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ARC AND PLASMA-POWDER SURFACING OF SEALING SURFACES OF PUMP IMPELLERS

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Technology of gas-shielded robotic arc surfacing of sealing surfaces of pump impellers with flux-cored wire of ARTINIT DUR 500 grade was developed. Corrosion resistance testing of deposited metal of this type according to GOST 9.912–89 showed that it is on the level of 12Kh18N12M3TL steel. Application of flux-cored wire ARTINIT DUR 500 for surfacing these parts is envisaged by the respective standards: GOST 31901–2013 (Appendix H) and GOST 33258–2015 (Appendix B). Technology of plasma-powder surfacing of sealing surfaces of pump impellers in automatic unit PM-302 with application of powders of cobalt alloys (stellite) was also developed. A particular method of surfacing the sealing surfaces of pump impellers is selected proceeding from the conditions of their operation and economic parameters. 9 Ref., 2 Figures.

Keywords: plasma-powder surfacing, arc surfacing, surfacing of sealing surfaces, deposited metal types, flux-cored wire for robotic surfacing

In hydraulic units the joints of movable parts are widely used, which are made with a guaranteed small gap and provide a mutual movement of parts and a certain degree of sealing without the use of special seals and tools. Such a seal, called a groove seal, represents a capillary groove, at the appropriate size and length of which the necessary resistance to the flow of fluid can be created. Their sealing effect is based on the use of hydraulic resistance of annular throttles with a small radial gap. A radial gap is considered to be minimal, in case that reliable assembly and operation of the rotating and stationary elements of the pump are provided without the metal contact.

During operation of the pumps, the surfaces joined in the sealing zone can be destroyed as a result of corrosion and erosion effects of the flow of working environment. Inaccuracies during the assembly of pump units, deformation of shafts and impellers during operation can lead to local contacts of groove sealing surfaces, which causes mechanical wear of groove sealing surfaces by friction forces. The abovementioned factors are the main causes of premature failure of equipment.

Based on the conditions of pumps operation, the sealing surfaces of impellers should meet the following requirements:

● be resistant to erosion damage when exposed to the flow of the working environment;

● have a high resistance to fretting and adhesion of contact surfaces;

● be resistant to general and intercrystalline corrosion;

● maintain structural stability in the conditions of contact friction and heating.

At the same time it is necessary to take into account the economic and technological parameters of the materials used.

In the designs of pumps for nuclear and heat power engineering, oilfield equipment and chemical industry, the impellers of steels 10Kh18N9L, 12Kh18N12M3TL and the like are widely used. At present, the main way of producing reliable sealing surfaces of a pump impeller is surfacing with wear-resistant and corrosion-resistant materials. The experience was gained in the use of three types of materials for deposition of sealing surfaces of pump impellers made of the mentioned steels [1].

The first type includes electrodes of grade TsN-6L and flux-cored wire PP-AN133 [2], which provide a production of deposited metal of type 08Kh17N8S6G. They have satisfactory welding and technological properties. The metal deposited with the use of electrodes TsN-6L and wire PP-AN133 has a relatively low susceptibility to cracking.

The second type of surfacing materials, which includes electrodes TsN-12M and flux-cored wire PP-AN157 [2], provides a deposited metal of type Kh16N8M5S5G4B with a higher hardness and, accordingly, resistance to fretting and adhesion in the contact zone, as compared to the first type. However, a high susceptibility of such metal to cracking requires high temperatures of product heating during surfacing and immediate heat treatment after surfacing.

During surfacing stop valves and pump impellers, stellites are also used. These are cobalt-based alloys which can be attributed to the third type of surfacing materials used for these purposes. The deposited metal of this type provides the best set of necessary properties — resistance to erosion and corrosion, excellent wear resistance during friction of metal against metal and structural stability in the process of heating during friction [3].

The stage centrifugal pumps TsNS-180 for pumping water into oil reservoirs with the purpose of maintaining pressure in a reservoir are in series production. The reservoir water is quite aggressive and therefore for manufacture of TsNS pumps the steel 12Kh18N12M3TL is used. The surfaces of impellers in the areas of groove seals were previously surfaced by manual argon arc welding with cobalt based rods of grades Pr-V3K or Stellite 6. The surfacing process envisaged a high preheating (550–650 °C) and immediate heat treatment after surfacing.

In order to optimize the surfacing process, the work was carried out aimed at solving the following tasks:

● increasing the labour efficiency;

● reducing the temperature of preliminary and accompanying heating of products during surfacing;

● improving working conditions of welders;

● reducing the costs for purchasing surfacing materials.

For automatic arc surfacing of sealing surfaces of impellers of rotary stage centrifugal pumps of TsNS-180 type, the wire of grade ARTINIT DUR 500 of the Bohler Company was selected. Welding and technological properties of the wire were evaluated during argon arc surfacing of separate beads on the plates of steels 12Kh18N10T and 12Kh18N12M3TL. The optimum welding mode was determined at which minimum spattening is observed. For measurements of hardness on 16 mm thick plates of steels 12Kh18N10T and 12Kh18N12M3TL, surfacing was performed in one, two and five layers. The hardness of deposited metal in the initial state and after heat treatment was measured at different temperatures. Heat treatment can increase the hardness of deposited metal; the most significant increase in hardness by 10–15 units of *HRC* is observed during heat treatment in the temperature range of 500–550 °C. At the temperatures above 860 °C, the strength of deposited metal may be reduced — coagulation of secondary carbides occurs, resulting in a decrease in the hardness of deposited metal.

