MODERN HYBRID SPRAYING METHOD FOR OBTAINING HIGH QUALITY COATINGS

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Abstract

The classical, ultrasonic thermal spraying of coatings is widely used to coat the critical wear parts, such as: chassis, bearing, valves and turbines and their components. The process is characterized by very high deposition rate, of about [1-4]:

- 70% at a flow rate of powder to 7.2 kg / h_{armat},
- 12 kg / h of fuel gas with a liquid fuel gun.

The porosity of the obtained coating by HVOF (high velocity oxygen fuel) system is a few percent. A coating is characterized by a very good adhesion to the substrate, of approximately 60 to 80 MPa and a low oxygen content - between 0.5 to a few percent [4].

Currently, the ultrasonic spraying methods develop in two basic directions:

1) First, it is the reduction of time of the spraying process. The diameter modification of gun ensures the acceleration of particles in the stream of gas and it increases the efficiency of the process, for example HVAF (high velocity air fuel) method. This problem is well described in the literature [1-5].

2) Second, it is the reduction of the thermal stress generated in the coating during the spraying process.

In this regard, the following technologies can be identified [6-11]:

a) cold spraying methods, for example: CGDM (Cold Gas Dynamic Spray Method) in which the kinetic energy, ie. the speed of the particles is increased while the thermal energy is reduced. Thus, it becomes possible to obtain a nearly oxygen-free coatings;
b) the thermal spray technology with cryogenic cooling presented and patented in the United States of America, that uses a cryogenic liquid as the medium of the cooling system in the thermal spray process.
c) the hybrid method - using equipment in the form of newly constructed cooling nozzles type micro-jet. The nozzles enable the precise and selective cooling of coating with micro-stream of selected gases immediately after spraying. The micro-jet nozzles are patented in Poland.

Hybrid technology is one of the innovative method of thermal spraying. The advantage of this method is the ability to control the spraying structure of coating with a precise and selective cooling of the surface immediately after spraying. The construction of micro-injector gives the possibility of a modification of the classical spraying or welding methods, because it is compatible with these systems. The developed hybrid method with the forced selective cooling is characterized by high intensity of heat transfer by obtaining a very high coefficient of heat exchange between the applied coating and micro-streams of cooling fluid. So far, this method is not completely described in the literature [11].

Therefore, the main aim of this article is to present: the genesis of the hybrid method, its possible applications, advantages and limitations. In the article, the selected results of tested coatings obtained by the innovative method are presented. For the preliminary findings of the process, the compressed air is used as the cooling medium with the micro-injector. It is most comparable to the classical HVOF process. The other gases, like a nitrogen (N_2) and helium (He_2), are used to spray in the hybrid process. The nitrogen gas is used for the research presented in this

article, because this is the main media in the process of thermal spraying and welding with cryogenic cooling process. According to literature data, it is found, that nitrogen gas should protect the coating against excessive oxidation during the process [2,10]. It is characterized by absence of the oxidation potential. The micro-steam of nitrogen gas was produced inside the injector. The installation of micro-jets is connected with a gun to thermal spraying The presented results of selected studies are aimed to demonstrate the possibilities of modern hybrid method in the range of the control structure of the deposited coatings. The obtained structure of coatings is analyzed by optics and scanning electron microscope. The micro-hardness and the thickness of the coating are measured on the TH170 micro-hardness tester and thickness gage. The selected tribological properties of the obtaining coatings are determined. The results of abrasion test on T07 stand and erosion tests under load 200g in ambient and elevated temperature are presented. The made samples are subject to cyclic oxidation tests at 600^0C.

The obtained results allow to conclude, that the coatings are characterized by: the high structure quality (appropriate density, compactness, very low (1%) porosity, uniformity and homogeneity throughout the volume) and good properties of oxidation resistance and a satisfactory erosion and abrasion resistance under the conditions of the laboratory tests.

The presented study confirms that the technology allows to obtain the desired structures, which indicates the correct implementation of the spraying process. Due to the promising possibilities, it can be assumed that the hybrid method has a wide application in industry.

6. References

[1]. B. Wielage, H. Pokhmurska, M. Student, V. Gvozdeckii, T. Stupnyckyj, V. Pokhmurskii (2013), Iron-based coatings arc-sprayed with cored wires for applications at elevated temperatures, *Surf. Coat. Tech*, **220**, 27-35.

[2]. T. Węgrzyn, T. Piwnik, J. Wieszała, D. Hadryś (2012). Control over the steel welding structure parameters by micro-jet cooling, *Arch. Metall. Mater*. **57**, 3, 679-685.

[3]. W. Tarasiuk, B. Szczucka-Lasota, J. Piwnik, W. Majewski (2014). Tribological Properties of Super Field Weld with Micro-Jet Process, *AMR*, **1036**,452-457.

[4]. M. Oksa, E. Turunen, T. Suhonen, T. Varis and S.-P. Hannula(2011). Optimization and Characterization of High Velocity Oxy-fuel Sprayed Coatings: Techniques, Materials, and Applications, *Coatings***,** **1**,1, 17-52; doi:10.3390/coatings1010017.

[5]. K. Szymanski, A. Hernas, G. Moskal, H. Myalska (2014). Thermally sprayed coatings resistant to erosion and corrosion for power plant boilers - a review, Surf. Coat. Tech. doi:10.1016/j.surfcoat.2014.10.046.

[6]. A. Gorlach, Evaluation of the HVAF Thermal Sprayed Coating (2008), R&D *J. SAIMechE*, **24,** 3,4-7

[7]. Z. Zurecki, R. Ghosh, T. Mebrahtu, M. J. Thayer, S.R. Stringer (2008). *Automated substrate cooling system for HVOF coating operations*, in: E. Lugscheider (Ed.) Air Products & Chemicals, Maastricht, Netherlands.

[8]. R. Ghosh (2007), Cryogenic Nitrogen Gas Cooling for Thermal Spray Coatings, *Spraytime*, **14**, 4, 2-4.

[9]. P. Fauchais, A. Vardelle (2012), *Thermal Sprayed Coatings Used Against Corrosion and Corrosive Wear* in: H. Jazi (Ed.), InTech, http://www.intechopen.com/books/advanced-plasma-spray-applications/thermal-sprayed-coatings-usedagainst-corrosion-and-corrosive-wear.

[10]. Węgrzyn, J. Piwnik, B. Łazarz, D. Hadryś (2013). Main micro-jet cooling gases for steel welding, *Arch. Metall. Mater*. **58**, 2, 555-557.

[11]. B. Szczucka-Lasota, K. Szymański, (2016) The selected tribological and structural properties of protective coatings obtained by different methods, *SSP*, **246,** 81-84.