

# THEORETICAL AND EXPERIMENTAL PIECES PLATING ULTRASONIC FIELD

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**ABSTRACT:** This paper presents the importance of the cladding for highly loaded parts from corrosion and / or wear and technologies currently used with advantages and disadvantages. It proposes a new plating technology loaded ultrasonic welding field and establishes the main stages of the technological process and the main process parameters of ultrasonic welding field. Are given the dependency relationships between the system parameters and welding from various ultrasonic oscillation amplitude. Following the experimental results are some recommendations on charging field ultrasonic welding of carbon steel alloy.

**KEY WORDS:** plating, ultrasounds, loading, welding, technological, process.

## 1. INTRODUCTION

The efficiency of the plating process in the ultrasonic field depends primarily of how the introduction of ultrasonic energy in 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 process of transfer of the material by the arc and weld the process of crystallization.

All these influences are attributed to two basic phenomena due to propagation of ultrasound in liquid media and ultrasonic cavitations i.e. accelerate diffusion.

The most difficult problem that arises is related to how the introduction of ultrasonic energy in the liquid metal bath [3],[5].

The paper was testing several options, the best results were obtained by the following methods:

- the introduction of direct ultrasonic welding bath;
- introduction of ultrasound directly by loading plated piece welded;
- introduction of ultrasound through the electrode is selected according to the welding process.

In the case of directly introducing ultrasonic welding bath are obtained the following advantages:

- It improves the transfer of the metal added to the bath of solder;
- Increases arc stability;
- Accelerates the ionization of the arc space;
- It evens filler metal particles that are deposited;
- Dilution reduces the phenomenon of the coating;
- Cavitation occurs which increases the cooling rate;
- Strongly influence the crystallization process;

- There is an accelerated clearance of bath gas welding.

The introduction of ultrasound directly plated piece, when depositing filler material over the base fabric gives the following benefits:

- provides a nearly perfect surface cleaning reconditioned due cavitation;
- accelerates the diffusion process;
- cavitation occurs welding bath, which increases the coolingrate influencing the solidification process;
- to obtain a fine grain structure due to the regular action of the ultrasonic waves;
- dilution phenomenon Maybe it be easier to control;
- disappear precipitation of grain boundary near the interface material - filler.

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

The introduction of ultrasound through the electrode gives the following advantages:

- increase substantially transfer filler material surface refurbished;
- increase the dynamic stability of the arc;
- accelerating the arc ionization space;
- to obtain a fine grain structure due to the action of a symmetrical periodic alternating ultrasonic wave soldering bath;
- increase the cooling rate and the degree of subcooling of the beginning of the crystallization, due to cavitation;
- it creates the possibility of extinction type Widmannstatten fragile structures;
- increased economic efficiency because the structure obtained is similar to that obtained after normalizing heat treatment.

Welding may be performed in direct current or alternating current, to maintain constant arc power being made by controlling the arc length [7].

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

Experimentally it has been found that charging parameters plating arc welding are as follows: -the type, nature and size of the load; -preheat temperature; the welding current  $I_s$ ; Welding-voltage  $U_a$ ; -geometrical parameters of deposited layers; -the number of layers deposited; -temperature lines.

In the case of coating by charging the flame-welded parts, operating parameters are: -the type, nature and size of the load; -preheat temperature; acetylene-pressure and flow, and  $QC_2H_2$   $pC_2H_2$ ; oxygen-pressure and flow,  $pO_2$  and  $Qo_2$ ; welding flame-nature; -welding technique; -the number of layers deposited; -welding speed.

### 2.1. Choice the type, nature and size of loading

For the deposition of thin layers is recommended to use small diameter electrodes, which afford thickness deposited in a single pass. For thicker layers, the diameter increases correspondingly to increase productivity. Currently are manufactured and used electrodes with a diameter between 1.6 and 6 mm.[10].

Wire electrode for welding in protective gas has diameters between 0.5 and 6.0 mm.

### 2.2. The choice of the preheating temperature of the workpiece to load cladding by welding ultrasonic field

Load the coated pieces are formed by welding two distinct parts in terms of chemical composition, thermo-physical characteristics and behavior of both the mechanical and the thermal stress. These components are part of the base and weld deposited layer.

