ELECTRIC ARC SPRAYING IN SUPERSONIC STREAM

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ABSTRACT

A new installation for spraying of coatings by electric arc metallization on the system ensuring ventilation of stabilized electric arc oriented .along axis gas stream direction and burning between two melting wires by hot gas (methane, propane, butane) fuel combustion products with air are developed. The velocity of injection is supersonic. This system ensures : 1) high stability of arc burning due to it's orientation in gas stream direction resulting in the high stability of heat transfer to the melting electrodes process; 2) intensive acceleration an splitting of melted metal particles and prevention of the oxidation of those during flight, decreasing of quantity of evaporated material due to two-phased stream formation by high velocity stream of combustion products. Quality and technical properties are 1. 5 - 2.0 times better in comparison with conventionally obtained ones. A new installation has been successfully tested in industry in applications of weared motor components repairing and corrosion protective coating deposition.

Theoretical background

The melted metal particles dispersion and acceleration processes and, therefore, coating quality are determined by sprayed gas outflow parameters and electrical gas-dynamic situation in wire melting zone with electric arc metallization. Arc and on-blowing flow are interrelated. Arc-heated gas moves downwards and stabilize the space position of arc. axial symmetric arc discharge in coaxial flow is described by boundary layer equation type expressions. The great magnitudes of physical parameters (temperature, density viscosity) gradients and electromagnetic action **of arc** onto the flow are characteristic for gas flow on-blowing of the arc. While the arc burnes in the surrounding flow, the pile of arc burning in the coaxial flow is observed as brightly lighting area of two-phased flow.

Below we shall discuss the processes of gas acceleration and electric arc heating when the products of stoichiornetric combustion of methane in air (excess air ratio $\alpha = 1$ and stagnation temperrature $T^* = 1700$ K) or of air only ($\alpha = \infty$, $T^* = 300$ K) are used as on-blowing gas.

Heat radius of the arc or enthalpy acquisition radius could be defined from energy equation of the arcs.

The own magnetic field of axial symmetric arc effects significantly on the arc. Firstly, it produces the forth directed to the axis that presses the arc pile and, therefore, increases the arc inside pressure.Secondly,the interact ion between the radial component of the arc current with the own magnetic field results in near-electrode gas provides velocity and additional involvement of gas in the discharge. Utilization of high-velocity methane cornbiistion products instead of air as spraying gas is technologically preferable. Reduction of the arccross dimension causes reduction of on-blowing flow disturbance with nearly equal electromagnetic acceleration effect of arc onto the gas without considering magnetic field effect and accounting the average flow velocity and dynamic head within the ionized gas layer are increasing with utilization of combustion products more than 2 times. The maximal pressure drop is also increased. It should be noted also that due to on-blowing gas viscosity increasing and it's decreasing in the arc < due to decreasing of temperature of arc burning in the methane combustion products flow).

The most important electric arc metallization process factor is dispersion of arc melted wires metal. Beside the electro dynamical and thermal origin forthes effect the carrying of the melted metal from the electrodes and drops grinding is influenced on the whole by the flow velocity head. Specifying the critical Veber number We = 22 the average diameter of the steel particles with spraying flow velocity $\lambda =$ 1 ... 1. 4 is found to be equal d == 0, 33 - 0, 42 mm for $\alpha = \infty$ and d =0, 12... 0, 18 mm for $\alpha =$ 1. Particles acceleration that is proportional to with utilization of the methane melting products ($\alpha =$ 1) as spraying gas is essentially intensifying both due to those diameter

decreasing as well and velocity head increasing, that is particles acceleration is increasing more than 4 times comparatively with air arc on-blowing.

ELECTRIC ARC METftLLIZftTOR AND IT'S BASIC PERFORMANCES

The basic of the new electric arc metallization coating deposition unit is the system providing stabilized upstream oriented electric arc burning between the central and lateral wires on-blowing by the hot methane combustion products. The feebly under expanded supersonic Jet of natural gas combustion products and air is used for arc on-blowing. with supersonic burner operation in wire spraying regime the efficient two-phased flow focusing with expansion angle 6-10°.

With the stable voltage on arc (in ranges 35 - 50 v) the current level is defined by central electrode feed rate. The rate depends on the applied voltage polarity in case of equal currencies, it is higher for direct polarity. The rate of lateral electrode melting is independent on polarity and it is always higher than the rate of the central electrode melting

More high wire supply rate obtained in case of utilization of combustion products as spraying gas with currents less than 300 350 A is accounted for the additional heating of those by combustion products at the section after outlet from the directing tips. The jet structure makes the predominant effect on the disperse phase formation process (average particles size, those velocities, trajectory, velocity and dimension distributions). Behind the lateral electrode the shadow zone is formed in which the dynamic head profile depression occurs. The flow structure like this is favourable for the present electric arc metal 1izat or, because it promotes the efficient acceleration of circumference particles. The measurements made for spray distance 200 - 300 mm show that there are almost no particles velocities dispersion along metal-flow radius. This is confirmed by the morphology analysis results that has been fulfilled with the aid of microscope POLYVAR MET (AUSTRIA) The surface video image has been explored by the computer, the data have been processed with the program VIDEOLAB - 2. Spray regime: I =, 200A, U = 40 V, distance 250 mm, α= 1, gas pressure -0. 7 MPa, rnatherial - Fe-basic powder wire. The bound strength obtained in the present regime was 55 MPa, the porosity - 2, 6 %. The average sprayed particles dimension was 100 mm, average flatten particles dimension - 370 mm, width — 20mm.

The shape factor is the ratio of cross—section area on micro-section to the area of circle with the perimeter of flatten particle.

Electric arc metallization in supersonic flow of combustion products provides obtaining of high-quality coverings with improved strength of bound with basement, reduced material porosity and oxidisation.

CONCLUSIONS

The high velocity of electric arc on-blowing flow of products of hydrocarbons combustion with the air (1000 m/s) provides the efficient melted metal drops dispersion and increasing the speed of those flight. This results in increasing of the time of melted particles contact with gas atmosphere The oxidizer content is no high in two-phased flow formation zone because of oxygen bindin by the burn able components. Both of those factors (contact time reduction and oxidizer content reduction) restrain undesirable chemical conversion in the material sprayed. Efficient focusing of two-phased flow and high kinetic energy of the sprayed particles furthers to covering quality increasing. In comparison with conventional electric arc metallization one more regulating parameter appears - burning gas—air proportion.