

Hybrid welding of dissimilar metals

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Abstract: The article addresses issues laser - plasma welding (LPW) dissimilar metals and the results of metallographic studies of the microstructure of welds ferrite - 40 steel and molybdenum - steel 40. Increasing potential opportunities the high-energy processing is carried out by integration the laser radiation (LR) and plasma, which allows you to create the desired spatial distribution of the energy flow for technological processes (TP) of laser-plasma heat treatment (LPT) of metals. The distribution of the thermal field is determined by the density distribution of energy flow LR and plasma exposure time, and the thermal characteristics of the treated metal. The most interesting is the treatment of details with ring flow of plasma and LR axial impact.

1 Introduction:

In order to ensure a high quality of performance of the welded joint in the manufacture of critical parts is used LPW. Application of LPW allows obtaining permanent connections in inert gas at atmospheric pressure. In contrast to laser welding, LPW can significantly increase the energy characteristics of technological installation by increasing the absorption coefficient of LR metals by preheating the details by plasma.

Another problem of laser welding is the residual stresses in the weld zone. Therefore, to reduce the residual stresses use thermal tempering of details. This requires additional time and energy expenditure.

This problem is solved by the use of LR and ring plasma torch. Linear annular plasmatron generates a ring-shaped plasma on the surface of the details, where the leading edge provides a temperature rise in the target area LR on the metal, and the rear zone heats the weld to a tempering temperature.

The most perspective way to improve the laser-plasma technological complex (LPTK) is an integrated approach that includes the creation of a high-energy heat treatment of CAD technology; synthesis of automatic control system (ACS) LPTK with feedback on the process parameters in the zone of interaction of plasma and LR with metals and the development of new processing methods with information parameters, allowing the creation of databases, in order to optimize the structure LPTK.

The urgency of the task of joining dissimilar materials explained by the difference the functional purpose of separate parts of details. For example, the gyroscope consists of a rotor core and shaft. axis function is to provide mechanical strength of the structure when the rotor rotates. Function of rotor Core is to provide high-permeability magnetic fields. Combination of this functions in homogenous materials increases the dimensions and weight of the rotor performance at a given mechanical and electromagnetic characteristics.



An important element of the TP manufacture is to ensure that the rotor the mechanical permanently attached connection with the magnetic core axis. This problem can be solved by applying laser welding to the steel ferrite core axis with specified mechanical properties.

It should be noted that the welding process in the manufacture of precision parts is responsible for the geometry and prevents the formation of defects in the structure of the weld seams (shells, poor fusion, burning, etc.), while required to provide minimum mechanical residual stress in the weld zone, that are may lead to its destruction [1]

Fig. 1 shows a linear plasmatron to generate thermal field at the weld. This plasmatron consists of two electrodes 1 and 2 formed in a ring shape with nozzles 3 and 3', 4 and 4', which are designed for supplying and removing coolant. They are also the current-supplying ends of the electrodes. The electrode spacing 5 is supplied plasma gas that directed to welded items 6 (Pat Russia 59931). The speed of the arc at a direct current of 100 - 600 A reaches 10 - 60 m / s (determined by means of high-speed motion picture).

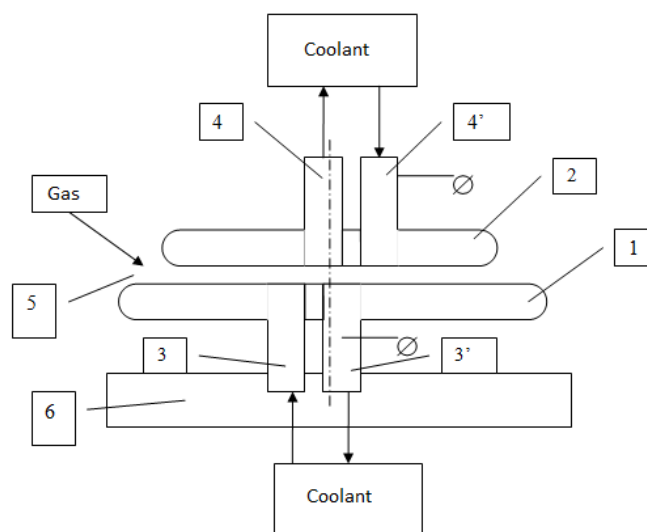


Fig. 1. The annular plasmatron.

LR is served in the center of the ring electrode linear plasmatron. Temperature field distribution is shown in Fig. 2.

