

CONTRIBUTIONS REGARDING TECHNOLOGICAL METAL DEPOSITION IMPROVING USING THE ULTRASONIC WAVES

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ABSTRACT: Paper presents some technologies of ultrasonic wave metal melting activation considering advantages and disadvantages for each method. A solution for an increased productivity is also presented. Direct method of melt metal ultrasonic activation is studied, followed by base metal ultrasonic activation and finally the electrode wire ultrasonic activation. Using of two electrode wires simultaneously working is analyzed.

KEY WORDS: metal, deposition, welding, ultrasonic field.

1. INTRODUCTION

Metal plating by welding technology presents some disadvantages eliminated by ultrasonic activation. The following solution are proposed:

- ultrasonic activation in the case of simple or complex geometrical shape configuration of the base metal. Small or medium dimension base metal were studied made by different materials;
- productivity increasing of welding deposition using two eletrodes is analised;
- welding deposition process informatisation and optimisation by technological parameters programming;
- better base metal-addition metal selection is studied.

2. CONTRIBUTIONS CHOOSING OPTIMAL PARAMETERS REGIMES LOAD PLATING ULTRASONIC WELDING FIELD OF PARTS

Metal plating by welding technology consists in additive metal material deposition on a base material in order to get specific characteristics and shape dimension (hard fatigue resistance, erosion or corosion better characteristics).

Plating technological process efficiency depends first by base metal-additive electrode wire couple behavior. Second, very important is also the atomic bond between two materials athoms placed in contact zone or near it. [3].

Homogenous conjunction is the result of deposition technological steps of the addition material on base material surface.

Most important steps of metal plating by welding technology are: mechanical working of base material, metal surface cleaning, capping, chemical cleaning in oder to create optimal adherence conditions, base material preheating to reduce the thermal gradient, metal depositon, solidification conditions assurance to avoid cracks, heat treatment for specific working conditions, metal cutting on specified dimensions [6], [8].

Each specified step can be more or less influenced if an ultrasonic energy is applied over the classic energy. Ultrasonic metal plating first depends on way of ultrasonic energy is introduced in the metal melting zone.

Welding plating in ultrasonic field depends most on the way of the ultrasonic energy introduction in the fusion bath. Our researches showed that ultrasonic wave propagation influences the adition material transfer process through electric arc and cristalisation process. All that influences are according to liquid ultrasonic wave properties: ultrasonic cavitation and diffusion acceleration process.

Most difficult problem regards ways of introduction the ultrasonic energy in the fussion bath.

Different methods were analised and experimented with best results for the following methods:

- direct ultrasonic wave introduction in the fusion bath (fig. 1);
- ultrasonic energy introduction in the metal base material (fig. 2 and fig. 3);
- ultrasonic energy introduction in the fusible electrode depending on the welding process (fig.4).

In the case of direct ultrasonic introduction in the fusion bath, the following advantages are discovered:

- a certain improving of the addition material transfer process to fusion bath;
- increasing electric arc stability;
- acceleration of ionization process in the electric arc space;
- uniform dimension of the deposited particles;
- decreasing of the dilution phenomenon;
- increasing cooling speed because of the cavitation process appearance;
- hard recrystallization influence;
- accelerated evacuation process of the gases;

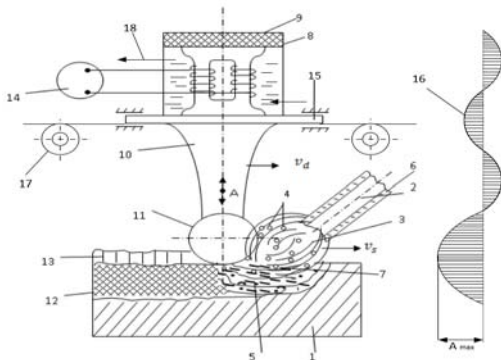


Figure 1. Direct ultrasonic wave introduction

1 – base material; 2 – addition material; 3 – electric arc; 4 – liquid metal stropi de metal lichid; 5 – fusion bath; 6 – electrode shell; 7 – melt shell protective layer; 8 – ultrasonic transducer; 9 – acoustic insulation; 10 – ultrasonic energy concentrator; 11 – active ultrasonic system part (sonotrode); 12 – deposited layer; 13 – wear layer; 14 – ultrasonic generator; 15 – nodal flange; 16 – speed variation diagram along ultrasonic system; 17- transport system; 18- cooling liquid.