Figure 1. Installation PM-302 for plasma-powder surfacing

The microstructure of the deposited metal in the initial state consists of austenite and ferrite (more than 50 % of the ferrite phase). Heating and holding at 550 °C did not lead to significant changes in the microstructure. The formation of excessive secondary phases is observed mainly along the boundaries and inside the ferrite regions.

The tests of the deposited metal for corrosion resistance were performed according to the instruction ITsK-01–99 (determination of weight losses) and in accordance with GOST 9.912–89 [4]. The corrosion resistance of the deposited metal was found at the level of steel 12Kh18N12M3TL.

To specify the technology, surfacing of a full-scale specimen, simulating the groove geometry and the impeller diameter in the surfacing area, was performed. Surfacing was performed without a preheating, of temperature of the specimen between surfacing of separate layers did not exceed 400 °C. After surfacing, slow cooling of the specimen was provided.

Visual inspection and colour flaw detection were performed after sequential grinding of deposited metal to a thickness of 0.5 mm. At the thickness of deposited layer of 2.5 mm a finish grinding was performed. No defects of deposited metal were detected by visual inspection and flaw detection testing. The hardness of the deposited metal in the initial state is *HRC* 40–43, after heat treatment at 860 °C *HRC* is 43–47.

The developed robotic and mechanized technology of argon arc surfacing of sealing surfaces of stage centrifugal pump impellers with the use of flux-cored wire of grade DUR 500 was introduced into production. Currently, the application of the flux-cored wire ARTINIT DUR 500 for surfacing is envisaged by the standards: GOST 31901–2013 (Appendix H) [5] and GOST 33258–2015 (Appendix B) [1].

Plasma-powder method is also used for surfacing sealing surfaces of pump impellers. A great advantage of this method is negligible stirring of deposited metal with base metal (3–8 %) and the possibility of surfacing thin layers (0.5–3.0 mm). Due to a low penetra-

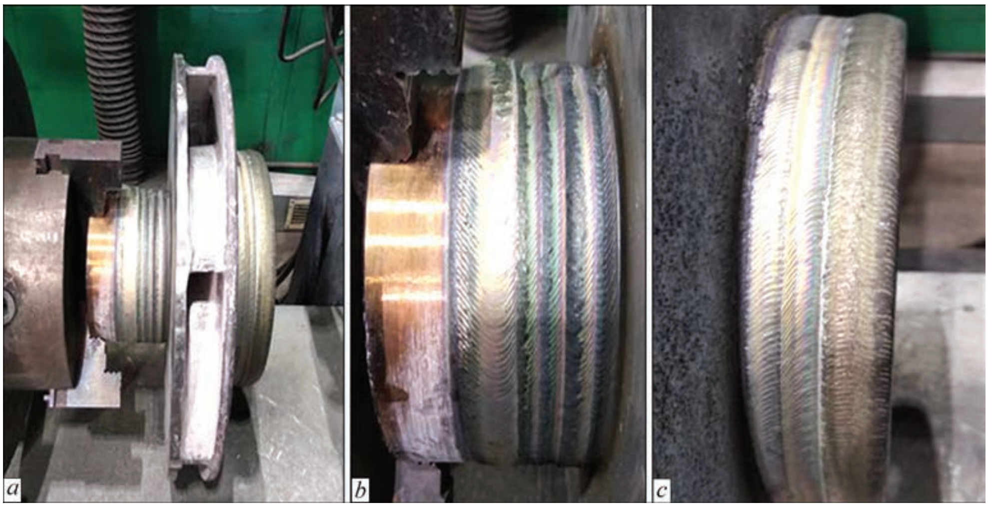

Figure 2. Plasma-powder surfacing of pump impeller (*a*) and appearance of deposited surface on small (*b*) and larger (*c*) diameters of impeller

tion of base metal, the required hardness and specified chemical composition of deposited metal are provided already in the first deposited layer [6–8].

In this case, as surfacing materials the alloy powders based on cobalt (stellites) and nickel (colmonoys) are used. In our experiments, a cobalt-based Stellite 6 alloy was used.

For surfacing the sealing surfaces of pump parts, a universal automated installation PM-302 for plasma-powder surfacing, manufactured by Plasma Master Company, was used (Figure 1).

Before surfacing, the operator of the installation PM-302 introduces the basic process parameters: direct arc current, powder consumption rate, surfacing speed, amplitude and oscillation frequency of the plasmatron, displacement of the arc from zenith and distance from the plasmatron to the product, gas consumption: plasma-forming one, transporting powder and shielding one. The selection of parameters depends on the size of the surfacing layer, dimensions and design of products and thermophysical properties of base and filler material. The criteria of optimality of the selected modes are a good formation of deposited bead, minimal penetration of base metal and absence of defects in the deposited layer (cracks, pores, nonmetallic inclusions, etc.).

Surfacing of sealing surfaces of pump impellers in the installation PM-302 is performed in an automatic mode, which provides a high quality of deposited surfaces (Figure 2). Visual inspection and colour flaw detection showed that there were no defects in deposited metal.

Conclusion

The technology of gas-shielded robotic arc surfacing of sealing surfaces of pump impellers with flux-cored wire of ARTINIT DUR 500 grade was developed. The technology of plasma-powder surfacing of these parts in automatic unit PM-302 with application of powder of cobalt alloy Stellite 6 was also developed. Both methods provide a high efficiency and a high quality of deposited metal at a low consumption of expensive surfacing materials and minimal costs. The choice of the method of surfacing sealing surfaces of pump impellers is made on the basis of their operating conditions and economic indicators.

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