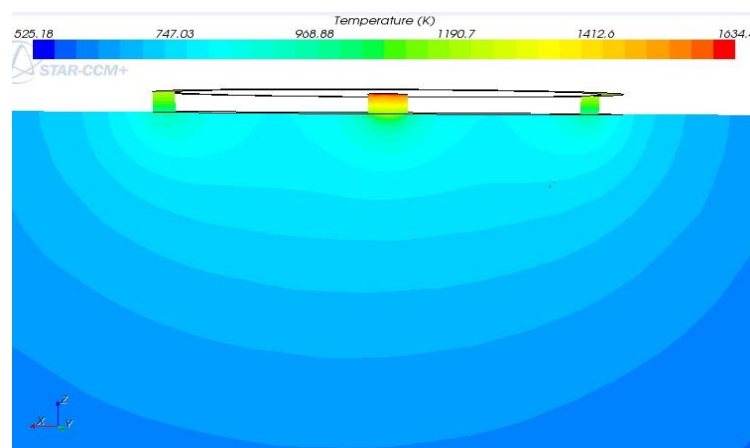


Fig 2. The distribution of the temperature field along the weld at the impact of LR and the annular plasma of plasma torch.

One of the essential steps of the laser welding process is the pre-treatment of surfaces to be welded. The surface of the metal in the weld zone cleaned of scale, rust and other contaminants as well as moisture. Dirt and moisture conditions are created for the formation of porosity, oxide inclusions, and in some cases, and cold cracking in the weld metal and heat affected zone due to saturation with hydrogen. After cleaning the surfaces of parts degreased.

Because thermal effect zone of LR in the metal has segment shape whose dimensions depend on the parameters of the energy source and the physical properties of metals [2], it is appropriate weld plane tilted at an angle, tangentially to this segment. In this case, by melting the refractory metal is melted the fusible metal by heat transfer. Thus, there is an interaction between the active metals with the surrounding gas medium, which is present in the junction area of the two metals due to surface roughness. When crystallization of metal occurs formation of voids in the metal, which impairs the quality of the weld. It is therefore necessary to minimize the roughness of the mating surfaces by mechanical lapping.

In order to assess the depth of penetration can be used formulas [1]:

$$h = \frac{P}{2\pi\lambda_{\text{T}}T_{\text{K}}} \ln \frac{r_{\text{Л}} + a/v_{\text{CB}}}{r_{\text{Л}}},$$

Where: λ_{T} – material thermal conductivity; T_{K} – boiling temperature; a – thermal coefficient material. Zone of thermal effects is formed by LPW is composed of several sections (fig. 3). At the bottom of the picture there is a ferrite microstructure, at the top - a modified steel structure. Between them is visible the zone of interaction of two dissimilar metals, characterized by the diffusion processes taking place in the transition zone. LR direction on.



Fig. 3. A micrograph of ferrite Welding & Steel 40, x500

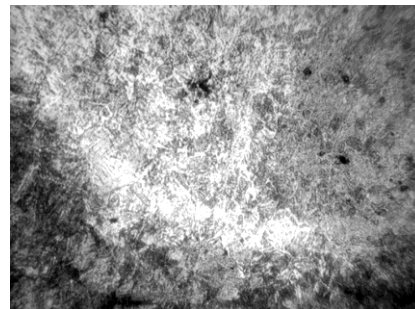


Fig. 4. A micrograph of a weld molybdenum and steel 40.; x500

Another pattern was observed in the analysis of photomicrographs of molybdenum welding ($T_{\text{m}} = 2620^{\circ}\text{C}$) and steel ($T_{\text{m}} = 1510^{\circ}\text{C}$). At the upper portion (Fig. 4, 5) molybdenum is visible region with a uniform structure throughout the thickness [6].



Fig. 5. Photo weldment of molybdenum and steel 40.

2. Conclusion:

The main influence on the process of welding of dissimilar materials have physical and chemical properties of both the material and the environment in which the TP. This is due to the distribution of thermal field in a variety of materials characterized by varying reactivity and thermal properties (thermal conductivity, heat capacity, melting point, crystallization temperature-tion, etc.). To achieve the required quality of the TP welding dissimilar materials is need to provide welding in neutral gas atmosphere (e.g., argon), and, the geometric shape of interface on the weld should be determined by the shape of the temperature distribution in the boundaries of the refractory material, and its value at the junction with the low-melting equal to the melting point of the fusible.

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