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INVESTIGATION OF THE PROCESS OF WIRE ARC SPRAYING

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INTRODUCTION

In the arc spray the metallic wires is melted by means of an electric arc. The molten material is atomized by compressed air and propelled towards the workpiece.

The molten spray solidifies on the component surface and form a dense, strongly adherent coating suitable for corrosion protection or component reclamation. Sprayed coatings may also be used to provide wear resistance, electrical and thermal conductive coating or for production of free-standing shapes.

Major advantages of the arc spray process are that the coatings are available for almost instant use with no drying or curing times and there is no risk of damaging the component. In addition, the deposits possess a higher degree of bond strength than most other thermally sprayed deposits and the use of compressed air and electricity alone mean more economic coatings. In wire arc spraying, atomizing gas velocity and particle velocity are important factors influencing coating quality [1]. The aim of this study was to investigate the possibilities of increase fly speed of particles projected by the gun Tafa 9000, when the thermal spray parameters are fixed.

STUDIES OF THE FLOWS OF JET BY COMPUTATIONAL FLUID DYNAMICS (CFD)

The software PHOENICS was chosen forFor numerical calculationwas chosen software PHOENICS. Developed by Company SHAM, PHOENICS is a general programme of mechanics of the fluids intended for the simulation of all types of flows and heat exchange [2].

In tThe main task of investigation was to estimatione of the influence of the configuration of the nozzle on the flow of the jet of wire arc spraying. This study is presenteds trials to change the configuration of standard TAFA nozzle. Many models of nozzles were tested (nozzle of Laval, nozzles with divergences or convergences). The flows of the six new nozzle configurations were modelled by the software PHOENICS. The influence of transporting gas (air) speed, configuration of jet, temperature gradients in jet, enthalpy and etc were calculated. All the results of modelling were compared with the process parameters of original nozzle.

After the comparison of the calculated parameters of various configurations of nozzles, for the future research were chosen the nozzle with exit extension equal to 3 mm. All other nozzle configurations (nozzle of Laval, nozzles with divergences or convergences) did not give better spray results.

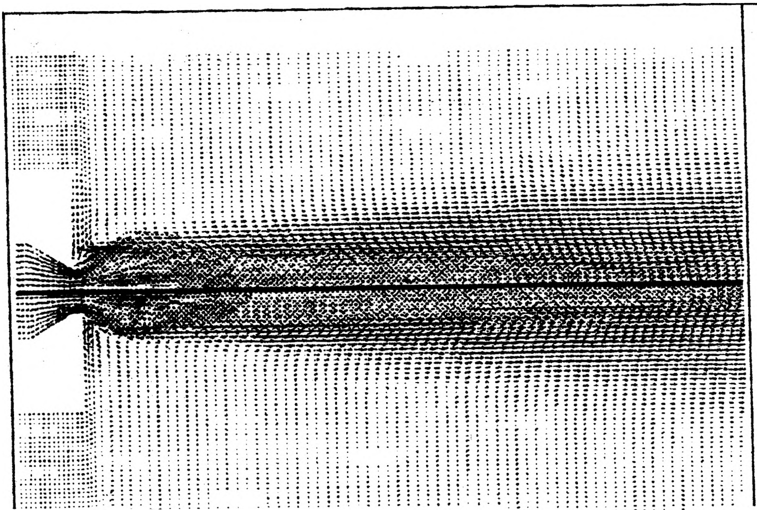

Fig 1. Vectors of the speed

The speed vectors (Fig. 1) shows that the divergence of the jet of the modified nozzle is smaller, than for the jet of the origin nozzle, but the size of the speed vector in the area adjacent to electric arc is larger.

This indication enables us to suppose, that the spray of the modified nozzle accelerate particles. The calculations allowed estimate air blow velocity in Y-Z directions. For the modified nozzle the blow speed on the direction Z is higher and is smaller in the direction Y. Thus it was assumedIt allowed predict, that jet in this case must be more concentrated.

For the same heating power, the calculated model of the jet temperature fields showed that temperature of jet flowing from origin TAFA nozzle is higher than jet temperature flowing from the modified nozzle. The rate of the flow of air is bigger from the modified nozzle. From the presented results it seems reasonable to investigate dependence of sprayed matter characteristics (temperature, velocity and size of particles) from the nozzles - original and modified. The measurements were provided by measurements system DPV 2000. This system allow to measure size, temperature and velocity of particles in flight and estimate in what degree the measured parameters depend on nozzle orifice.

ESTIMATION OF PARTICLES FLIGHT BY THE DPV METHOD

After analysis of the particles images carried out by SEM and laser granulometry was made conclusion, that the size of the particles decreases with increase in transporting gas flow speed. Size of the particles sprayed by the modified nozzle is bigger than sprayed by the original nozzle. Fig.2 present SEM photographs of the particles sprayed with various nozzles.

The equipment DPV 2000 was used in this study to characterize flight of arc spray particles. The provided investigations allowed too estimate suitability, potentialities and limitations of this equipment.

