DETONATION COATING AND ULTRASOUND MODIFIED SURFACE INTERACTION

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Abstract

In the given work the investigation of the possibility of ultrasound modification of constructional steels surfaces to be sputtered with detonation is carried out. To sputter the coatings the pure metals powders Ni, Cr, Mo and the NiCrBSi system alloy were used. The plant allows to accelerate powder particles up to the speed of 1000m/s. Prepreparation of surfaces to be sputtered after turning level was carried out by several ways. Maximum area of prehension centers between coating and base is formed on the surface after the sand – blasting processing. The area of prehension centers at ultrasound mechanical polishing is somewhat less. Being coated on to the grinded substrate, bonds between coating and substrate do not appear. Peeling of the coating happens immediately in sputtering.

Coating as one of the most effective methods for modified surfaces and forming composite structures, is a prior technology of modern industries aimed to reducing of energy and material sources outlay.

There are different methods of surface coating; detonation spraying is characterized by the impulse process where gas explosion is applied for driving parts of powder at high speed and for heating them (ULIANITSKY 2001). Heat emission at the detonation spraying causes heating of product of detonation and its expansion, thus it flows from the torch under high pressure and carries along tiny parts of coating powder with high speed. Thermal and percussive interaction of powder and surface substrate layer causes attaching of the general mass of the powder and coating layer forming.

In the paper the roughness of substrate layer is considered as a prime factor for bonding strength. Detonation coatings were layered on surfaces processed by different methods such as classical method of sand-blasting, grinding, ultrasonic modification.

For initial preparing of the surface for spraying an original method with ultrasonic installation was applied. The complex installation is intended for obtaining of required roughness of surfaces and improving of wear-resistance of surfaces at machining of products made from metals and alloys by method of ultrasonic plastic deformation. Ultrasonic modification is produced by means of vibration of the intender with frequency 24 kHz that planishes the surface. This processing method causes also strengthening of the surface layer (blanket) at the depth of some hundreds microns. The strengthening is obtained by means of intensive plastic deformation of the surface layer of the metal which is obtained through alternation of compression and shift deformations; those appear as a result of revolving of the detail and travel of the indenter along the surface proceeded (fig.2). As a result of the ultrasonic treatment, the grain structure is reduced to sub-microcrystal one. Ultrasonic modification forms a specific morphology of the surface treated.
For spraying a detonating plant was used, that is designed in the M. A. Lavrentyev Hydrodynamics Institute. As a fuel a mixture of acetylene and oxygen was used. The powder of pure metals such as nickel, chrome and molybdenum were used. The plant races parts of powder to the speed of 1000 m/sec (ULIANITSKY 1991). The spraying was made without moving the example towards to the nozzle of the detonating gun to the “spot” of 250 mm thick. The spraying surface was settled in 100 mm from the nozzle edge. The rates of spraying were chosen to obtain the most complete melting of the powder and provide the high quality of the coating.

Detonation complex plant consists of the gun, manipulator, computing system of control and operation autonomous cooler system and some auxiliary devises; it is intended to spraying wear-resistant, heat resistant and corrosion-resistant coatings to the machine parts. The scheme of the detonation complex plant see on fig. 1.

Technical characteristics of the plant: powder parts velocity 1500 m/sec; fuel – acetylene, propane, butane, hydrogen; oxidizer – oxygen; rapid-firing 6 shots per second, productivity 2 kg/h, coefficient of powder usage 70%, thickness of coating per 1 shot – 10 micron, porosity of the coating less than 1%, adhesion till 150 MPa, electricity consumption not more then 1 kilowatt.

For investigating of roughness and morphology of the basic surface and for the analysis of defects of adhesion of coatings to the surface layer and state of the surface in the damaged places the “MICRO MEASURE 3D station” was used. The roughness of examples is measured by laser scanning the surfaces per layer; that gives pictures (morphology) of the measured area of the surface with the high accuracy caused by discrete motion of the laser ray along the surface of the example examined. Roughness was measures in accordance with State Standards (ГОСТ 2789t73) on the base length of 2.5 mm. Using microscope “Philips SEM 515” the state of surface layer after removing the coating was investigated. With the use of graphic program the area of adhesion of the coating with the blanket was estimated in accordance with adhesion strength prognosis. Micro hardness of the covering and the base surface was measured with “Nano Hardness Testes” with the load on the pyramid 30 and 50 gs. With the use of the optical metallographic microscope Olympus GX-71 pictures of micro sections of the coating and base surface in cross section were obtained.

