Improving the efficiency of plasma heat treatment of metals

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Abstract. This paper proposes an effective way of the plasma hardening the surface layer at the expense combined influence of the plasma jet and a cold air flow. After that influence occurs a distinctive by plasma treatment microstructure with increased microhardness (an increase of 35%) and depth. There is proposed an improved design of the vortex tube for receiving the air flow with a temperature of 20 C to -120 C.

1. Introduction

The plasma hardening of details from a steel and cast iron is one of the most effective and efficient way to increase a resource of work elements of machines and mechanisms, as well as reducing their consumption of materials. Increasing operational properties hardenable parts achieved due to the improvement of technology hardening that, ultimately, to ensure the optimal thermal cycle (heating-cooling) based on the patterns of structural, phase and polymorphic transitions of the hardening material [1, 2].

A significant feature of the surface hardening is to maintain the quality the bulk metal, which is also heats up with the surface layer. In the plasma quenching amount of energy nested in the metal is sufficient to heat the surface, and the mass of the metal remains cold. [3-5]

2. Experimental studies

In this paper proposes an effective way of the plasma hardening the surface layer due to summary influence of the plasma flow and the coolant in the treatment zone.

The air is used as a supporting source of the coolant, which is readily available and cost-effective cooling medium, and its use in the hardening of steel products a laser quenching can be promising trend in improving this technology.

As a result of the conducted investigations was developed an experimental setup - "vortex tube." The invention relates to refrigeration technology in particular, to the installation, using a vortex effect of separating the gas on the hot and cold flows [6, 7]. The flow can be prepared with a temperature of 20 C to -120 C using pneumatic system as a source of compressed air.

The installation of design shows in Figure 1 [8, 9].
Figure 1. The vortex tube; a) a schematic diagram, b) the appearance

The feature of this device is the vortex zone, having the form of a truncated cone with expansion to the end of the exit stream with a higher temperature. To improve the effectiveness of the "vortex tube", separating chamber provided with finning from outside for cooling the periphery of flow separation.

During the plasma heat treatment on the sample - a steel 45 at the same time supplied cold air flow from the vortex tube with a temperature down to minus 100 °C. This method of quenching allows to produce a big depth of the hardening and the complex properties of the steel.

3. Results of experimental investigation

The results of experimentally received samples after treatment pulsed plasma generator shows in Fig. 2.

Metallographic researches of the steel 45 in the field of the plasma hardening shows (Fig. 2a), that the area of the thermal impact of the plasma jet has the form of a segment [10]. It is established that, depending on the microstructure and microhardness in the steel 45 the depth formed three layers:

1. The area reflow, consisting of non-equilibrium fine-dispersed structure close to an amorphous, it takes place during quenching from the molten state, has a columnar structure with crystals, extended in the direction of the heat sink. The main structural component is martensite. In this example, the martensite has 6-7 points. This zone microstructurally reveals as weakly etching the layer extremel high hardness and uneven of the treated surface across the width, the maximum depth of the central part is 0.022mm. With the hardness of the surface layer 874HV.

2. The area of the quenching from the solid phase. Directly under the weak etching the layer located area of the plasma influence, which borders with the area complete and incomplete of the hardening with microhardness, corresponding the hardness of a small spicular martensite and martensite turning into sorbitol of the hardening and sorbitol tempering closer to the main (initial) structure. The thickness of the area is also not uniform and varies 0.45 mm. The depth layer characterized by a strong structural inhomogeneity. In the upper boundary of the layer closer to the surface is observed
martensite and retained austenite. In the lower boundary of the layer closer to the original metal together with martensite is observed elements of the original structure ferrite.

Figure 2. Samples of the steel 45 after plasma treatment × 50 a) without cooling with the reflow of the surface, b) without cooling without the reflow of the surface, c) with cooling with the reflow of the surface, d) with cooling without the reflow of the surface.

3. The transition area. In this zone the metal is heated to a temperature below the Ac1, in which the main structures are structure of the tempering. The zone of the original structure and hardness, representing a fine-dispersed sorbitol tempering. Transitional layer has the most disordered and heterogeneous structure.
The sample in Fig. 2. b) no fusion zone while maintaining the remaining zone and correspondingly less microhardness on the sample surface.

When combined treatment zone thermal effect of the plasma jet also has the shape of a segment, but the third transition area is virtually absent, homogeneous hardened zone and with greater microhardness.

4. The conclusion

After the plasma quenching metals with the cooling zone of the influence by the flow of a cold air increases the quality of treated parts. This technology of the heat treatment metals is the very effective way of directional changes in physical-chemical and mechanical properties of the surface layers, as the combination of these properties of the material determines many operational characteristics products. If the plasma quenching near a cooled object has a factorial or airborne pneumatic system with the surplus resources, there are many applications where compact and inexpensive cold vortex generator called "vortex tube" there is no alternative.

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