Method of determining the preheating temperature with carbon equivalent can apply only if carbon steel or low alloy steels. This includes the following: - What is determined carbon equivalent, the relationship:

$$\%C_e = \%C + \frac{\%Mn}{6} + \frac{\%Ni}{15} + \frac{\%Mo}{4} + \frac{\%Cr}{5} + \left( \frac{\%Cu}{13} + \frac{\%Si}{4} + \frac{\%P}{2} + \frac{\%V}{5} \right) \quad (1).$$

-based on the value obtained for the carbon equivalent  $T_{pi}$  preheat temperature is determined as follows:

-for  $Ce \leq 0,45$  choose  $T_{pi} \leq 373^\circ K$ ;

-for  $0,45 \leq Ce \leq 0,60$  choose  $373 \leq T_{pi} \leq 523^\circ K$ ;

-for  $0,60 \leq Ce$  choose  $523^\circ K \leq T_{pi}$ .

### 2.3. Determination of welding current plating load ultrasonic welding field

Increase welding current leads to: - increase the depth of penetration; - increasing dilution; - increased productivity; - overheating of alloying elements that can vaporize and be lost.

Welding current  $I_s$  depends largely on the material submitted and each manufacturer recommends optimum ranges for each type of electrode or wire that can be used.

If ultrasonic activation piece welded clad during charging can be used experimentally determined values below in the analysis of functional characteristics of deposited layer: - for coated electrodes for electric welding is recommended:

$$I_s = (20 + 5,2 \cdot d_e) \cdot d_e + 0,8 a \quad (2)$$

where:  $d_e$  in the electrode is a welding wire diameter in mm; a- ultrasonic oscillation amplitude in  $\mu m$ ;

### 2.4. Determination of the arc voltage plating welding load [15].

Arc voltage is proportional to the arc length and truncated form given arc, arc voltage characteristic dimensions of heat transfer by piece plated. Consequently, low voltage will characterize a short arc, with a small opening and will lead to greater penetration. A high voltage characterizes a long bow with a large opening and lead to a widening of the deposited layer with a low strike.

Temperature between rows is part temperature or the surrounding area that can submit a new weld. It is only necessary to determine if more rows of deposits and passages.

It is determined for the control on the rate of cooling and to prevent overheating of the load area. It should not be higher than the temperature of constituents forming the fragile, susceptible to cracking.

### 2.5. Determination of geometric parameters of deposited layers

Submission to the cladding layers parts is usually several times and passes. How to place rows, each other affects the homogeneity of deposit, dilution and residual stress level.

To obtain a quality submission the following recommendations:

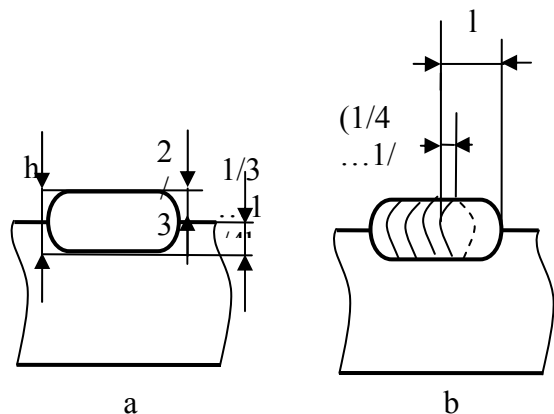
- penetration at the welding be approximately 1/3...1/4 thickness  $h$  of the film formed by plating (fig. 1, a);

- overlapping rows to be about 1/4 to 1/3 of the width  $b$  of the row.

The problems are more complicated than in the case of the filler layering is done using two electrode wires to melt simultaneously [12], [13].

## 2. 6. Determination of heat treatment after plating welded load

Experimentally established that heat treatment after plating parts by welding load is applied in the following situations:



**Figure 1.** Geometrical parameters lines reconditioned by welding load:

a - row geometric parameters; b - overlapping geometric rows

- must play to avoid cracking the tension on cooling or operation;[3].

- to obtain special properties resulting from heat treatment required by the functional role;
- for the ease of further processing.

The technology heat treatment should be designed in such a way as to avoid incompatibilities with the heat treatment of the two different materials of the base material and the coating material.

The main treatments are performed after welding coating loading are dehydrogenation treatments; annealing treatment, quenching-recovery treatments; precipitation treatments; special treatment.

Dehydrogenation is to heat and maintain for 4 ... 8 hours (sometimes several days) at a temperature of 523 ... 623K, in order to reduce the diffusion of the hydrogen content of the deposited layer by welding. Runs to avoid cracking and fissures delayed "fisheye".

Annealing charging plate by welding parts can be made with the following purposes: relief; for improved machinability by cutting; rarely, for recrystallization.

