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THE INFLUENCE OF THE ELECTRICAL ARC CHARACTERISTICS ON FORMING OF THE WELD

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ABSTRACT

Stability and controllability of a welding arc have a large influence on both the weld quality and welding productivity in the process of welding. Metal fusing and weld forming depend on the forces affecting the arc. Welding current creates electromagnetic forces, which basically define the influence of arc forces on molten metal. While estimating the magnitude of the influence of electromagnetic forces, it is necessary to investigate the radial distribution of arc pressure on the surface of a weld pool and take into account the dependence of distribution of electromagnetic forces on the non-consumable electrode tip geometry.

INTRODUCTION

One of the most important objectives in modern research is improving the quality of welded joints and profitability of manufacture of different components through wide application of technological processes which allow prevent formation of waste products.

Research works on creating various methods and instruments of the welded joint quality monitoring at the stage of its formation are intensively conducted. Electric arc and welding pool are considered to be the basic objects of the control. The processes running in them define the quality of a weld.

During an TIG welding process it is the welding area and arc plasma that contain the information on the characteristics defining the quality of the welded joint of the running process: mode and intensity of liquid metal convection, degree of arc compression as well as forming of the weld. In case of fusion welding the arc has both the thermal and mechanical effects on the welded metal [1]. The mechanical effect of the arc asserts through the mechanical pressure of gas stream, vapours of metals and action of ionised particles directed to the surface of metal in treatment [2]. Volumetric electromagnetic forces occur and operate both in the arc column and in the welding pool, creating a mechanical compression in arc column and causing the liquid metal convection [3, 4, 5]. Therefore, the complete effect of arc forces consists from arc gas stream pressure and action of volumetric electromagnetic forces in the welding arc and pool.

RESEARCH TECHNIQUE

In research of welding arc power action the manometric way of arc pressure measuring was used [6]. In all experiments welding was carried out by using a fixed magnitude direct current of the straight polarity: welding current I = 150 A, diameter of electrode f = 5 mm, the length of an arc column - 2.4 mm. The shape of the tungsten electrode tip: sphere, cone 30°, cone 60° and cone 90°.

For mathematical modelling of processes, which are taking place in the welding arc and the pool, the finite element method (FEM) was used. The spatial model of welding arc and pool was generated from 4-node or 8-node finite elements "Solid 96". For FEM simulation 2-temperature model of a welding arc was used.

The analysis of the distribution of electrical and magnetic fields, and also of arising electromagnetic forces was made with estimation of the thermal effect of a power source on welded metal, geometrical shape of tungsten electrode tip (cylindrical, spherical and conic), arc shape (electrode not immersed, immersed electrode) and the temperature-dependent physical characteristics the welded metal and argon plasma.

DISSCUSION

In manometric research of the arc force action the experimental curve usually is asymmetrical. At the moment the arc pressure will reach the maximum on the outlet of the analyser and start to decrease, the residual pressure in the strobe of the analyser then deflects the arc and can disturb arc parameters. Therefore, the ascending part of the curve characterizes the dynamic process more precisely. Besides, it is necessary to take into account the inertia of measuring process and make appropriate corrections of the obtained data (Fig.1).

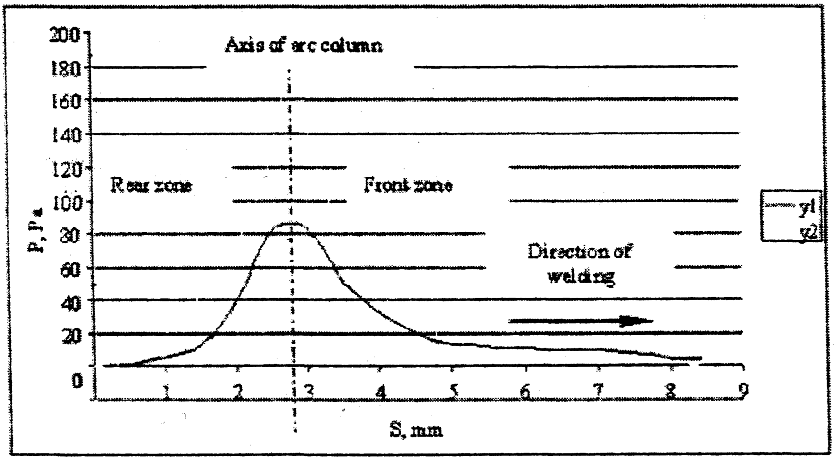

Fig.1 Distribution of electric arc pressure on the surface of the welding pool (shape of the tungsten electrode tip - cone 60°): y1 - an experimental curve; y2 - an experimental curve with the account of the inertia of the analyser.

The maximal real pressure of an arc was established when the tip of the tungsten electrode was cone 30°, and the minimal when the tip of the tungsten electrode was cone 90°.

Using FEM the distribution of electromagnetic force in the welding arc and pool was calculated depending on the shape of the tungsten electrode tip (Fig.2). The greatest magnitude of electromagnetic force was established when the tungsten electrode tip had cylindrical shape and welding process was provided with an immersed electrode.