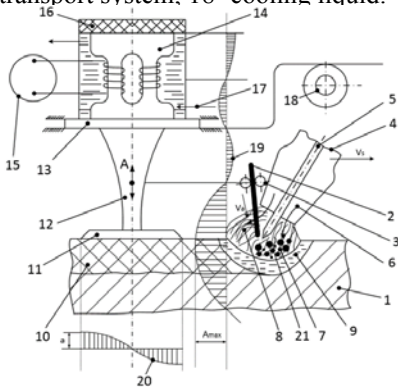


Figure 2. Scheme introducing ultrasonic welding bath at right angles to the direction of welding:

1- base material; 2- addition material; 3 – driving rollers; 4 – welding head; 5 – Wolfram electrode; 6 – protective gas; 7 – electric arc; 8 – covering layer of the fusion bath 9 – fusion bath; 10 – deposited layer; 11 – ultrasonic system active part; 12 – ultrasonic energy concentrator; 13 – nodal flange; 14 – ultrasonic transducer; 15 – ultrasonic generator; 16 – acoustic insulation; 17 – cooling liquid; 18 – guidance roller; 19 – speed variation diagram along longitudinal ultrasonic system; 20 – speed variation diagram along transversal ultrasonic system; 21 – drops of addition material; v_s – welding direction; v_a – moving direction of electrode .

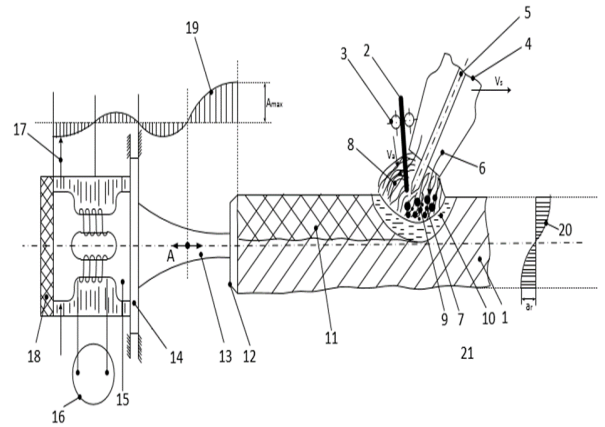


Figure 3. Ultrasonic energy penetration in a paralel plane with welding direction

1 – base material; 2 – addition material; 3 – driving rollers 4 – welding head; 5 – wolfram electrode; 6 – protective gas; 7 – electric arc; 8 – covering layer; 9 – added material drops; 10 – welding bath; 11 – deposited layer; 12 – active part of the ultrasonic system; 13 – ultrasonic energy concentrator; 14 – nodal flange; 15 – ultrasonic transducer; 16 – ultrasonic generator; 17 – cooling liquid; 18 – acoustic layer; 19 – speed variation diagram along longitudinal ultrasonic system; 20 – speed dvariatio diagram along transversal ultrasonic system

