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ULTRASOUND EFFECT ON THE MECHANICAL PROPERTIES OF PARTS LOADED BY WELDING

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The reconditioning problem by loading parts through welding is a special one because with this operation is desired in addition to a recovery of the initial size of the piece and also an increasement of resistance to fatigue and wear by erosion and/or corrosion. The paper presents research results on the mechanical properties of parts reconditioned by manual coated arc welding directly respectively by introducing ultrasounds in the welding bath. Application of ultrasounds in the welding process showed an increase in hardness, shock tensile and bending resistence for the parts material.

Key words: mechanical properties, loading by welding, ultrasonic energy, manual arc welding with coated electrode

INTRODUCTION

Loading by welding involves lodging of a filler material over a substrate in order to obtain desired characteristics and dimensions (high resistance to fatigue and wear of erosion and/or corrosion) [1].

The efficiency of the technological process of reconstruction depends primarily on the behavior of the base layer - filler layer torque and how it connects marginal homogeneity between atoms of the two materials in the contact area and near the contact area [3].

Homogeneous bond formation is the result of technological steps for the submission of the filler material over support material [4,5].

The most important technological steps in the process of reconditioning by welding are: suitable processing of the surface over which the filler material is put, cleaning, pickling, degreasing to create better conditions of accession of material added to the base material, preheating base material to reduce the temperature gradient; the deposit itself, providing conditions to prevent solidification cracks, application of appropriate heat treatment with the desired operating characteristics and processing at the size of operation [6-8].

Researchers have shown that the propagation of ultrasounds in the liquid metal bath has significant influence on the process of transfer of the filler material by the arc and the crystallization process. All these influences are attributed to two basic phenomena due to the propagation of ultrasounds in liquid media, namely the ultraacoustic cavitation and the acceleration of the diffusion process [9].

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In the paper it was used directly introducing ultrasonics in the welding bath (Figure 1);

MATERIALS

To optimize the parameters of the reconstruction process by ultrasonic field welding have produced several samples loaded by welding in certain technological conditions, namely:

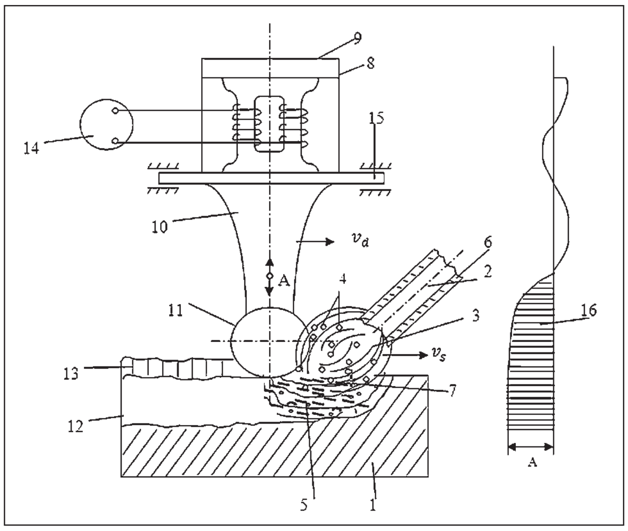

Figure 1 Diagram of direct ultrasonic introducing in the welding bath: 1 - basic material, 2 - filler material, 3 - arc, 4 - drops of liquid metal, 5 - welding bath, 6 - coating 7 - The outer protective layer melted , 8 - ultrasonic transducer; 9 - acoustic insulation, 10 - ultrasonic energy concentrator, 11 - the active part of ultrasonic concentrator (sonotroda), 12 - deposited layer, 13 - wear layer, 14 - ultrasonic generator, 15 - flange nodal , 16 - diagram of variation of particle velocity amplitude along the ultraacoustic system

SAMPLE 1 – made in the following technological conditions:

- base material: OL 42;
- sheet thickness: 10 mm;
- filler material: alloy steel in an electrode shape diameter ø 4 mm and chemical composition provided by the manufacturer listed in Table 1;
- hardness of the filler material: 64÷65 HRC;
- welding procedure: manual arc welding and coated electrode;
- welding intensity: Is = 160 A;
- frequency ultrasound: 24 KHz;
- amplitude of vibration: 43÷85 μm;
- ultrasonic energy concentrator sole type;
- activation time of the weld: 5 min
- welding voltage: Us = 25 V;
- theoretical deposition coefficient (kg weld metal/kg electrodes): 0,58;
- coefficient of deposition measured (kg weld metal welded/kg electrodes consumed): 0,45.