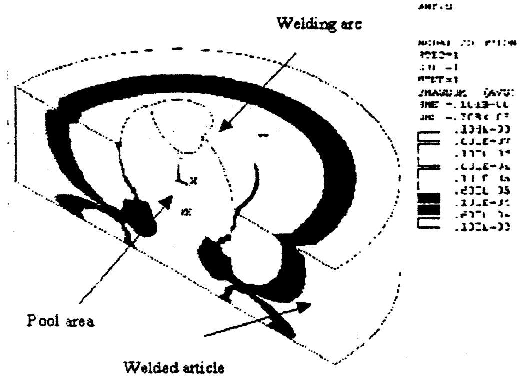

Fig.2 Distribution of a volumetric electromagnetic force in the welding arc and the workpiece (shape of the tungsten electrode tip - sphere).

During electric arc welding the current of a welding circuit determines the appearance of volumetric electromagnetic forces. These forces operate the movement of the welding arc and convection of liquid metal pool. The processes occurring in the welding pool and formation of weld depend on the total effect of magnetic fields and electromagnetic forces created by welding current. Under the influence of the electromagnetic force in the welding pool two circular streams of liquid metal (from the surface of the pool towards the fusion line) convection are formed (Fig.3).

Even the small changes of physical and chemical state of the surface of tungsten electrode and shape of its tip determine the change of important parameters of the welding arc: the shape of the plasma column, distribution of equipotential fields of arc voltage, magnitude of current density on the surface of the welding pool. In peripheral area of the arc the distribution of current density is not completely symmetrical in relation to the axis of the arc, but near to the arc column and in the column itself it can be considered as approximately symmetric.

In case of the conic shape of the tungsten electrode tip, in the arc there will be a maximal absolute magnitude of the vector of current density, and in case of the spherical shape of the tungsten electrode tip - the maximal magnitude of only a vertical component of the current density.

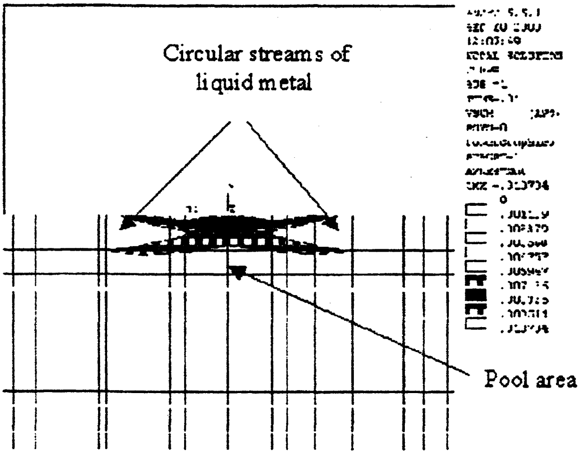

Fig.3. Distribution of convection velocity within liquid metal under the influence of the electromagnetic force in a weld pool (the shape of the tungsten electrode tip - cone 60).

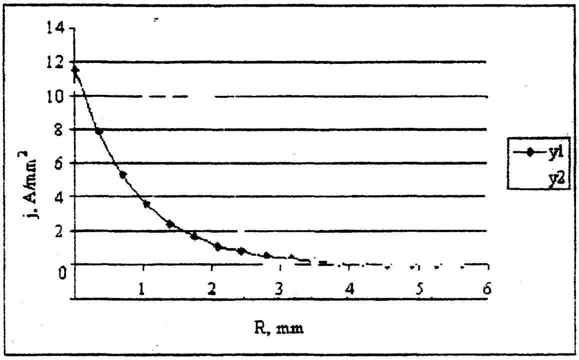

Fig.4. Distribution of arc current density on the surface of the metal obtained by different methods (the shape of the tungsten electrode tip - cone 60°):
y1 - an experimental curve; y2 - a curve obtained by FEM.

Comparing the experimental and calculated distribution curves of current density it was established, that in arc zone with 10000 °K temperature the curves do not coincide, though the greatest magnitude of the current density in both cases is practically identical. In the arc zone of the low temperature (5000 °K) the experimental and calculated curves coincide (Fig.4).

The possible error of the results occurs because the two-temperature mathematical model of a welding arc of was used. In a real welding arc the wide temperature distribution takes place.

CONCLUSIONS

1. The greatest electromagnetic force magnitude calculated by FEM was establis when the tungsten electrode tip had a cylindrical shape and electrode end was immer into arc column.

2. Comparing the experimental and calculated current density distribution curve was established, that though the greatest magnitude of the current density is practica identical, in the arc high temperature zone (10000 °K) the curves do not coincide, but in t low temperature zone (5000 °K) curves coincide very well.

3. The comparison of the experimental and calculated current density distribution sho that two-temperature area welding arc mathematical model describe enough precisely t electromagnetic processes, which occur in the arc zone of low temperature zone (5000 °K but in the arc high temperature zone (10000 °K) the inaccuracy of the results arises.

4. The change of the electrode tip shape allows to influence distribution electromagnetic forces in the arc and welding pool and as well as the geometry of weld the stage of its forming.

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