Possibility of obtaining complex form details using additive surface technology

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Abstract. The authors consider the possibilities of using welding in protective gasses with a melting electrode for the manufacture of parts of complex shape. The results of surfacing parts such as square and cylinder are presented. In the course of the research, the technological features associated with the parameters of the welding arc and melting of the surfacing wire were established. Arc current has the greatest effect on the appearance of the molding. The wire feed speed affects the height of the deposited roller. It is shown that the stability of the formation of deposited rollers depends on the transfer modes of the metal, which depend on the conditions of supply and input of wire into the melt pool. The additive technology of metal deposition allows one obtaining parts with a surface different from the base metal, high wear resistance at normal and elevated temperatures, and corrosion resistance. Surfacing can be performed both in the manufacture of new parts and in repair and restoration work, significantly extending the life of parts and assemblies, thereby ensuring a high economic effect.

1. Introduction

Additive technology. (AT) today are a modern and promising method for the production of parts and products of complex configuration [1-12]. They are based not on the “subtraction” of the material, but on its addition, layer-by-layer building up of the material in order to create an object based on an electronic three-dimensional model. These technologies make it possible to use practically the same amount of material during manufacturing that will subsequently remain in the finished part. Due to this approach, the utilization rate of the material increases and it becomes possible to produce parts that cannot be obtained by casting or machining. AT is universal, flexible, easily customizable and therefore can be used in most sectors of industrial production. The materials for the manufacture of various parts of machine parts and units can be of various types. These include metallic, ceramic, and polymeric materials, as well as combinations of composite, hybrid, or functionally gradient materials (FGMs). The most interesting and effective technologies for the manufacture of metal products by the method of layer-by-layer application of material as applied to industry are the following: WAAM (GMAW, PAW, CMT), DMD, LBDMD, EBAM. WAAM - Wire Arc Additive Manufacturing) is one
of the additive technologies that use wire as a surfacing material [7-12]. Various research groups are working on improving such technologies of wire-arc additive production as metal electrode welding in a gas medium (GMAW), gas-electric welding with a tungsten electrode (GTAW) and plasma arc welding (PAW) [12-19]. GMAW is a type of welding, otherwise called MIG / MAG welding (arc welding with a consumable electrode in an inert gas environment), which involves the automatic supply of a continuous solid melting electrode in a protective external gas atmosphere.

2. Materials and research methods

The energy source selected for this AT-process is an electric arc with a floating electrode (GTAW), and not a laser or electronic beam, due to a combination of advantages, including low cost, no need for a vacuum chamber (compared to electron beam), the ability to economically apply the process for a very large working volume and a much higher deposition rate. The GTAW process can be combined with industrial welding robots and multi-sensor control systems to achieve high accuracy in arc positioning. The experimental setup includes an industrial current source, a wire feeder, a carbon dioxide cylinder, a work table and a working chamber. In the manufacture of parts of complex shape, the main geometric parameters that must be controlled are the effective wall width and layer height. These sizes are set from the initial parameters of the weld pool and then the rollers are superimposed on each other. Figure 1 shows a fragment of the formation of a cylindrical part.

Figure 2 shows a typical surface profile of a complex part in the form of a square made on the basis of GMAW. Part of the weld square was machined. As it is shown in Figure 3, the uneven appearance of the deposited surface is observed noticeably in the adjacent layers, due to the layer height of more than 1 mm, during the deposition, many deposited layers. This phenomenon is known as the step effect, which inevitably arises in additive manufacturing. Due to the greater layer height, this effect is more predominant in WAAM compared to the effect of selective laser melting (SLM).

In general, the surface quality of the deposited parts has a significant effect on the amount of processed metals in the process of subsequent finishing. A fully dense material is necessary for the manufacture of most parts in order to achieve optimum mechanical strength to meet or exceed service requirements. Full density is achieved by optimizing both process parameters and the trajectory of the welding head to maintain a continuous melt pool. Figure 3 shows layers consisting of a cellular microstructure. Continuity from layer to layer is maintained by melting and back-melting into previous layers when a new metal layer is added. The depth of reverse melting varies from a fraction of the previous layer to repeated melting through several layers, depending on the selected process parameters.

Figure 1. Additive technology of semi-automatic CO₂ deposition technology to produce cylinder-shaped parts.
Figure 2. Additive technology of semi-automatic deposition technology in CO₂ to obtain a square part.

On the whole, during the experiments, a good formation of deposited layers was established. The results of mechanical processing showed the absence of pores and cracks in the deposited wall of the square of Figure 3. No fusion between the layers is not fixed. At the same time, it is necessary to note the presence of defects during surfacing (Fig. 3).

With semi-automatic deposition of metal on the surface of a product with the participation of a welder, the following technological difficulties arise:

- during surfacing it is often necessary to take breaks;
- with increasing height of the deposited metal, the shape of the circle begins to decrease;
- due to severe overheating, the metal begins to spread, thereby increasing the surface area of the part;
- it is possible to change the specified form of surfacing.

Figure 3. Surfacing defects.
The change in the shape of the circle (see Fig. 3) is due to the fact that, for the initial base, it is necessary to lay the rollers of a larger area. Changing the shape of the deposition depends on the welder. The latter, for subjective reasons, cannot surface up with constant speed.

Under suboptimal conditions, the formation of porosity of the microstructure is possible, which occurs mainly as a result of gas evolution during solidification and the absence of melting between layers or adjacent passages of the molten bath. Increasing the power of the welding arc, reducing the speed of movement, or using thinner layers can help merge and reduce or eliminate this type of voids. Based on the experimental results, it was found that the arc current has the greatest influence on the appearance of the molding.

3. Conclusion

In the course of the research, the technological features associated with the parameters of the welding arc and melting of the surfacing wire were established. Arc current has the greatest effect on the appearance of the molding. The wire feed speed affects the height of the deposited roller. It is shown that the stability of the formation of deposited rollers depends on the transfer modes of the metal, which depend on the conditions of supply and input of wire into the melt pool.

The additive technology of metal deposition allows one obtaining parts with a surface different from the base metal, high wear resistance at normal and elevated temperatures, and corrosion resistance. Surfacing can be performed both in the manufacture of new parts and in repair and restoration work, significantly extending the life of parts and assemblies, thereby ensuring a high economic effect.

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