Table 1 **Chemical composition of filler material / wt / %**

C	Mn	Si	Cr	Mo	V	W
0,9	1,3	1,5	4,5	7,5	1,5	1,8

SAMPLE 2 - achieved in the following technological conditions:

- basic material: OL 42;
- sheet thickness: 10 mm;
- material containing: welding wire with self production type LINCORE 60-G as an electrode with the diameter ø 2 mm and chemical composition provided by the manufacturer given in Table 2.
- welding procedure used to loading, manual arc welding and coated electrode;
- welding intensity: Is= 180 A;
- welding voltage: Us = 27 V;
- hardness of the filler material: 58÷60 HRC;
- frequency ultrasound: 20 KHz;
- amplitude of vibration: 55÷32 μm;
- ultrasonic energy concentrator: sole type;
- ultrasonic activation time: 5 min;
- theoretical deposition coefficient: 0,6;
- deposit ratio measured 0,4.

Table 2 **Chemical composition of filler material / wt / %**

No.	Loading:	C	Mn	Si	Cr
1	1 layer	4,6	1,2	0,5	13,8
2	2 layers	5,5	1,3	0,6	17,3

SAMPLE 3 – achieved in the following technological conditions:

- basic material: OL 42;
- sheet thickness: 10 mm;
- filler material: semi hard loading wire with electrode form diameter of ø 4 mm and chemical composition provided by the manufacturer, given in Table 3;
- welding procedure used to load classic manual arc welding and coated electrode ultrasonic activated;
- welding intensity: Is = 140 A;
- welding voltage: Us = 24 V;
- frequency ultrasonic waves: 22 KHz;
- amplitude of oscillation: 45÷22 μm;
- ultrasonic energy concentrator: type sole
- hardness of the filler material: 200÷230 HB;
- the theoretical coefficient of deposit: 0,87;
- coefficient measured application; 0,81.

Table 3 **Chemical composition of filler material / wt / %**

C	Mn	Si	Cr	Mo	V
0,2	0,8	1,0	1,5	0,5	0,1

Sample 1 was made in three variants: sample 1-1 (with a classical welding layer), sample 1-2 (with three layers of classical welding) sample 1-3 (with two layers and ultrasonic activation)

Sample 2 was made in three variants: sample 2-1 (classic deposited layer) sample 2-2 (a layer deposited in the ultrasonic field) sample 2-3 (two layers classically deposited);

Sample 3 was made in three variants: sample 3-1 (one classical deposited layer) sample 3-2 (two layers classically deposited) sample 3-3 (a layer deposited in the ultrasonic field).

All samples were made using sheets of OL 42, with the thickness of 10mm, properly prepared for welding, which was filed with the filler material in TIG welding positions, in accordance with ISO 9467, the enabling of the ultrasonic plates was made with a sole concentrator at the frequency of 24 KHz and amplitude of vibration 22÷85 μm.

RESULTS AND DISCUSSION

The results of hardness tests showed the following:

- hardness obtained for these two partner materials (OL42 - tool steel) is between 56 HRC and 62 HRC;
- there is a maximum hardness at penetration of 1,5 mm for sample 1-1 and the penetration of 2,0 mm, sample 1-2, 1-3 sample hardness penetration depth decreased substantially;
- the highest hardness is obtained when welding with a field ultrasonic (sample 1-3), the decrease being relatively uniform.

Theoretically at the third layer deposited, the hardness should have increased due to the decreasing dilution with the base material, but there was still a decrease in hardness compared to the option of depositing two layers.

This is because of the welding regime, when the part is already hot and the temperature between the layers is approximately 350 °C, compared to the first layer when the piece had only 100 °C. So if there are no requirements on the thickness is preferably to weld in two layers in the field ultrasonic.

– hardness obtained for these two partner materials (OL 42 - LINCORE 60-G) is between 48 and 56 HRC;
– there is maximum penetration hardness of 2,7 mm in the sample 2-1 and a minimum hardness penetration of 2,0 mm in the sample 2-2, respectively, of 3,6 mm for the sample 2-3;
– the best hardness is obtained when welding to deposit one layer (sample 2-1), when approaching the one given by the manufacturer, unlike the sample 2-3, where the hardness variation is very high (48÷54 HRC) although dilution is much smaller than for sample 2-1.
– hardness obtained for these two materials partner (OL 42 - semi hard wire) is between 197 HB and 232 HB;
– there is a maximum hardness, at the submission of two layers of filler material, at the penetration of 1,5 mm and a minimum hardness, when depositing in an ultrasonic field, the penetration of 1,5 mm but then hardness increases;
– the best variation of hardness is obtained after submission in the ultrasonic field as dilution is much smaller than the submission of a single layer or two layers.