Stress relief annealing is applied to reduce internal stress accumulated loaded welded parts. The elimination of internal stress starts about 673 ... 723K and ends in the temperature range 873 ... 973K. The majority of the voltage is attenuated in the first two hours maintaining the temperature of the heat treatment. Therefore, in order to tension easing effective, it is recommended that the heating and maintaining time at 873 K for 4 hours.

Annealing to improve, improve machinability by cutting is a tough constituents spheroidization annealing (pearlite, cementite, any carbons). Given the wide range of charge materials and their behavior in the different treatment is necessary that the heating-maintaining-cooling to conduct strictly according to the chemical composition of the deposited material.

If activation charge ultrasonic welding process have noted the following:

- pickling-changing conditions, refining and promoting the formation of the structure and spread of filler material in the base material;
- decrease surface tension at the interface of the liquid phase - solid phase crystallization stabilize the embryos, and to form a fine grain structure;

- appearance of current ultrasonic bath ultrasonic welding and energy dissipation in the environment lead to changes in the thermal field uniformity sense ambient temperature and the substantial increase in the rate of cooling;

- due to the phenomenon of cavitation, which produces powerful shock waves is changed dynamically balance leading to a decrease in the solubility of the filler material and the base material greatly reducing the dilution zone.

As a result of these effects, the ultrasonic waves is carried out a true strain relief annealing or aging of the parameters of the coating process, as shown by metallographic analysis of the structures obtained by welding different deposition processes.

### 3. SEVERAL RECOMMENDATIONS PLATING CHARGE FIELD ULTRASONIC WELDING OF LOW ALLOY STEELS

In general, low alloy steels fall into the category of those steels in which the amount of alloying elements content is below 5%. The behavior of the welding of these materials, with a particularly wide use is determined primarily by the chemical composition. It is usually assessed based on the concept of carbon equivalent.

There are a large number of formulas for determining a carbon equivalent. They can be divided into three groups. The first group is home Dearden-O'Neill's formula (CellW). The second group comprises the formula  $P_{cm}$ , in which the carbon content has the meanings given above for the first group. In the case of the third group, CEN Type relationship is used, and the significance of the alloying elements depends on the carbon content. Among the most commonly used formulas are:

- formula IIW (International Institute of Welding, Dearden-O'Neill) as:

$$\%Ce_{IIV} = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15} \quad (2)$$

especially true for carbon steels with a relatively high content ( $> 0,18\% C$ ) and a tensile strength of  $R_m = 400 \dots 700 \text{ N/mm}^2$ . Carbon equivalent type  $C_{e_{iiv}}$  described in addition susceptibility to cold cracking and hardening in the ZIT.

Japanese formula  $P_{cm}$  (Ito-Bessyo) resulting from expression:

$$\%P_{cm} = \%C + \frac{\%Si}{30} + \frac{\%Mn + \%Cu + \%Cr}{20} + \frac{\%Ni}{60} + \frac{\%Mo}{15} + \frac{\%V}{10} + 5\%B \quad (3)$$

used especially for low alloy steels with low carbon content (under than  $0.17\% C$ ).

- CEN japanese formula, given by the expression:

$$CEN = C + A(C) \left( \frac{Si}{24} + \frac{Mn}{6} + \frac{Cu}{15} + \frac{Ni}{20} + \frac{Cr + Mo + Nb + V}{5} + 5B \right) \quad (4)$$

under:

$$A(C) = 0,75 + 0,25 \text{ th } [20(C - 0,12)] \quad (5)$$

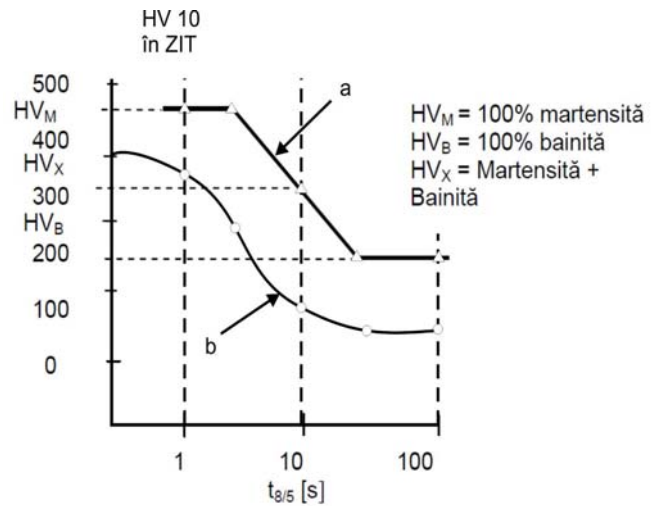
This formula can be used in both previous cases, the correctness of the results obtained in assessing behavior welding is superior to other two formulas. The steel has a lower carbon equivalent, the more he will present a more favorable reaction to welding.

