Выбор того или иного метода очистки зависит от концентрации загрязняющих веществ, степени их вредности, а также других факторов и определяется конкретными условиями.

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УДК 621.7

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RESEARCH OF ARC SPRAYING PROCESS VARIABLES

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Thermal spraying processes form a continuous coating by melting the consumable material into droplets and impinging these droplets on the substrate. The mechanism of bonding to surface in thermal sprayings is the same as platings, both mechanical interlocking and atomic interaction, with the shear strength around 7 MPa. The thickness of the coatings may range from 25 μm to 3 mm. In practice, the thermal sprayings are capable of competing with platings and paintings for atmospheric corrosion resistance in water tanks, TV towers, bridges, and other large steel structures.

In arc spraying process electric arc uses wires of opposite polarity to create an electric arc when they come together. This electric arc melts the two wires at their tips and because the two wires are continuously feed they continuously melt. At the point where the two wires meet and are melted the raw material turns into molten droplets. These droplets are then blown towards the substrate by compressed air or an inert gas. Using innovative air flow designs the velocity of the processing gases can reach the speed of sound (Mach 1) and therefore the density of the electric-arc coatings are considered to be superior compared to flame spray coatings. The electric-arc also has an excellent deposition rate and can deposit up to a hundred pounds of material an hour. The electric-arc process is also very inexpensive to operate and is fairly portable. The disadvantage of the electric-arc is the fact that, because an electrically conductive wire must be used, the material selection and thus the coating selection are greatly reduced.

Experimental: Materials and spray guns

Commercially available Tafa's steel (95MXC) cored wire (1.6 mm. diameter) was used for the spray operations in this research. The spray gun was mounted on at ABB 4400 robot arm so that the spray process (Fig. 1), e.g. meander of the gun and spray time, can be controlled precisely. All the spray operations were performed by a Model 9000 TAFA arc spray system (Tafa Inc., Concord, NH), two different spray nozzles were studied to evaluate the effects of different nozzle geometries.

The first nozzle was the standart TAFA 9000 spray nozzle. The second one was the modified Tafa's nozzle. The process parameters remained fixed: voltage — 30 V, arc current — 150A, spraying distance — 15 cm.

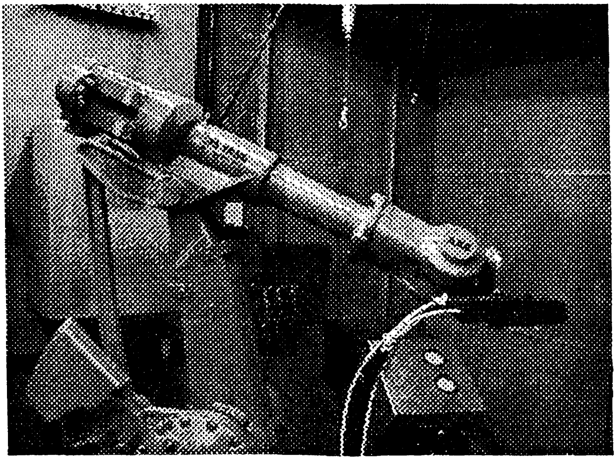

Fig. 1. Arc spray gun on robotic arm

Results and discussions

The sprayed coating is built up particle by particle and, therefore, higher atomizing air pressure results in higher impact velocity of smaller particles on the substrate. Air atomization is commonly used in the wire arc spray process. The major advantages are the availability and economy of compressed air. In the air atomisation wire-arc spray process, the oxide content of the sprayed coating is relatively high due to oxidation of the molten wire material. This higher oxide content can increase the coating hardness so that the abrasion and wear resistance of the coatings is improved. However, the oxide content may also be detrimental to coating properties because oxides may reduce the adhesion strength between coating and substrate. Also, hard oxide particles embedded in sprayed coatings impose problems during machining. Furthermore, coatings sprayed with air atomisation often contain relatively high porosity, which is frequently detrimental. Another disadvantage of air atomisation is related to the burn off of alloying elements contained in parent wires. These elements are essential ingredients to produce the required coating characteristics. As a consequence, coatings with specified characteristics cannot be produced reliably.