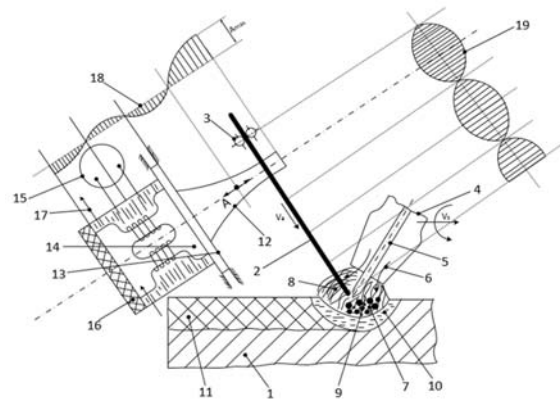


Figure 4 Ultrasonic waves activation system by electrode wire

1 – base material; 2 – additive material; 3 – driving rollers; 4 – welding head; 5 – wolfram electrode; 6 – protective gas; 7 – electric arc; 8 – protective gas layer; 9 – additive liquide material drops; 10 – welding bath; 11 – deposited layer; 12 – ultrasonic energy concentrator; 13 – nodal flange; 14 – ultrasonic transducer; 15 – ultrasonic generator; 16 – acoustic layer insulator; 17 – cooling liquid; 18 – diagram of longitudinal particle velocity amplitude variation; 19 – speed variation diagram along longitudinal ultrasonic system; v_a – additve electrode moving direction; v_s – welding speed.

This system disadvantages are closed linked to direct contact between welding bath and ultrasonic system energy concentrator. When ultrasonic energy is directly introduced in the base material, when additive material is deposited, the following advantages are achieved.

- a perfect base material cleaning;
- accelarated difusion process;
- cavitation process in the welding bath;
- fine granular structure;
- better controled diffusion process;

- internal stress elimination and no needed thermal treatment;
- better functional properties;

Main disadvantages occurs due to ultrasonic system corelation with geometrical shape.

When ultrasonic waves are introduced with the help of electrode, the following advantages are found:

- high rate of additive material transfer;
- increased dynamic arc stability;
- ionization process transfer acceleration;
- fine granular structure;
- increased cooling speed when cristalization starts;

- low Widmannstatten structure appearance possibility.

Main process disadvantages are closed to difficult mathematic corelation between ultrasonic system elements and welding system component [2], [6], .

The welding plating process will be clasified by the following criteria:

- by welding method: with oxygas flame; electric arc; with plasma; by pressure;
- by mecanization system: automat and semiautomat;
- by additive material presentation: plated electrodes; hard wire; one or two electrodes; plain electodes; etc;

For some plane surfaces or cylindrical, the manual welding method is used. The additive electrode material is a very important step an dis according to the following:

- chemical base material composition;
- technological and mechanical properties of the deposited layer;
- lack of damages according to welding process (metalic inclusions, exces penetration, cracks, etc.).

Studies on the behavior of carbon steel welded cladding. Carbon steels do not contain other alloying elements besides carbon and elements required for making and casting: silicon, manganese, aluminum, sulfur and phosphorus in certain concentrations [3],

The mechanical characteristics and behavior of the welding of carbon steels are primarily determined by the carbon content. Figure 5 shows the influence of carbon content on the main mechanical characteristics (HB, KCU, A, RM).

Experimentally it was found that increasing the carbon content of 0.1% increases tensile strength of about 90 N/mm² and yield 40 ... 50 N/mm². As stated maximum HAZ hardness is generally limited to carbon and low alloy steels to 350 HV 5. This hardness is achieved with a carbon content of 0.22% and a 50% martensite structure.

The cladding by welding of steel with a high carbon content can occur in the hardening of the heat affected material. Tensile strength and hardness increase greatly in the area, while the plasticity decreases, so a request, sometimes the internal stresses can occur due to cracking of the material. Figure 5 shows the dependence of the carbon content and hardness of the material structure. Hardness depends almost exclusively on the carbon content of the steel. Therefore, it is considered that the welding of carbon steel with less than 0.22% C, generally no danger of cracking in the cold (the hardening). Steels with 0.22% C than is considered weldable condition to avoid brittle material requiring a series of technological measures, namely:

- *Pre-heating*, the cooling rates are reduced, and therefore, the risk of hardening. The temperature of pre-heating depending on the carbon content of the steel, the thickness of the material, the shape of the joint and the welding process. Data indicative of the choice of the pre-heating temperature are shown in Table 1. The piece has a thickness greater than the preheat temperature must be high under the conditions of heat propagation dimensional

Table 1. The choice of pre-heat temperature

content carbon [%]	Preheating temperature [°C]	The minimum thickness [mm]
0.25	100	50
0.35	100 – 250	10
0.45	150 – 300	5
0.60	300 – 400	5

Figure 5 shows the influence of temperature on the hardness of the ZIT reheat for a particular carbon steel and some linear energy.