The dependence of the structure, hardness and size of equivalent carbon can have a real sense only if we take into account the cooling rate appreciated simplified by size  $t_{8/5}$  which is the duration in which the cooling of the material in the temperature range  $800/500^\circ\text{C}$ . This is illustrated in figure 1. We can see that at a given steel, the hardness decreases with increasing  $t_{8/5}$  for and there of [3].

HVmax maximum hardness is determined by:  
 – carbon content of the steel, the structure is martensitic, content of alloying elements in the case of a bainite structure, content of alloying elements and the size of  $t_{8/5}$ , the structure is composed of martensite and bainite.

That, with decreasing size of the  $t_{8/5}$ , the significance of the carbon content on the hardness increases, while the significance of the contents of the alloying elements decreases (figure 1).

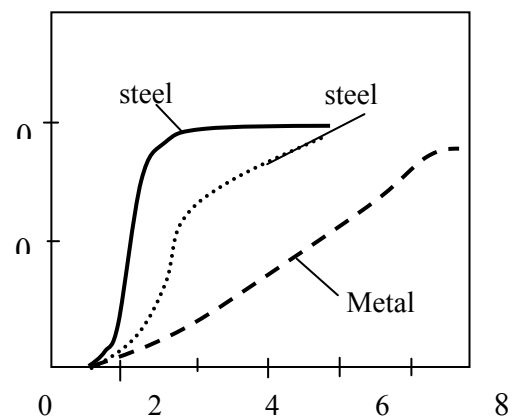
Steels with high purity and particularly with a low sulfur content shows a marked tendency for hardening compared to the conventional steels.



**Figure 2.** The main effect of the cooling time  $t_{8/5}$ , the hardness in the ZYT in welding of low alloy steel.

a - classical welding; b - ultrasonic welding field.

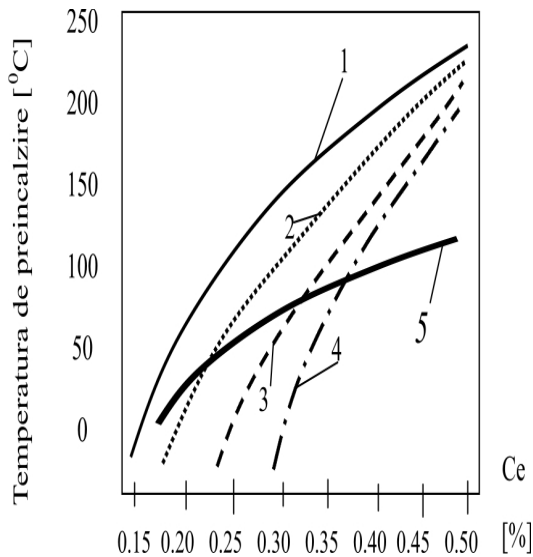
Figure 3 shows the effect of the increment of hardness steel purity steels with niobium and vanadium. The effect on the purity of the steel hardening in the ZIT is insignificant in the case of normal structural steel where the oxygen content is below 50 ppm and the sulfur content is below 0.02%. If the carbon equivalent exceeds a critical value, depending on the thickness and type of parts and welding of the welded joint must be made with special precautions. These relate primarily to preheat, welding with high linear energy field ultrasonic welding or heat treatment after welding.



**Figure 3.** Effect of increasing the hardness of steel ZIT hardness, low alloy steels with niobium and vanadium

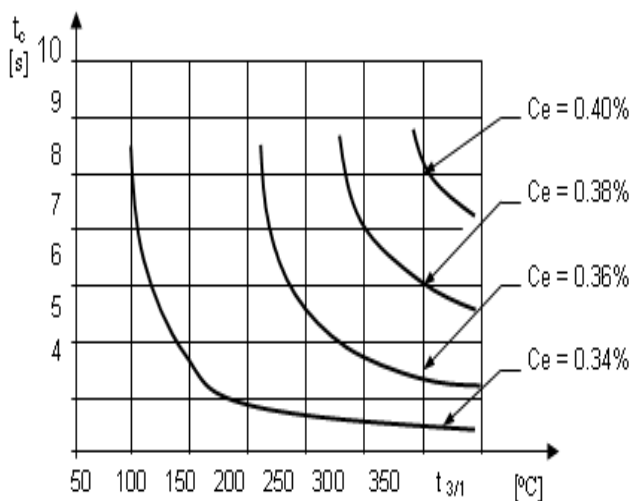
Figure 4 shows, by way of example, the pre-heating temperature variation depending on the carbon equivalent  $C_{e_{IIV}}$ , for the case of linear welding energy  $8 \dots 9 \text{ KJ/cm}$  and various levels of hydrogen content. These data were determined experimentally by the implant method,

