semi-automatic; automatically;
- after the presentation of the filler material, the most commonly used are: with powder; with rods; with warppeded electrodes; with one or more wire-electrode filled; one or more powdery core wire; with self-protecting cored wire; two full bands; powdery core band .

For some flat surfaces and exterior cylindrical surfaces of some pieces, parts of wellhead, it is used the manual welding process using electric arc and wrapped electrodes, where the arc is primed between the electrode and the workpiece wchich will be plated , melting filler material and a part of the material of the plated piece (basic material MB).

3. CONCLUSIONS

- The construction industry of cars, railway trasnports industry, metallurgy, petrochemical and chemical industry, there are used multiple plating technology , the most commonly used are: plating by plastic deformation; by welding; by sticking; the metallization; by splintering; by micro-splintering and by depositing metallic materials;
- Filler materials must be compatible with basic materials and form metallic bonds homogeneous as much as possible, to be submitted by the simple processes, without possibility of defects aperring and lead to functional and technological properties better than the base material;
- At plating by loading by welding with electric arc, regime parameters are: the type, nature and size of filler material and base material; pre-heating

temperature; welding current; welding voltage; geometric parameters of the deposited layers, the temperature between the rows and the number of layers deposited;

- At plating by loading by welding in the ultrasonic field regime parameters are: the nature and size of filler material and base material; welding current; welding voltage; linear energy; welding speed; the way of introduction of ultrasonic energy in the welding bath; the time of ultrasonic action; intensity, frequency and type of ultrasonic waves; amplitude of vibration; geometric parameters and the number of layers deposited;
- The efficiency of technological process of plating by loading by welding depends primarily on the behavior of couples of partner materials (base material, filler material), the method to make the consistent contact between fringe atoms of contact surfaces and how is the dilution made;
- On plating by loading by welding of steel with a high carbon content may occur in the HAZ a hardening of the material, so the risk of cold cracking;
- To avoid material embrittlement in HAZ is required a series of technological measures, namely: pre-heating; welding with large linear energy; achieving a high plasticity deposits by choosing suitable filler material, ultrasonic activation of welding bath and others;
- Ultrasonic activation of welding bath evens out the temperature and increase the heat exchange with base and intermediate layer increasing the cooling rate by 4 ... 8 times in the middle of the bath and by 1.5 ... 2 times in the marginal area concurrently with the increase over 4 times of the coefficient at plating by welding in ultrasonic field was a substantial reduction of porosities deposited structures and the disappearance of cracks in and near the heat affected zone;
- At palting by welding in ultrasonic field has been a substantial reduction in porosities in the deposited structures and disappearance of cracks in and near the heat affected zone;
- At palting in the ultrasonic field, dilution has decreased by 42 % in the first deposited layer and 66% in the second layer deposited in comparison with plating by welding without ultrasonic activation due to acceleration of diffusion proess of filler material to base material and blocking the diffusion from the base to the filler material .

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