科技報導

SURFACE TREATMENT OF MICRO DISCHARGE OXIDATION (MDO) (微弧放電氧化)

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Surface Treatment at Electrolytic Plasma or Micro Discharge Oxidation (MDO – process) – one of the most perspective kinds of surface treatment, receiving recently more and more broad distribution for obtaining multifunctional coatings, finding application in the most various industries.

The given kind of treatment concerns to electrochemical processes, but its distinctive peculiarity is using of electrical micro-discharges energy in an electrolyte on the surface of the article under treatment to obtain the special properties of coatings. It allows to receive ceramic-like coating with adjustable in a broad band its composition, structure and properties and to use them as wear- and corrosion-resistant, electric-insulating and heat-resistant, and also as decorative coatings.

The surface treatment in electrolytic plasma takes the beginning from conventional anodizing, however it has a number of essential differences, namely: the process is being conducted at voltage on the order above than at anodizing (up to 1000 V); alternating and pulsed currents are used, in main, rather than direct current; weak-alkaline electrolytes are applied, in main, rather than acidic electrolyte.

The MDO - process has received the greatest distribution for treatment of the so-called rectifier metals and their alloys (aluminum, magnesium, titanium, tantalum, niobium, zirconium etc.), i.e. metals, whose oxide films, formed by an electrochemical way, have one-direction conductivity.

The follows possible to relate to characteristics of MDO -process: high temperatures in discharge channels and, as a consequence, formation of high-temperature phases in the coating, for example, firm -Al2O3 - corundum - for aluminum alloys thermal destruction of water with formation of atomic and ionized oxygen; local increase of electrolyte concentration and specific plasma-chemical reactions in the discharge zone; local successive transformations in the discharge of electrochemically formed oxides.

The composition and structure of oxide layers are determined by conditions of their formation. So, for example, the thick coatings on aluminum, formed in a silicate-containing electrolyte, comprises three layers: the thin transition layer - 1; the main working layer which has the maximum hardness and minimum porosity, constituted, in main, by corundum (-Al2O3) - 2; the outer technological layer enriched in aluminosilicates – 3 as indicated in Figs. 1-2.

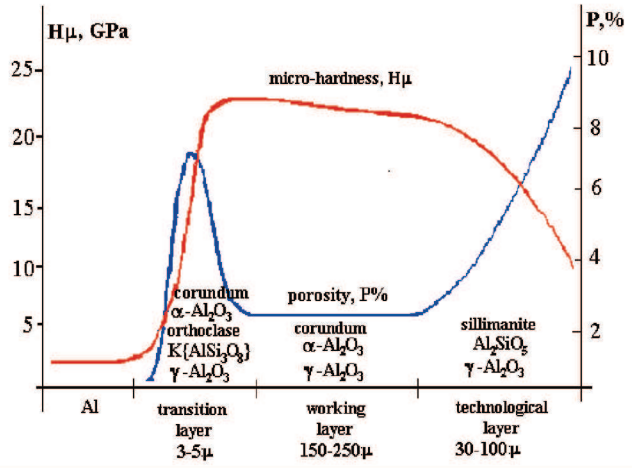

Fig. 1 Micro-hardness and porosity distribution

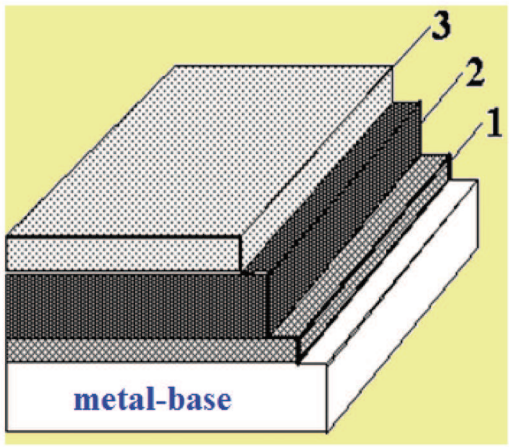

Fig. 2 Structure of oxide layers

The properties of MDO -coatings are determined by their composition and structure, which in turn, depend on the substrate material, the electrolyte bath, time and the electrical modes of processing. For MDO -coatings, received on aluminum alloys, it is possible to result some data:

Parameter	MDO	Anodizing	Thermal Spraying
• thickness, μm	up to 400	up to 150	up to 5000
• roughness Ra, μm	0.1 – 10	0.1 – 15	more 20
•adhesion, kg/mm^2	up to 50	up to 12	up to 30
• microhardness HV, kg/mm^2	up to 2200	up to 750	up to 1800
• breakdown voltage, V	up to 5000	up to 600	up to 4000
• corrosion resistance, mark	9	6	6-7
• volume wear indicator, mm^3·10^{-3}	1.5	more 10	2.0
• thermal shock resistance, ^{0}C	up to 2500	up to 800	up to 2000
• porosity, %	2 – 50% (controllable)	2 – 45% (limited controllable)	more 30
• ecological compatibility	+	–	±

Peculiarities and Advantages of MDO -Technology in comparison with anodizing.