To determine the tensile strength and plastic flow behavior while there were prepared more test specimens from samples welded in the technological conditions from above. Attempts have been made on the equipment for tensile - compression testing type ATS 1600. Experimental results obtained from the tensile tests are presented in Table 4.

Table 4 **Experimental results obtained from tensile testing**

No.	Sample from:		R_m / MPa	A_5/ %	Z / %
1	Test 1	test 1-1	882	21,2	35,4
2		test 1-2	824	19,0	31,2
3		test 1-3	1275	25,4	37,8
4	Test 2	test 2-1	701	14,5	26,2
5		test 2-2	1102	24,7	43,2
6		test 2-3	876	20,7	39,7
7	Test 3	test 3-1	498	28,6	54,2
8		test 3-2	515	24,4	47,5
9		test 3-3	892	32,7	61,3

To determine the behavior of a reconditioned part by welding in some dynamic stress conditions (speed, temperature or tension space) there were prepared several samples loaded under certain technological conditions presented from which the test samples were processed. Impact bending test was performed on a test equipment type TECNOTEST F O40/S.

The results obtained from impact bend testing show the following:
– resistance to dynamic loads is the best for the samples welded with a filler material with a lower hardness (semi hard materials) corresponding to sample 3, when the tearing is mixed, predominating the ductile character of rupture, while the lowest resistance to dynamic loads is obtained for sample 2, loaded with three layers (sample 2-3) when the section is dominated by brittle fracture;
– generally in all the samples prevail mixed ruptures (brittle plus ductile) that may be dominant ductile (sample 3) or dominant brittle (sample 2). Therefore, to obtain parts reconditioned by welding with good resistance to dynamic loading and temperature conditions and complex space applications (in case the of some axles from the railway industry) we recommend the technological conditions of the samples 3-3 and for maximum wear resistance we recommend the technological conditions of the sample 2-2
– from this test you can determine not only the behavior but also the susceptibility to cracking of a piece to form a crack coming from the outside or to stop a crack coming from the outside. When the in the section brittle ruptures dominate, crack propagation can not be stopped and the piece is decommissioned, unlike the section where ductile rupture predominantes, crack propagation can be stopped or fracture may occur after a long operation. From the analysis results there were found:
– tensile strength of welded samples in ultrasonic field with deposition of the filler material layer is the best, the results can be explained because in this case the dilution between the base metal and the filler material is the smallest therefore from the point of view of tensile resistance it is recommended the reconditioning by welding with submission of the filler layer under ultrasonic field;
– tear elongation A5 and bottleneck tear Z are better in samples loaded with a filler material with lower hardness (sample 3) using conventional welding because in this case the dilution between the base material and the filler material is higher and plasticity properties of the base material do not drop too much;
– in the first group of samples (sample 1 and sample 2) was a brittle fracture, the separation section being approximately perpendicular to the specimen and the crystal structure as opposed to the second category of samples (sample 3), where the tearing was mixed (68 % ductile and 32 % fragile) it trickles from the center of the test specimen propagating on the maximum shear stress directions

CONCLUSIONS

– As a deposit is characterized by: low roughness, high adhesion between the deposited layer and base layer, high hardness, low porosity, low oxide content, resistance to wear and resistance to dynamic loads;
– To highlight the behavior of service of a charging reconditioned by welding a series of tests are re-

quired: hardness testing, wear testing, tensile testing, bend testing shock

- Highest hardness is obtained when welding with two layers of filler material in ultrasonic field;
- Breaking strength of welded samples is the best when the weld was done with three layers of filler material in ultrasonic field;
- Elongation tear and bottleneck tear samples are better in samples loaded with filler material with lower hardness, in an ultrasonic field because the dilution of the base material and filler material is smaller;
- Experiments showed a substantial increase in hardness in the layer area, also a greater plasticity and toughness;
- Accelerated diffusion under the action of ultrasonic waves leads to the formation of intermetallic better links at a lower dilution, the avoidance of defects in the transition and the best functional and technological features.

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