For low alloy steels have been widely used high-temperature diagrams for determining the pre-heating, depending on the type of the joint, the thickness of the piece and linear energy used.



**Figure 4.** Advice selection of the preheating temperature according to the equivalent carbon content at various levels of hydrogen and  $E_L = 8 \dots 9 \text{ KJ / cm}$ : 1 - electrode cellulose (40 cm 3/100 g); 2 - basic electrodes (10 cm 3 / 100g); 3 - electrode bases (10 cm 3 / 100g) 4 - MAG welding (3 cm 3/100 g); 5-field ultrasonic welding; 6-welding WIG.

A parent metal, or preferably a combination of parent metal and filler material is then associated with a critical cooling time  $t_c$ , which avoid cold cracking in the baseline data specified by the carbon equivalent and the cooling time  $t_{8/5}$   $t_1$  or  $t_{3/1}$  (fig. 5). A recent method preheat temperature determination using different charts based on the carbon equivalent CEN and consider the following elements: chemical composition, content of hydrogen, linear power, material thickness, weld strength and tighten the coercion.



**Figure 5.** The dependence of the critical cooling time carbon equivalent and cooling time  $t_{3/1}$

In conclusion, welding these steels will be such as to ensure minimized heating of the material, adopting

technological measures to limit energy linear. At the same time, a portion of the ZIT softening, it is possible to produce a rough structural hardening constituents in another portion, which requires the use of welding preheating.

It now states that the current trend of steel producers is to produce materials with good welding behavior, goal materializing mainly by lowering the carbon content and increasing material purity.

#### 4. CONCLUSIONS

1. The car industry, railway industry, metallurgy, petrochemical and chemical use multiple plating technology, the most commonly used are: plating plastic deformation; by welding; solder; the metallization; cutting; by micro chipping and deposit metallic materials;

2. Filler material must be compatible with the materials, and forming metallic bonds as homogeneous as possible, can be made by the simple processes, without the possibility of defects and lead to technological and functional properties better than the base material ;

3. Loading at plating welding arc system parameters are: the type, nature and size of filler material and base material; pre-heating temperature; welding current; welding voltage; geometric parameters and temperature deposited layers between rows, the number of layers deposited;

4. Plating charge at field ultrasonic welding parameters regime 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 bath of welding; during the ultrasonic actuator; intensity, frequency and type of ultrasonic waves; amplitude of vibration; geometric parameters and the number of layers deposited;

5. Plating efficiency of technological process welding load depends primarily on the behavior of couples partner material (base material, filler material), how to make consistent contact between atoms fringe of contact surfaces and how is dilution;

6. When plating of alloy steel welding load with a high content of carbon may occur in the ZIT hardening of the material, so the danger of cracking in the cold .[3].

7. To avoid fragility in ZIT material required a series of technological measures, namely: pre; welding with high linear energy; achieving a high plasticity deposits by choosing suitable filler material, activating ultrasonic welding bath and others;

8. Activation ultrasonic welding bath and evens out the temperature increase of the heat exchange core and intermediate layer increases the cooling rate of 4 ... 8 times in the middle of the bath and of 1.5 ... 2 times the while the marginal increase of over 4 times the coefficient of transfer of heat;

9. Propagation of ultrasonic welding bath accentuates diffusion process causing a slight movement of atoms in a stable state to another stable state under the action of breaths cavitation, ultrasonic pressure causing the destruction of border film liquid phase and solid phase;

10. Ultrasonic energy introduced into the welding bath leads to the complete elimination of the dendritic structure, reducing the hardness and increasing brittleness due to obtain a fine grain structure, uniform and compact.

11. Cladding by welding in the ultrasonic field there is a substantial reduction of the phenomenon of dilution due to the fact that the cooling rate increases substantially and then decreases penetration, while the size of the heat release coefficient.

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