Peculiarities	Advantages
Ecologically purity and non-hostility of electrolytes.	There is no wastes, requiring salvaging. Production safety.
Simple surface preparation, if necessary - usual degreasing.	Absence of surface special preliminary preparation necessity, as at anodizing.
Simple and convenient equipment, made in view of wishes of the customer.	It is not required too high qualification of the personnel. Full automation of technological process is possible.
Compactness of the equipment.	Occupies little working area at the factory.
Capability of thick coatings (up to 300-400 microns) obtaining without high cooling of an electrolyte.	Application of complex (and harmful because of freon) refrigerating equipment is not demanded.
High coatings hardness (up to 2000-2500 kg/mm^2).	Unique wear resistance under conditions of abrasive wear and erosion.
Consistent, easily reproducible process.	Simplicity of control and use. Stable characteristics of coatings.

The simplicity of MDO -technology is that it includes only some technological operations: Cleaning before coating (degreasing), the MDO -process, swilling after coating and drying, and the capital equipment consists only of three items: electrolyte bath for coating, power source and bath for swilling in a water.

Salt Spray Test of MDO-Treated Mg Alloy and Mg Metal Matrix Composites (Mg MMCs)

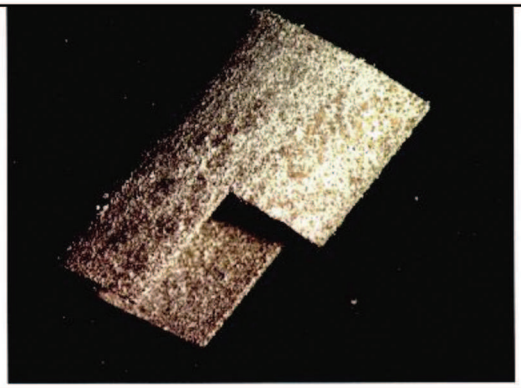

Fig. 3. Changes caused by corrosion in external and internal surfaces of Mg alloy raw material

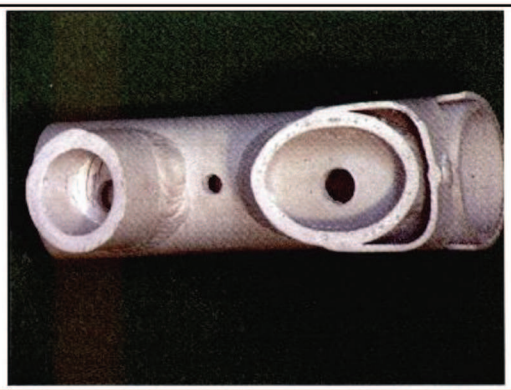

Fig. 4. Changes caused by corrosion in external and internal surfaces of MDO-treated Mg alloy supporting fork in bike frame

Fig. 3. Changes caused by corrosion in external and internal surfaces of Mg alloy raw material

(a)

(b)

Fig. 5. Salt spray test of AZ61 Mg MMCs tube after (a) 24 hrs (b)240 hrs

Fig. 4. Changes caused by corrosion in external and internal surfaces of MDO-treated Mg alloy supporting fork in bike frame

(a)

(b)

Fig. 6. Salt spray test of MDO-treated AZ61 Mg MMCs tube after (a) 336 hrs (b)1008 hrs

Application Areas of MDO -Coatings.

Numerous tests of articles with MDO -coatings, working in the various operation conditions, have shown its high protective ability that enables to find their wide use in various branches:

Particular Examples of MDO -coatings Application.

Machine building—rotors of turbo-molecular pumps, foundry molds and cores, mandrels (cores) - for forming articles from a fiberglass.

• Engine building—elements of cylinder-piston group.

• Tools industry—gauges and laps, lapping disks for dressing the hard-alloy tools.

• Aerospace industry—nozzle, blades of turbines, plating (sheets of the skin), parts of pumps, panels and components of devices, chassis (landing gear) of airplanes.

• Electric and electronic industry—anti-diffusion layers of heating systems, dielectric layers of heat withdrawals of microcircuits, absorbers of heat sinks, anodes of electrolytic capacitors.

• Oil and gas industry—plungers and face seals of pumps, gates of dampers, casings, catalysts for oxide catalysis.

• Construction—panel for decorative styling, primer for the subsequent applying a varnish, lacquer, paint and etc.

• Textile industry—rollers for rayon fabrication, spindles for twist of a natural fibers.

• Communal water supply—detail of water pumps and valve gates.

• Medical industry—non-rejection action-ceramics for implants, fine filters.

• Food-processing industry—porous filters and membranes, parts of grinders-disintegrators of food products.

• Production of the consumer goods bottoms of irons, knitting needles, body of bicycle pumps, accessories, aluminum crockery.

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