Device for Surfacing Parts of Agricultural Machinery

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Abstract: In increasing labor productivity, improving product quality and saving raw materials, the surfacing method plays an important role in the production of industrial equipment, its operation and repair. During active operation, parts of machines and mechanisms fail due to shock loads, abrasion, etc. Modern technology has various methods for restoring and strengthening parts to increase their service life. One of the modern technological processes for restoring parts is surfacing. Surfacing is the application of a layer of metal to the surface of a work piece or product through fusion welding. The proposed device for surfacing parts in a hydrogen-oxygen environment is a solution to the problems of the technological process of repair and restoration welding and surfacing.

1 INTRODUCTION

During active operation parts of machines and mechanisms fail due to shock loads, abrasion, etc. Modern technology has various methods of restoration and hardening of parts to increase their service life (Avdeev et al., 1986; Gorlova & Tadjibekova, 2010; Khudayorov et al., 2023; Khaliknazarov et al., 2024; Khaliknazarov & Ibrokhimov, 2024).

One of the modern technological processes of parts restoration is cladding. Cladding is the application of a layer of metal on the surface of the workpiece or product by means of fusion welding.

At repair works of any kinds of technics mainly the restorative surfacing is used. Restorative surfacing is used to obtain the original dimensions of worn or damaged parts. In this case, the clad metal is similar in composition and mechanical properties to the base metal. Cladding is most widely used in repair work to restore housing parts of various internal combustion engines, camshafts, crankshafts, valves, pulleys, flywheels and wheel hubs. Cladding can be performed by almost all known methods of fusion welding. The most important requirements for cladding are as follows:

- minimum penetration of the base metal;
- minimum value of residual stresses and metal deformation in the cladding zone;
- reduction of allowances for post-processing of parts to acceptable values.

2 MATERIALS AND METHODS

Rational method of repair of machinery and equipment is determined by the choice of surfacing method and is determined by the possibility of obtaining a clad layer of the required composition and mechanical properties, as well as the nature and permissible amount of wear. The choice of cladding method is influenced by the size and configuration of parts, productivity and the share of base metal in the clad layer. The main types of surfacing: argon-arc with a non-melting electrode, melting electrode in a protective gas, manual arc welding with coated electrodes, arc welding with self-shielded wire, plasma powder.

Cladding work is carried out by various methods of welding arc, gas, plasma, electronic, etc. Cladding process can be mechanized and automated. Special cladding units with automation of the main operations are produced**.** The device presented in this article belongs to the field of agricultural engineering, in particular to devices for surfacing new or used worn-out machine parts.

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The most commonly used cladding devices contain a nozzle, channels for supplying cladding powder, oxygen, conveying and combustible gas. The disadvantage is excessively high plasma temperature, which reaches 7000-15000 0C, because of which it is impossible to use easily fusible polymer powders or non-ferrous metal powders, which limits the technological capabilities of the devices.

The standard device is a prototype and for plasma-arc surfacing, consisting of a plasma-forming head, with a non-fusible electrode and with a cooling cavity and side channels of tubes for supplying coolant and powder materials, a mechanism for feeding long metal or polymer materials, vaporizing manifold and hinge mechanism. The disadvantage of such a device is the complexity of the vapor-forming system and the use of inert gas to obtain the plasma-forming medium, which leads to an increase in the cost of clad parts, as well as to an increase in air pollution at the workplace, high energy and metal consumption of the cladding process, increased losses of clad materials due to the formation of large droplets of cooling medium (Muhammadiev et al., 2020; Khaliknazarov et al., 2021; Bokiev et al., 2021; Alimova et al., 2022; Djiyanov et al., 2022; Saidova et al., 2023; Djiyanov et al., 2024a; Djiyanov et al., 2024b; Isakova et al., 2024; Irisov, 2024).

In addition, burnout occurs under the influence of high temperatures, and due to burnout of easily fusible, both metal, polymer and powder materials, the range of cladding parts of machines is reduced.

The task of the presented device useful model, is to expand the technological possibilities of cladding device, increase the range of clad parts and reduce harmful emissions into the environment. The set task is achieved by the fact that the device for surfacing parts in hydrogen-oxygen medium, consisting of a plasma-forming head with a non-fusible electrode and with a cooling cavity and side channels, tubes for supplying coolant and powder materials, a mechanism for supplying long material and a hinge mechanism, is distinguished by the fact that the plasma-forming head is additionally equipped with a mixing chamber and a system for forming a hydrogen-oxygen combustible mixture, that the plasma-forming head is additionally equipped with a mixing chamber and a system for the formation of hydrogen-oxygen combustible mixture, and the non-fusible electrode is mounted symmetrically on the back side of the perforated flap, the hinge mechanism is made multilink, one end of which is connected to the body of the plasma-forming head, and with the other to the mouthpiece of the mechanism for feeding long-size surfacing rods, and the device is equipped with an exhaust system.

