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On the issue of studying the formation of a welded joint during high-frequency welding

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ABSTRACT: This article presents a study of the formation of a welded joint during high-frequency welding

KEY WORDS: High frequency current welding, thermal deformation, ferromagnetic material, weld

I. INTRODUCTION

High-frequency welding of metals is based on the use of the laws of electromagnetic induction and full current, as well as the following phenomena: surface effect, proximity effect, ring or coil effect, the influence of magnetic circuits and copper screens on the distribution of current in the conductor, changes in the properties of metals with changes in temperature and voltage ness of the magnetic field, the occurrence of electromagnetic forces

II. LITERATURE SURVEY

The law of electromagnetic induction manifests itself in the fact that if the magnetic flux Φ passing through a surface bounded by a certain contour changes in time, an emf is induced (induced) in this circuit, the instantaneous value of which e is determined by the formula

$$e = \oint E_{инд} dl = -d\Phi / dt \quad (1)$$

where E_{ind} is the electric field strength vector (induced); dl is a vector equal to the length of the contour section dl and directed tangentially to the contour towards the bypass; dΦ is the change in the magnetic flux through the surface bounded by the contour during the time dt [1].

Welding with high frequency currents (HF) up to 500 kHz is used for the production of pipes with a diameter of 6–529 mm with a wall thickness of 0.5–10 mm. The main advantages of this method are: the possibility of a significant increase in the welding speed of pipes (up to 120 m/min) from carbon and alloy steels, non-ferrous metals; obtaining pipes with a high-quality seam from hot-rolled non-etched tape, a significant reduction in electricity consumption per ton of finished pipes; implementation of welding of pipes from various metals on one welding equipment. [1-3].

This made it expedient to transfer a large number of existing electric pipe welding mills to welding with high frequency currents. Most of the newly commissioned pipe welding plants have high-frequency welding equipment. The use of a

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current with a frequency of 450–500 kHz for pipe welding is based on the fact that the current at this frequency follows the path of not the least ohmic resistance, but the least inductive resistance. To increase the inductance of the workpiece perimeter circuit in order to concentrate the current in the edges of the workpiece, a ferromagnetic (ferrite) core is introduced into the workpiece [4–5].

III. METODOLOGY

Based on the current distribution pattern, it can be argued that during high-frequency welding with flashing, the deposit occurs under current. Consequently, the conditions for the formation of a welded joint and the removal of molten metal from the weld zone are even more facilitated and improved. Precipitation under current favors the processes of recrystallization and the formation of common grains, which increases the ductility of the welded joint [5]. This is clearly seen in the microstructure of a welded joint made of low-carbon steel, shown in fig. 1.

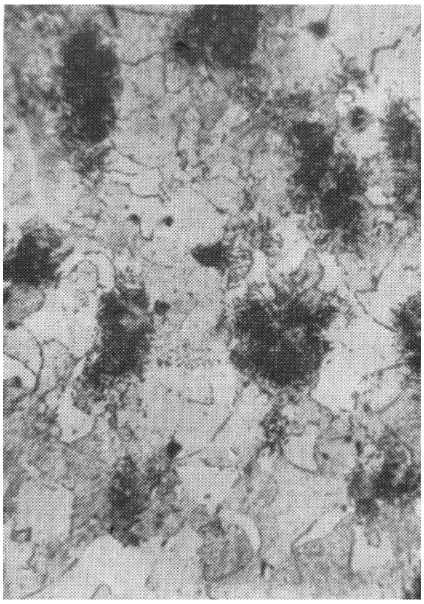

Fig. 1. Microstructure of a welded joint made of steel 08 (X300). The thickness of the edges to be welded is 0,4 mm, v_{cv} = 40m/min, v_{oc}≈700 mm/s, f=440 kHz

The upsetting current is sufficient for almost complete recrystallization of the weld zone. Places of welding are allocated only with a flash. The microstructures of the weld, transition zone and base metal are identical. Standard test methods did not reveal any differences in the ductility of the weld and the parent metal.
Consider the second main parameter - draft Δ_{os}. For a symmetric system, it is determined

$$\Delta_{oc} = (F_{в} + F_{н}) / 2s \qquad (2)$$

where F_B and F_H are the areas of the inner and outer burrs.

On fig. 2 shows a draft diagram. Measurements of the values of F_b and F_h were carried out during welding with heating by a current of 440 kHz frequency of straight-seam pipes made of various materials, followed by the manufacture of microsections.