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![Diagram showing ultrasonic finishing treatment](image)

**Fig. 2.** Scheme of ultrasonic finishing treatment: $P$ – dynamic power; $P_{st}$ – static power, $A$ – motion indenter amplitude, $r$ – indenter sphere radius, $S$ – longitudinal feeding, $S_{V}$ – relative feeding per a period of indicator rippling, $S_{S}$ – longitudinal feeding per a turn, $V$ – revolving velocity, $V_{1}$ – rippling velocity of the indenter, $D$ – diameter of the detail.

Indenter under action of static and dynamics power produced by rippling system plastically deforms the surface layer initially treated by cutting process.

Technical characteristics of the ultrasonic equipment: voltage 220 W, power 0,25 kWt, ultrasonic transformer – magneto striction, working frequency – 22 kHz, transformer air cooler, cooler air consumption 30 m$^3$ at pressure not less then 0,3 MPa, graduated regulation of generator power, 20 power grades.

Effectiveness of joining of coating with base surface was investigated by examining the example blankets after removing the coatings. In all cases surface looks like following: parts of setting of sprayed powder with the base surface layer are characterized by cohesion destruction of the coating altered with adhesion removing of the coating. Ratio of these areas determines the efficiency of setting of coating with base surface (KLIMENOV 2006).

Quantitative estimation of sprayed coatings adhesion was made by estimation of total area of all sites of settings of sprayed powder with basis layer. It is known, the more is the
area of setting of sprayed powder – the higher is adhesion durability of the coating (SHMAKOV 1986).

Fig 3 presents a picture of the base surface after removing chrome and molybdenum coatings, a view obtained from electronic microscope. These coatings were sprayed on the substrate ultrasonically modified. The picture shows that these coating have different areas of adhesion interaction and quantity of parts of setting. Parts kept on the substrate after removing the coating, are indicated with arrows. Fig. 3b presents substrate after removing molybdenum coating. You can see that almost all the surface layer is covered with particles kept after removing the coating.

At removing molybdenum power sprayed coating the area of adhesion interaction appeared to be about 80%, chrome powder coating - about 40%, nickel powder coating – not more than 20% setting.

The difference between areas of adhesion interaction depends on different melting points of coatings formed from these metals. “Hot” particles of molybdenum melt the substrate through and give the most optimal adhesion links, less “hot” chrome and nickel particles do not melt the substrate through, thus the adhesion is less durable.

Fig 4. The picture of basic layer surface after removing of chrome coating a) substrate treated with grinding b) substrate treated with sand-blasting
Fig. 4 shows pictures of basic surface layer after removing chrome coating sprayed on the grinded (4a) and sand-blasted (4b) surface. As the coating is sprayed on the grinded surface, the area of settings is minimal (less than 10%). At this method of treatment of the substrate only large particles of powder interact and form ‘dick-like’ splats with synchronous spread and consolidation (see indicating arrows) (SOLONENKO 2001).

When the surface is sand-blasted, on the contrary, at removing the coating a cohesive destruction takes place, that proves a high adhesive durability of the coating sprayed on the sand-blasted substrate.

Fig. 5 presents a graph of microhardness value distribution of the cross-sections of examples in composition (coating - basic layer) at different methods of initial treatment of surfaces before spraying. Growth of values of microhardness in layers proceeded with ultrasound is caused by increase in powdering and unsoundness of grain structure and also by forming of compression in surface layers (blankets). Pay attention to the smoothing of microhardness’ value jump which takes place at spraying of extremely hard coatings.

Fig. 5. Distribution of microhardness in composition “coating – basic”: 1- after sand-blasting; 2 – after ultrasonic modifying, 3 – after grinding.

At the same time taking into consideration the character of microhardness distribution near the boundary and the favorable influence of the process of structure decomposition and the formation of compressive stress when ultrasound processed on the base strengthening allow to speak about the availability of the application of this kind of processing when obtaining wear proof coatings first of all on the figure of revolution (KLIMENOV 2007).

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**LITERATURE REFERENCES**