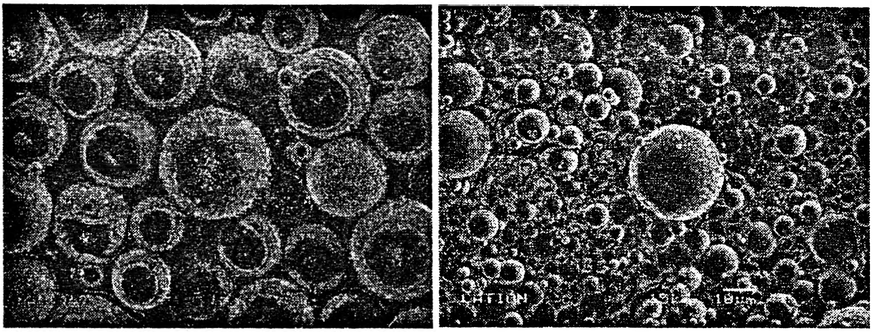

Fig.2: Sprayed particles of original nozzle (on the left) and of modified nozzle (on the right)

The DPV is a system of diagnosis employing the optical sensors in the area of thermal spraying. Based on a technology developed by the CNRC (National Research Center of Canada), the system of measurement DPV 2000 makes it possible to detect the particles in flight, to measure their speed, temperature of surface and diameter [5,7] like their position in the jet. The principle of measurement is based on the detection of the radiation emitted by the particles. It is thus possible to detect only hot particles. The DPV employs a system of infra-red pyrometry placed opposite a system of two optical slits and a camera CCD (Charged Coupled Device) to carry out the diagnosis of particles in flight. The equipment allow the measurement of the individual particles as to carry out measurement the profile of intensity on the whole of the matter jet. The DPV 2000 makes it possible to obtain values of temperature, speed and diameter of a maximum of 125 particles a second. Measurements are recorded uninterruptedly and regularly posted on the control screen of the equipment.

RESULTS OF MEASUREMENT OF PARTICLES IN FLIGHT

By comparing comparison of the results of experimental measurements carried out by laser granulometry, SEM photo of the particles and the characteristics of particles in flight measured by DVP 2000, were estimated that the mean velocity of the particles for the modified nozzle is 20% higher compared to the original nozzle,, but the temperature of the particles remained constant.

Distribution of diameter of the particles sprayed by the modified nozzle is broader. That can be explained by the dissociation of the particles in flight. In general, dissociation appears when the aerodynamic pressure of gas of atomization areis sufficiently powerful to generate disturbances on the droplet surface, thus causing the formation of fluid streams in the surface and volume of liquid drops. If aerodynamic energy is sufficient, a secondary atomization breaks these drops intoothers smaller ones.

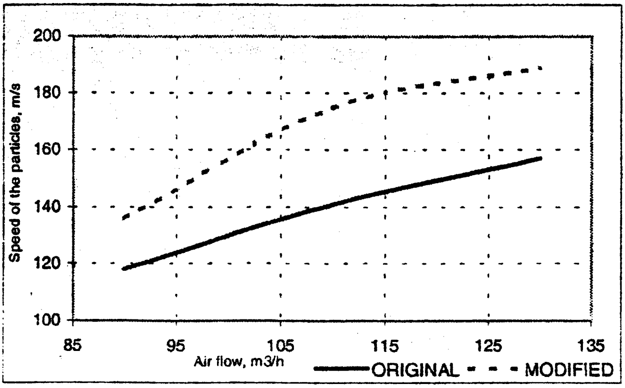

Fig.3. Speed of the particles for the nozzles original and modified

This phenomenon depends very largely on the number of WeberWeber number:

$$W_e = \frac{\rho_G d_0 u_0^2}{\sigma};$$

There:p – matter the density (kg/m3), d - the diameter (m), u - speed (in fact, the relative speed between gas and the particle m/s), and s - the surface tension (Pa) of the molten matter on the end of the wire. Indices G and 0 represent, respectively, the gas, and liquid substances.

In case, when all the parameters of spraying for the nozzles TAFA and modified nozzles are identical (voltage, current, transport gas flow, etc.), moreover, the temperatures of the particles are equal, we can contend that the density ? and the surface tension s of the liquid droplets are the same level. The diameter of particles d and speed u vary: the speed of particles for the modified nozzle are higher (see Fig. 3) than for the original nozzle. The growing Weber number allowed to predict, that particles in flight are split into smaller particles. The modified nozzle giave higher Weber number and we could state, that diversity of particles size, in comparing with origin nozzle, will be bigger.

In accordance with this analysis, it should be noted that in the manufacturing of metal powder by gas atomisation, the size of the generated particles is inversely proportional to the Weber number.

CONCLUSIONS

Results of investigation showed PHOENICS software package suitability for simulation of spray parameters and gun nozzle geometry.

Modelling makes it possible to predict position, speed and temperature of particles at the moment of their impact on the substrate depending on the nozzle configuration and optimise the flows of the jet.

Modified configuration of the nozzle allowed theo increase of the speed of the particles by ~20 % and the kinetic energy of particles impacts by ~40 %.

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