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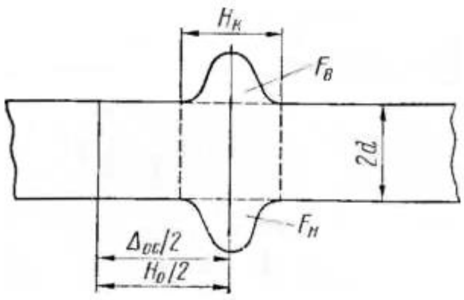

Fig. 2. Scheme for determining draft

For comparison, in fig. 3 shows the dependence of settlement Δ_{os} on thickness $2d$ for steel strips in continuous flash welding.

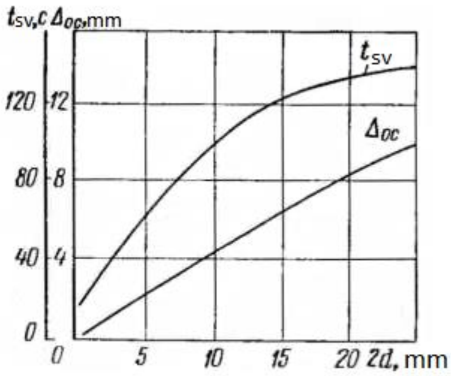

Fig. 3. Dependence of settlement Δ_{oc} and welding time on the thickness of welded strips 2s

The curve indicates that in high-frequency flash welding, the deposit is an order of magnitude smaller than in conventional flash butt welding. In butt welding of metals and alloys with high thermal conductivity, flashing is carried out at a very high speed, as a result of which deep craters are formed on the welded surfaces [5]. In addition, it is assumed that it is difficult to obtain a uniform layer of liquid metal at the ends, and therefore it is necessary to mechanically destroy the hard films on the solid metal. All this leads to large deformations, essentially the same as in resistance welding.

If we apply this hypothesis to the process we are considering and assume that as a result of the current flow along the edges, their uniform monotonous heating and melting occur, then the formation of craters is excluded. This may be the reason for the small value of Δ_{os}. However, during high-frequency flash welding, uneven heating of the elements to be welded due to disturbances is possible. When studying the nature of the disturbances and their influence on the temperature regime of the heated elements and Δ_{oc}, it was found that the disturbances are associated with the instability of the energy regime of the power source, the operation of the mechanisms for preparing and upsetting the elements to be welded, and the quality of the workpiece.

Excessive upsetting leads to distortion of the fibers and, as a rule, to a deterioration in ductility and a decrease in toughness (fig. 4).

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Fig. 4. Fiber distortion due to excessive upset

The most typical and significant are the disturbances caused by the presence of a variable component at the output of the rectifier that feeds the lamp generator, and the associated periodic changes in the active power released in the welded elements (the case of welding at radio frequencies).
The third parameter, which depends on the previous two, is the precipitation pressure P_{oc}. As is known, with an increase in the rate of upsetting, the resistance to deformation increases and, as a result, P_{oc} increases. This phenomenon in high-frequency flash welding was analyzed in [2], where it is proposed to estimate the average strain rate w_{cp} of welded edges according to the formula

$$w_{cp} = (1/t_{oc}) \ln (H_0/H_к) , \quad (3)$$

where t_{oc} is the settling time; H_0, $H_к$ are the initial and final widths of the edge deformation zone (fig. 5).
The edge deformation rates calculated by formula (3) in straight-seam pipe welding are 300–450 1/s, which exceeds the rates.
It is known that pressure welding processes without flashing in the absence of a reducing medium can provide satisfactory joint quality only in a narrow temperature range and with deformations sufficient to destroy oxide films. For low-carbon steels, this condition corresponds to the interval 150–200° C and Δ_{oc} = 1,5÷2,0 mm, and for aluminum alloys – 40–50 ° C and Δ_{oc} = 1,2÷1,4 mm. Let's imagine two metal bars *2*, located tightly end to end and placed in the magnetic field of the inductor *1* (fig. 5).