3 RESULTS AND DISCUSSION

Figure 1 shows the proposed device for cladding parts in hydrogen-oxygen medium (where: ω - rotation frequency of the clad part; α - angle of plasma torch touch; R - radius of the part; δ - thickness of cladding; H-height of plasma-forming head nozzle (plasmatron) installation; e - eccentricity; Δp - working pressure drop; qohl - flow rate of cooling medium; q51Bvx - flow rate of hydrogen-oxygen medium. hydrogen-oxygen medium.

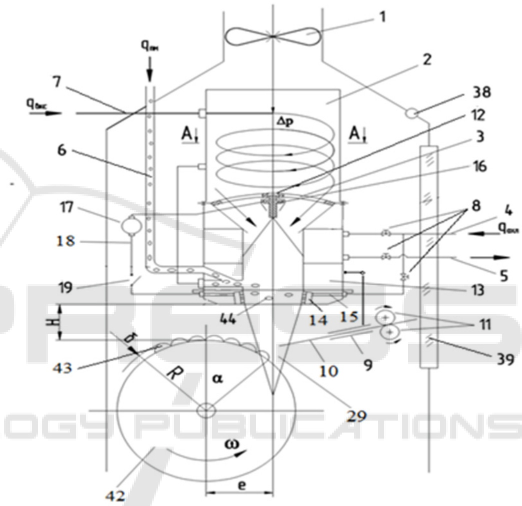

Figure 1: Schematic diagram of the device for surfacing parts in hydrogen-oxygen medium.

The device for surfacing parts in hydrogen-oxygen medium consists of a mixing chamber 1 (Fig.1), with perforated flap 2, cooling cavity 3 with supply 4 and withdrawal 5 tubes, providing continuous supply and withdrawal of coolant, side channel 6 for powder material supply and tube 7 for supply of local portion of hydrogen-oxygen combustible mixture formed in the system, three valves 8, mouthpiece 9 for feeding a long rod 10, feed rollers of a multi-link hinge mechanism 11, plasma-forming head 12 of a perforated flap, nozzle of the plasma-forming head, which is equipped with a vapor-forming system consisting of a perforated ring-shaped working chamber 13 with feed channels 14 and 15. The perforated flap is equipped with a non-fusible tungsten electrode 16, a generator 17, an electric circuit 18 with a switch 19. The device is additionally equipped with a viewing window 38 and exhaust system 39.

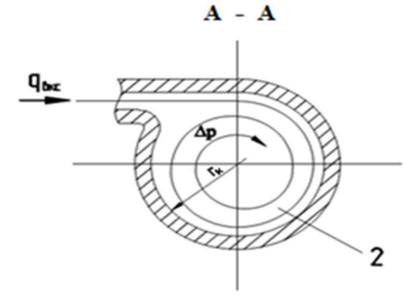

Figure 2: A-A cross section of the mixing chamber (where rk is the radius of the mixing chamber).

Fig. 2 shows the cross-section of the mixing chamber along A-A (where rk - radius of the mixing chamber), in which the perforated flap is made replaceable and has the shape of a confuser.

Fig. 3 shows the schematic diagram of hydrogen-oxygen combustible mixture formation (where: A - ammeter; V - voltmeter; O2 - oxygen; H2 - hydrogen; BIT – pulse current block).

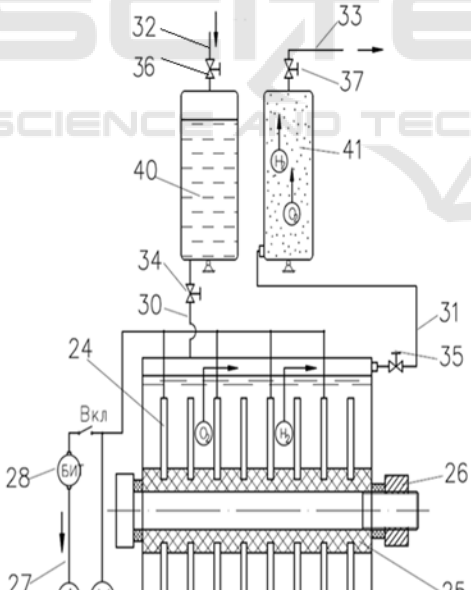

Figure 3: Principal scheme of hydrogen-oxygen combustible mixture formation (HOCM).

The proposed device is also equipped with an autonomous system for the formation of hydrogen-oxygen combustible mixture (Fig. 3) and consists of a number of flat disks 24, rigidly mounted in a horizontal dielectric axis 25 and tightened on both sides of the nut 26 in a single monoblock, and flat disks 24 are connected to the electrical circuit 27 pulse current block (PIB) 28.

