Equipment for plasma processing in C0₂

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Abstract. The article shows the possibility of restoring the internal surfaces of parts and regulating the processes occurring in the plasma stream to create various micro- and nanostructures through the use of a number of design solutions of the plasma torch.

Currently, nanotechnology is widely used in the automotive industry, in nodes to extend the life of parts, create unique properties of their materials and give new properties to surfaces by creating functional coatings. The use of nanotechnology is due to the need to improve the characteristics of structural materials with a small potential resource, as well as to change the approach to the formation of their structure and properties. The resource of modern automobile engines depends on the wear resistance of friction pairs, one of which is a pair of cylinder-piston groups, which during major repairs is replaced by a new or reconditioned bore for repair size. The latter entails a decrease in the hardness of the inner surface and the need for additional production of pistons and rings for the repair size. The use of wear-resistant coatings with special properties makes it possible to sharply improve the quality and reduce the consumption of resources in comparison with traditionally used materials for this. A progressive way to create such surfaces is plasma spraying. The use of plasma of various gases as a working medium, due to its high chemical activity in relation to various materials, allows the formation of various coatings, including superhard, micro- and nanostructures, from powders, rods and liquids in the coatings formed. or to synthesize certain nanosized inclusions in its layers that increase the operational characteristics of parts of transport machines [1-4].

To implement automatic plasma processing in CO₂ with a filler wire, on the basis of the studies and the developed technological scheme, equipment was designed and manufactured that consists of a small plasma torch equipped with an electrode assembly, a control cabinet, a power supply, and a feeding mechanism equipped with an additional attachment [5,6].

When developing a plasma torch, the requirements of minimum weight and dimensions, manufacturability, maintainability and durability were taken into account. The operating experience of the plasma torch showed that the nature of the wear of commercially available cathodes of zirconium or hafnium insert during plasma welding in CO₂ is similar to wear during plasma cutting in oxygen-containing environments. Along with regular wear during the welding process, wear of the cathode insert and nozzle during arc ignition is of great importance. When using cathodes with a hafnium insert at currents up to 300 A at a water flow rate of 100 g/s, their resource is about 300 inclusions.

The developed plasmatron (figure 1) ensured the formation of a plasma arc using active and inert gases.
The plasmatron contains:
- a nozzle assembly, consisting of a water-cooled housing 1, a pin of a current supply of a pilot arc, 2 - fittings of a cooling system 2, 5, a forming nozzle 3, a shielding gas divider 4, fittings of a gas supply system 6, an insulating sleeve 7 for fastening an electrode assembly and adjusting the gap between the electrode and the forming nozzle 3, the plasma swirl gas 8:
- electrode assembly, consisting of a housing 9, a divider cooling medium 10 and an electrode with a working insert 11.

The divider in this electrode assembly also serves to remove the electrode 11.

Figure 1. Design and appearance of a plasmatron for plasma welding and processing of welded joints in the environment of active and inert gases.

Table 1 shows the technical characteristics of the plasmatron.

| Processed material                  | Plasma processing gas | S, mm | Polarity | Electrode                              | Current range, A | Voltage, V |
|------------------------------------|-----------------------|-------|----------|----------------------------------------|------------------|------------|
| Carbon                             | CO₂                   | 7-10  | Direct   | Copper with zirconium or hafnium insertion | 80…300           | 100        |
| Low alloy and
alloy stainless steels |                       |       |          |                                        | 50…65            |            |

Table 1. Technical characteristics of the plasmatron.
Copper and Bronze
Aluminum alloys

|            | Ar | 5-8 | Direct/Copper with insertion | 60…350 | 60 | 30…40 |
|------------|----|-----|-----------------------------|--------|----|-------|
|            |    |     | Reverse Copper              | 60…250 |    |       |

Arc excitation by high-frequency discharge.

Water consumption, g / s - 100.

Dimensions:
- Diameter, mm - 40.
- Vasota, mm - 90.
- Weight, kg - 420.

To increase the reliability of the sealing of the cooling system in this design, the plasma torch is implemented without gaskets.

Based on the nature of the working section of the static I – V characteristics of the plasma arc in CO\(_2\) and to ensure the stability of the system, the power source is the arc in accordance with the inequality:

\[
K_y = \left(\frac{dU}{dt} \cdot \frac{dU}{dI}\right)_{I=Io} > 0\]

the power source may have dipping, falling and bayonet IVCs. However, during welding under production conditions, disturbances occur that cause a change in the arc voltage (a change in the length of the plasma discharge and the electric field strength); therefore, in order to stabilize the current necessary for technological purposes, the power supply must have a steeply dropping or bayonet current-voltage characteristic. Given the characteristics of the process of excitation and burning of the arc, the open circuit voltage of the power source should be 1.5 ... 2 times higher than the operating voltage.

To implement the developed processing scheme, a power source for plasma spraying IPN 160/600, a power source from a plasma welding unit UPS 804 UHL4 and other sources corresponding to the I – V characteristic can be recommended.

The filler wire can be supplied by any commercially available semi-automatic or automatic machine.

To improve the quality of welding, it is necessary to exclude vibrations of the end face of the filler wire over the cross section of the plasma arc column. Usually, the correct mechanisms are used for this, but in this case, the braking force increases sharply, which leads to fluctuations in the feed rate. As a result of this, the position of the melting point of the wire in the arc changes and the formation of seams is disrupted.

To stabilize the filler wire feed, a prefix to serial feeding mechanisms was developed, in which the straightening and feeding operations are combined. With this design, an increase in the straightening force leads to an increase in the pulling force, which excludes slipping of the filler wire.

To ensure the working cycle of the welding installation, the control unit and spark exciter (SE) built into the control cabinet were designed and manufactured.

Excitation of the welding (main) arc occurs when applying idling from the power source. In this case, using the SE between the electrode and the plasma torch nozzle, an auxiliary arc is excited. When the torch of the auxiliary arc is in contact with the surface of the product, the main arc is excited - between the plasma electrode and the product.

The control circuit provides the installation in automatic and commissioning modes.

In automatic mode, the circuit provides:
- a) gas purge before arc excitation;
- b) excitation of the main arc;
- c) stepwise increase in the current of the main arc;
- d) protection of the plasma torch from double arcing;
- e) the inclusion of the filler wire;
- f) cutting off filler wire when welding crater seam;
g) gas purge after arc breaking.

In addition, the circuit ensures the operation of the installation in plasma welding mode without filler wire feeding.

The developed equipment and technology for plasma welding with filler wire can be introduced for the production of welded structures of low-carbon, alloy steels, as well as surfacing and hardening of welds and surface of products. The economic effect is achieved due to the economy of electricity, metal (welding wire) and increased labor productivity.

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