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Research regarding the influence of axial electromagnetic pulsation of the liquid metal bath upon the characteristics of the weld

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Abstract

Special studies made lately have pointed out the good effects of the electromagnetic oscillation upon the characteristics of the weld. Less studied though, is the problem of the influence of the axial pulsation of the liquid metal bath (axial oscillation) upon the characteristics of the weld when using external magnetic field.

Introduction

The present paper treats exactly this problem.

The basic diagram of this variant is presented in figure 1 where:

1-electrode, 2-coil, 3-a drop of liquid metal, 4-the electric arc, 5-the trajectory of the electrons, 6-the liquid metal bath, 7,8-positions of the liquid metal bath.

Fig.1. The basic diagram of the axial pulsation of the liquid metal bath

Upon the action of the induction magnetic field B , produced by the coil 2, coaxial with electrode 1, and supplied with a pulsating tension the surface of the liquid metal bath 6 starts an oscillation movement having the frequency of the supplied pulsations of the coil, reaching the positions 7 and 8. At the same time, due to the radial components of the induction B , the electrons from the electric arc 4 describe a complex spiral movement 5.

Fig. 2. Stand for the measuring of the cracking tendency at heat.

In order to determine the influence of the phenomena described upon the geometrical parameters and upon the characteristics of the weld, experiments have been made, using a TIG welding head with axial pulsation of the liquid metal bath, fixed on a stand for the measuring of the cracking tendency at heat, as presented in Fig. 2.

Experiments made

T.I.G. welds have been made, without additional material, using test pieces of austenitic steel, type w1.4541, having the dimensions $200 \times 100 \times 4$ mm, in the following situations:

1. normal TIG weld, without magnetic field;
2. TIG weld with constant magnetic field;
3. TIG weld with pulsating frequency of 5, 10, 15 and 20 Hz.

The values of the magnetic field induced, measured with the Hall sounding rod were 4,8 and 16 mT respectively.

Eighteen tests have been made in order to study the influence of the axial pulsation on the characteristics of the weld, and 10 tests for the cracking tendency at heat, in the conditions mentioned above. For some of the tests for the cracking tendency at heat, Cu and Sn were introduced in the weld from the outside, in order to point out the effects of these elements upon the cracking tendency at heat.

The tests were made for two distortion speeds (v_d) that is 20 and 61 mm/min respectively.

The technological parameters used during the welding were the following :

- the diameter of the tungsten electrode , $d = 2.5 \text{ mm}$;
- the welding current, $I_s = 95\text{-}100 \text{ A}$;
- the tension of the electric arc, $U_a = 12\text{-}15 \text{ V}$;
- the gas flow , $Q = 10 \text{ l/min}$;
- the welding speed, $v_s = 20 \text{ cm/min}$.

Aspects of the macrostructure and microstructure for some of the tests made are presented in Fig.3, 4, 5 and 6.

Fig.3. Macrostructure for a test for cracking tendency at heat
A-with axial pulsation
B-without axial pulsation

Fig.4. Macrostructure for a test weld
1.1. TIG welding without pulsation
2.2. TIG welding with pulsation

Fig. 5. Microstructure for a test weld

Fig. 6. Microstructure for a test

Conclusions

From the macroscopic analysis of the welds, made in the experimental conditions presented, we can draw the conclusion that the presence of the electromagnetic axial pulsation of the electric arc, leads to a smaller penetration and to the enlarging of the width of the weld, a favourable effect from the point of view of the cracking at heat, being well known the fact that the deep and narrow welds run a higher risk of cracking at heat.

From the microscopic analysis of the tests made we can point out that the presence of the constant or variable magnetic field at frequencies under 10 Hz, lead to smaller grains as a result of the breaking of the dendrites.

The measurements made did not distinctly point out this fact(also because of the fact that the dimensions of the grains was considered between 2 limit values).

Above the frequency of 15 Hz, the exterior aspects of the weld is not adequate, and therefore, the range of the frequency must be below 15 Hz.

The electromagnetic axial pulsation of the electric arc triggers a small change(1-2 per cent) of the content of ferrite.

The smallest hardness in the weld were obtained when welding without magnetic field, and in the case of pulsating magnetic field, the hardness raises at the same time the frequency does.

The tests for cracking at heat managed to point out directly the influence of the axial electromagnetic pulsation upon the tendency of cracking at heat.

In the case of only one test made with a constant magnetic field of 8 mT, the cracking did not take place, for all the other cases when in the weld were introduced Cu and Sn, the welds cracked at the speed of approximately 20 mm/min., the content of Cu being about 2%.

All the other samples had visible cracks, even though the deformation speed was the same (20 mm/min.),but the content of Cu and Sn for these samples were over 5%.

Later research must be directed towards the finding of the values of the frequency and the intensity of the magnetic field for which the best performances can be obtained.

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