A small portion of liquid, enters through the perforated ring-shaped working chambers 13 under the influence of a high temperature gradient of the torch 29 of the electric arc. The self-contained system is provided with a system of tubes 30, 31, 32, 33 with valves 34, 35, 36 and 37. The system includes a tank 40 for distilled water and a broiler 41 for collecting the hydrogen-oxygen mixture. The plasma-forming head 12 is connected to the multi-link hinge mechanism 11 in the lower part. The inner wall of the nozzle of the plasma-forming head is perforated.

The device for surfacing parts in hydrogen-oxygen medium works as follows. In the process of cladding new or worn parts 42 with fusible metal or polymer powders, the hydrogen-oxygen combustible mixture supplied through the chamber is ignited from the electric arc of the tungsten electrode 16 and further, flowing around the electric arc, forms a high-temperature plasma torch 29, which is transported at high speed to the cladding zone. Powdered metallic polymeric materials 44 fed through the side channel 6 are injected into the plasma torch structure and transformed into liquid droplets 43 and further applied to the surface of the workpiece 42, forming a wear-resistant thin metal or polymer coating of thickness "δ". Pulsed current (IT), intensively acting on the walls of spherical disks 24, increases the WCGS productivity. With the growth of the reactor WCGS productivity, the pressure drop Δp and the rate of WCGS feeding into the mixing chamber 1 of the plasma-forming head 12 increase. Under the action of IT there is a local expansion of distilled water (DW) to atomic hydrogen (H2 ↑) and oxygen (O2 ↑), which in the form of a swarm of bubbles, floating above the level (DW) of the working fluid and further, through broiler 41 and supply tube 33, are transported into the cavity of mixing chamber 1, providing stability of formation of high-temperature plasma, providing surfacing of a large range of new or worn machine parts. The coolant flow rate and VKGS are regulated through valves 8, and the cladding mode is regulated by setting the height H of the nozzle of the plasma-forming head relative to the surface of the part to be restored 42. When cladding light-melting metal or polymer powders, it is sufficient to select the optimal dose of coolant supplied through the tube 4 by adjusting the valve. In the process of using long lengths of fusible metal or polymer rods, the supply of powder materials through the side channel 6 is temporarily suspended, and the hinged rod feeding mechanism 11 is put into operation. Long-length fusible rod 10 under the action of plasma torch temperature melts, forming small metal or polymer liquid droplets 43, which under the action of high velocity of plasma torch of plasma electric arc are applied to the surface of the clad part 42, forming a cladding thickness equal to (δ).

Selection of the optimum plasma torch height 29 and cladding quality is achieved by adjusting the plasma torch height H and the working pressure Δp of the plasma arc in the mixing chamber 1. Exhaust system 38 with a viewing window 39 provides periodic process control over the process of cladding and reliable protection of the breathing zone of the operator from harmful chemical components emitted during the cladding process. Turning off the supply of powder materials through the side channel 6 of the plasma-forming part, as well as the metal rod 10, through the mouthpiece 9 can be carried out and heat treatment of the working surface of the part without cladding, thereby increasing its wear resistance. The multi-link hinge mechanism ensures optimum plasma torch height. By varying the coolant flow rate through the perforated side working chamber, the optimum cladding and heat treatment mode can be selected depending on the type and size of the materials to be clad.

Due to adjustable supply of VKGS to the cladding zone, in comparison with the temperature of electric arc, relative to the temperature of hydrogen-oxygen combustible mixture, the optimal mode for cladding of both low-melting powders or rods and refractory powders or rods is created, which significantly increases the nomenclature of clad parts, thus expanding the technological capabilities of the proposed device. The coolant supplies through the perforated wall of the nozzle of the plasma-forming head creates optimal conditions for reliable deposition of harmful components emitted in the process of cladding parts. By reducing the temperature gradient of the plasma plume formed by the supplied working mixture, burnout of easily fusible metal or polymer materials is excluded. The method of heat treatment significantly reduces the cost of restored parts. All this in general will give the national economy of the country a significant technical and economic effect.

4 CONCLUSIONS

In comparison with other methods of surface treatment of metal, the use of the device for surfacing of parts in hydrogen-oxygen environment has a number of advantages:

1. the possibility of applying a metal coating of large thickness; it gives a significant effect in the restoration of severely worn parts, which is more economical compared to the previously used technology of manufacturing similar vessels from clad steel obtained by rolling;
2. high productivity;
3. relative simplicity of design and transportability of equipment adapted for outdoor work, for example, cladding of parts of earthmoving and agricultural machinery in the field;
4. no limitations on the size of the cladding surfaces of the products; e.) have a significant limitation on the size of the processed products;
5. ease of performance, especially in automatic or semi-automatic cladding mode;
6. the possibility of applying a wear-resistant coating on the base metal of any composition;
7. the possibility of increasing the efficiency of cladding by combining it with other methods of surface treatment.

This device is aimed at maintaining and restoring the resource of agricultural machinery and is recommended for use in repair and restoration work at repair enterprises.

The method of heat treatment significantly reduces the cost of restored parts and all this in general will give the national economy of the country a significant technical and economic effect.

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