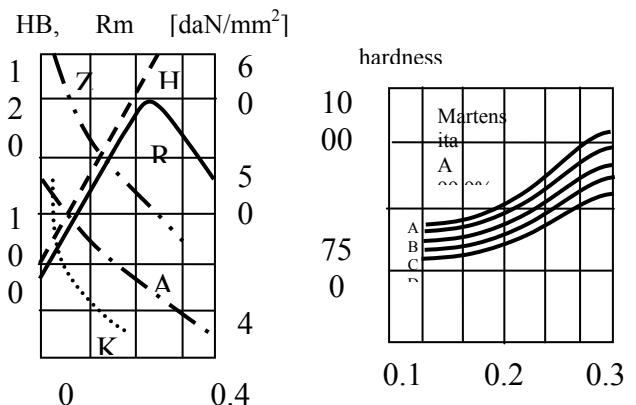


Figure 5. Influence of carbon content on the mechanical characteristics f carbon steels: HB-hardness; RM-tensile strength; A-plasticity; KCU-tenacity; Z-constriction at break

Welding of high linear energy. This measure is similar to the preheating effect. The tendency of hardening decreases with the use of electrodes

(wires) or the larger diameter of welding processes are energy intensive (e.g., in the weld line). Figure 3.40 shows the influence of power to the linear travel speed and the hardness in the case of a carbon steel with 0.44% C, and 0.53% C.

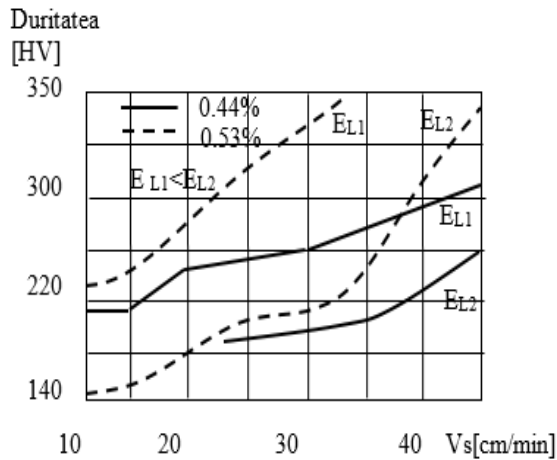


Figure . 6 Influence of linear energy and the welding speed hardness in the ZIT

- *Ultrasonic welding field.* To this end, depending on how ultrasonic energy is introduced into welding bath held a series of events that have positive effects on the characteristics of the deposited layer, as follows:

- Smooths the welding bath temperature and increases the heat exchange core layer increases the cooling rate up to 800% in the central area of the bath of welding and 200% in the edge area; 400% increasing rate of heat release and the heat exchange rate;
- Accelerating the diffusion process resulting in thorough mixing of atoms in a stable state to another stable state by the action of cavitation breaths, the pressure of the ultrasonic causing turbulent mixing and boundary film destruction of the liquid phase and the solid phase;

3. CONTRIBUTIONS REGARDING PLATING PRODUCTIVITY INCREASING BY USING A TWO WIRES WIG WELDING DEVICE

One of the main disadvantages of any welding plating process is lower productivity especially for complex surfaces and high volumes.

Considering this, the deposited layer thickness is limited by many technological and constructive parameters. The paper proposed a high deposited layer thickness according to a special WIG device with two welding wires (fig.7).

Because of intellectual property problems, only a general view is presented and the two wires position during the deposition process.