Table 1

Sprayed coatings properties

Spray gun nozzle	Air debit (m^3/h)	Particle speed (m/s)	Porosity (%)	Oxides (%)	Adhesion (MPa)
TAFA 9000	90	118	0.77	13.1	52.7; 49.2; 62.0; 53.8
	110	141	0.57	15	>59.4; >63.1; >55.5; 57.2
	130	157	0.37	14.2	>67.1; >68.3; 56.0; 48.8
Modified	90	136	1.23	12.3	>54.0; >64.3; 50.9; 67.0
	110	175	0.63	14.4	>71.0; >68.6; >55.0; >50.5
	130	189	0.31	15	>53.2; >58.9; >51.8; 63.9

The adhesion of the coatings depends upon the interactions between individual lamellae and between lamellae and substrate. The bond strength of a coating is affected by the extent of both physical and chemical interactions between the coating and the substrate material and on the microstructure of the interfacial region. Poor adhesion can be attributed to poor interfacial interlocking, low degree of metallurgical bonding, and high internal stresses. The degradation modes of the coating depend on both the nature of the coating-substrate interface and on the chemical phenomena that occur at the interface during deposition and solidification.

The samples for the tensile test were glued up together to sample holders by the polymer glue FM 1000. For the glue polymerisation the samples that had been assembled were treated by the two — hour heating under the temperature 170 ^{0}C. After the glue final hardening prepared samples were ruptured by standard tensile test procedure. The results of these tests are presented in Table 1.

It sometimes happened during the test that spallation did not take place at the interface coating /substrate but within the coating or in the glue. For instance, when rupture occurred in the glue, the real adhesion of the coating onto its substrate was higher than the recorded value. The « > » sing was then used to point it out.

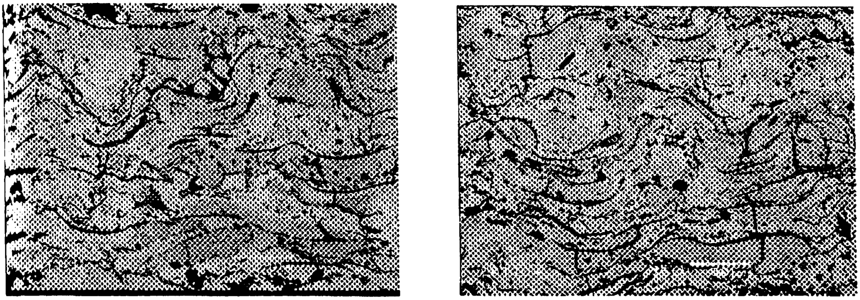
a b

Fig. 2. SEM photographs of micro sections of sprayed coatings: a — standard TAFA 9000 nozzle; b — modified Tafa's nozzle

Sprayed coatings are formed by the impact, deformation, and rapid solidification of individual molten droplets so that coating structure consists of a series of overlapping lamellae. Faster molten particles with higher kinetic energy spread and deform more readily on impact, thus increasing coating density and reducing porosity. The particle velocity and the particle temperature determine the coating structure at the instant of impact on the substrate. Completely molten particles impinging on the substrate spread out radially in the form of thin disks. In reality, however, the deposit is not uniform in thickness, and the periphery of the flattened particle is not circular.

Arc sprayed metal coatings contain a certain amount of oxides (Fig. 2). During spraying, the effect of atomising air and the entrainment of the surrounding air into the spray stream caused significant in flight oxidation of the molten metal particles. Increasing the atomising air pressure leads to higher gas stream velocities, which in turn break up the molten particles into smaller droplets. The smaller droplets react more readily with oxygen than the larger droplets, because of their greater specific surface area. The Table 1 shows that size of particles is evidentely decreasing whereas air debit increases and the temperature of particles variates very insignificantly within possible error range in measurement. That allows stating that the temperature remains constant.

Investigation of coatings microstructure revealed dependence of structure morphology on sprayed particles velocity. The density and dispersity of the lamellar structure increases with the increase of particles velocity. With the increase of particles velocity the size of droplets decrease. Small size droplets have a relatively big surface area; during the flight they are oxidised on bigger degree in comparison with big size droplets, and in these coatings bigger probability of increase of oxide inclusions is possible. On the other hand, the small particles have bigger velocity, shorter fly duration and less time for oxidation reactions. The more particles velocity is, the bigger coating density and less developed porosity is. The optimal selection of spray parameters in matching with the degree of oxidation and adhesion of coating allows reaching the highest strength of adhesion. The optimal coatings were produced when the spray operations were performed by Modified TAFA spray guns with 110 and 130 m^3/h air debits.

Conclusions

1. The spray gun nozzle design has a strong influence on spray geometry, its dynamics characteristics and coating properties. The minor modification of spray gun nozzle design can strongly improve the coating characteristics.
2. The precise estimation of adhesion quality of thin coatings is a difficult task. Sample preparation, sort of glue, heating time to polymerise the glue is of the prime importance to obtain good results of the bond tensile test.
3. In the case of optimal spray process characteristics in several specimens it was difficult to estimate the coatings adhesion strength. This happened when the strength of coating adhesion was bigger than glue bond between sample holder and substrate.

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