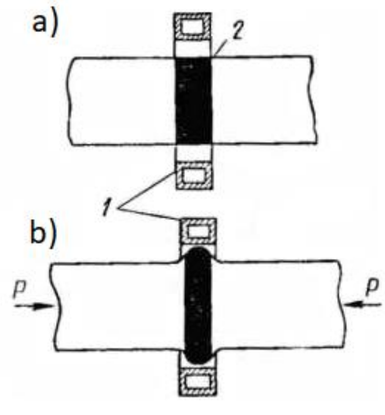

Fig. 5. Scheme of welding without flashing:
a - heating; b - sediment

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If the width of the inductive wire is sufficiently small (5–10 mm), then the temperature gradient along the axis of the bars is quite large. In this case, the width of the heating zone and the steepness of the front of the temperature curve weakly depend on the frequency of the current of the power source. For the process of weld formation during upsetting, such a distribution of the temperature field should be considered favorable, since plastic deformation is concentrated in a narrow zone and a minimum burr is formed.

The distribution of the temperature field along the radius of the rod is always sharply uneven. A temperature difference acceptable for the conditions of weldability can be achieved only with sufficiently small sections of the workpiece to be welded, a heating time calculated in seconds or tens of seconds, and a low frequency of the power source current (fig. 6).

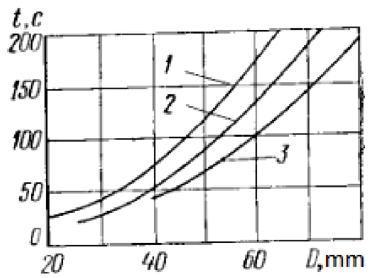

Fig. 6. Steel heating time at different power supply current frequencies:
1 - 1000 Hz; 2 - 2500 Hz; 3 - 10000 Hz

Such conditions for the distribution of the temperature field over the cross section of the welded rod and the heating conditions as a whole should be considered unfavorable for the welding process. From consideration of the heating circuit, it is easy to conclude that with the smallest temperature difference over the cross section and along the generatrix, a cylindrical hollow body with a wall thickness of $2d \leq \Delta_к$ can be heated. Therefore, this method has limited application - for butt welding of thin-walled pipes.

Obviously, in order to achieve a narrow heating zone, the inductor can only be single-turn, but in such an inductor it is difficult to obtain a symmetrical field and, consequently, a symmetrical temperature distribution along the perimeter of the heated product. In addition, an additional non-uniformity of the temperature field along the perimeter is introduced by the difference in wall thickness of the pipe billet. This makes it difficult to heat the welded pipes in a narrow temperature range. Therefore, this method is used in butt welding of pipes made of low-carbon steels. The heating rate does not exceed 400 ºC/s.

Significant difficulties are associated with the destruction and removal of oxides during precipitation. For their complete destruction, it is necessary to fulfill the condition Δ_{oc} = 1,5÷2,0 mm. It is feasible only for large gaps in the inductor–pipe system, but in this case the temperature field gradient along the tube axis decreases and even larger deformations are required. Attempts have been made to overcome this difficulty in the following ways.

1. Increasing the heating temperature above the melting point of FeO (for its melting). In this case, although it is possible to completely remove molten oxides from the zone of the welded joint, however, grain growth occurs and a widmann-state structure is formed. In addition, partial melting of the grain boundaries occurs, and sedimentary looseness appears during crystallization.
2. Application of gas shielding or fluxes. When heated to T = 1200÷1250°C, it is possible to obtain a high-quality welded joint and a satisfactory microstructure of the near-weld zone. The protective environment must be restorative. Severe welding temperature limits and the need for a protective environment limit the application of this method.

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REFERENCES

[1]. Zairkulov E.E., Dunyashin N.S. To the question of determining the power absorbed by a conductive medium during high-frequency welding of longitudinal pipes // Actual issues in the field of technical and socio-economic sciences. Republican interuniversity collection. - Tashkent: TCTI, 2019 - S.255-257

[2]. Zairkulov E.E., Dunyashin N.S. To the question of studying the influence of high-frequency welding mode parameters on the quality of welded joints // Materials of the Republican Scientific and Technical Conference "Resource- and Energy-Saving, Environmentally Friendly" - T .: SUE "Fan VA Tarrakiyot", 2019 - P. 162-164

[3]. Alzhanov MK, Tursunbekova A. U. Issues of improving the design of pipe welding equipment based on ferrite heaters // Young scientist. - 2016. - No. 2. - S. 117-121.

[4]. Danchenko V.N., Kolikov A.P., Romantsev B.A., Samusev S.V. - Technology of pipe production: Textbook for universities /.- M.: Intermet Engineering, 2002

[5]. Osadchy V.Ya., Vavilin A.S. - Technology and equipment for pipe production. Intermet Engineering, 2001

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