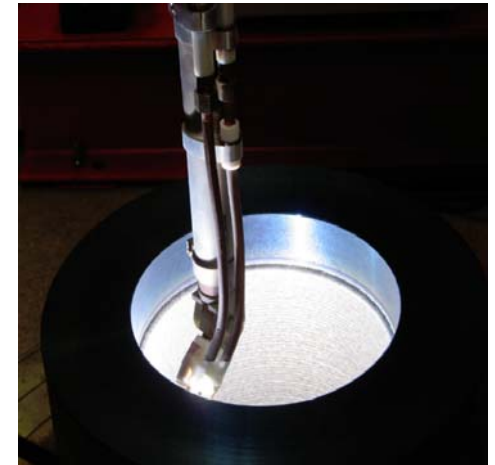
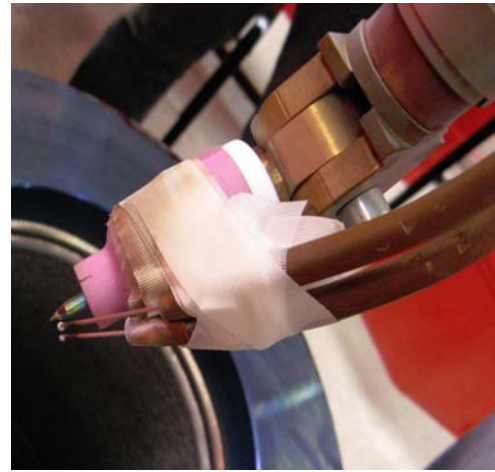


Figure 7. Two wires welding electrode

Figure 8. presents the difference between the layers according two one or two electrodes in the same time fused when the deposition rate is about 100% increased.[2].

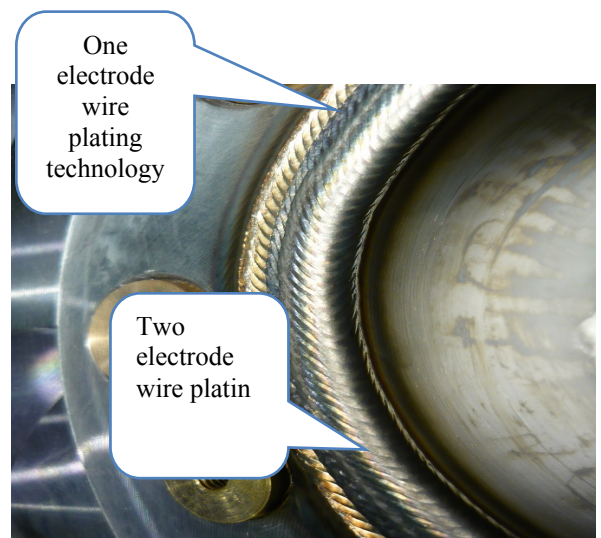


Figure 8. Differences between one or two electrode technology in metal deposition

The most important problem regards the two electrode speed correlation in the same position according to electrode intersection [6], [15].

This problem can be achieved by using a specialized software.

4. CONCLUSIONS

1. In machine construction industry, transportation industry, metalurgical industry, chemical and petrochemical industry, many plating technology are used ;
2. Additive materials should be compatible with base material and should form metallic homogenous links, has to be deposited by simplest methods without damages and with better functional and technological properties than base material ;
3. At welding plating, the working parameters are the following : type, nature and dimension of the addition material, preheating temperature, welding electric current, welding voltage, geometrical materials shape, temperature between deposited rows, numbers of layers.
4. At ultrasonic welding plating process, the welding parameters are: nature and dimension of the base material and additive material, electrical voltage, electrical current, ultrasonic energy activation time, ultrasonic wave frequency, intensity and type, vibration amplitude, number and geometrical dimensions of the deposited layer;
5. Technological efficiency of the plating method depends on the materials couple, way of how the atoms are linked and how the dilution is made ;
6. When highly carbon concentration materials are used, a ZIT zone hardness can appears and the cracks are possible;
7. Technological prevention measures are needed to avoid the material fragilization, high energy welding, high plasticity deposited layers, high energy welding, fusion bath ultrasonic activation.

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