Preparation of metal surfaces for application of functional coatings

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Abstract. This paper proposes an efficient method of plasma purification of metal surfaces before applying coatings or the product finishing treatment. The plasma purification is performed in a steam-gas discharge with an aluminum anode and a liquid cathode.

1. Introduction

During the production process (manufacturing, processing, storage) on the surface of metal parts appear contaminations or foreign substances, whose presence is undesirable or harmful.

The purification of metal surfaces is a process of removing contaminations from the metal surface to a certain level of purity. The purification is produced by various methods - mechanical, physical, chemical, physicochemical and thermochemical.

Mechanical purification of removing contaminations occurs due to their mechanical destruction by rubbing, scraping, milling, under the impact of water jet, solid particles (cast-iron and grit, glass spheres, etc.). The increase in productivity of mechanical purification is achieved by use of mechanized tools (brushes, milling cutters) with electric or pneumatic actuator by increasing of pressure jets to 5-63 MPa. The advantages of the process of mechanical purification are low energy capacity, the versatility, the removing of various contaminations, the simplicity of utilization, the disadvantage is the application of manual labor.

Mechanical physical purification consists in dissolving contaminations in various solvents and its removal from the surface of cleaned product. The intensification of the purification process is achieved by introducing into the zone of purification of ultrasonic oscillations, and also the application of a jet stream dousing and solvent vapors. The advantages of physical purification method are a large purification speed and its high quality, non-waste production, the possibility of the mechanization and the automation of purification processes. At the same time, this method's disadvantage involves the fact that occupational hazard, a difficult of waste disposal, the application for a small group of contaminations.

Physicochemical purification method consists in dissolving contaminations in various solvents and its removal from the surface of cleaned product. The intensification of the purification process is achieved by introducing into the zone of purification of ultrasonic oscillations, and also the application of a jet stream dousing and solvent vapors. The advantages of physical purification method are a large purification speed and its high quality, non-waste production, the possibility of the mechanization and the automation of purification processes. At the same time, this method's disadvantage involves the fact that occupational hazard, a difficult of waste disposal, the application for a small group of contaminations.

Physicochemical purification method consists in dissolving, emulsification, and chemical destruction of contaminations (application of a dissolving-emulsifying means with rinsing in solutions of synthetic detergents). The possibility of increasing the speed and quality of purification consists the movement (vibration, rotation) of the object which cleaning during the purification process. The positive aspect of the physicochemical method is high speed of purification and its high quality, low energy capacity of the purification process, moderate temperature of the authority process (20-500°C), the possibility of
the mechanization and the automation of the process, and negative is the application for a small group of contaminations, occupational hazard and the presence of waste products.

Thermochemical method consists of chemical destruction (combustion) of contaminations in a flame or in an alkaline melt at high temperature (400-4500°C), and also in volumetric and structural changes of contaminations. The improving of purification productivity is possible by optimizing the composition of alkaline melt and the automation of the process. The advantages of this method is high speed of purification and its high quality, and also the ability to automate the process, disadvantages - the application for a small group of contaminations, high energy capacity of the purification process, the deformation and the failure of parts.

2. Experimental studies
This paper proposes an efficient and non-polluting method of the purification of metal surfaces in the steam-gas discharge [1-3]. The discharge area is located in the air space between the liquid electrolyte and the aluminum anode [4]. The plasma stream expires from the discharge area in the surrounding atmosphere. The electrolyte stream circulates inside the cathode unit, thus, creating favorable conditions to reduce of heat losses at the cathode. The cleaning detail used as the cathode.

The structures and the current-voltage characteristics of the discharge between the aluminum anode and the electrolytic cathode under atmospheric pressure at different inter-electrode distances were experimentally studied (Figure 1).

Figure 1. The current-voltage characteristics of the discharge electrode, diameter d = 4.5 mm, the liquid electrolyte- distilled water; ● - L (electrode gap) of 2 mm; ● - L = 4 mm; ▲ - L = 6 mm;

The pictures of the discharge at different regimes were obtained during the experimental research (Figure 2). Multichannel discharge between the aluminum anode and electrolytic cathode has the shape of a truncated cone under atmospheric pressure with sharply defined borders, where threadlike lines chaotically move [5]. With growth of interelectrode distance these lines break up into separate, clearly delineated channels. The lower, larger base is the cathode spot and the top-anodic. As a result of influence of the discharge, the electrolyte evaporates. Its vapors enter the positive pole through the cathode spot. The strength of the vapor several distorts the cathode spot, so the liquid surface is not flat. Its convexity faces the depth of the electrolyte.
Figure 2. Pictures of the discharge, diameter of the electrode d=4.5 mm, the liquid electrode - distilled water; a) U=1150В, I=120mA; b) U=1210В, I=172 mA; c) U=1800V, I=450 mA;

The samples before treatment and after treatment were presented for evaluation the effectiveness of the purification detail (Figure 3) [6].

Figure 3. The samples (st20, the thickness of 0.5mm 100х150 mm) a) before treatment; b) after treatment, diameter of the electrode d=4.5 mm, the liquid electrode - distilled water; L=4 mm, U=1200V, I=150mA;

3. The conclusion

The results of these studies show that the proposed method provides high-performance and high-quality purification of the surfaces from any contaminations – mineral and organic greases, rust, scale, and remnants of the old galvanic and lacquer coating, enamel insulation with an electric wires[7-12].
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