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Fabrication of an electrode insulation layer for electrochemical machining by using hot dip aluminizing and micro-arc oxidation method

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Abstract

In electrochemical machining, the machining accuracy will be affected by stray current. The most effective improvement is to coat the insulation layer on the electrode sidewall so that current can only be accurately released from the desired area. In this study, the tungsten carbide tool coated by aluminum is performed by the hot dip aluminizing process. Thereafter, which were oxidized by the micro-arc oxidized process to form an aluminum oxide insulating layer to improve extend the life of the electrodes and accurate shape. The electrode is tested in sodium chloride solution and expected to develop a long-life precision electrode with insulation layer for electrochemical machining, reducing the stray electrochemical machining effects to achieve the improving the shape precision of the mold cavity.

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*Keywords:*hot dip aluminizing, aluminum oxide, micro-arc oxdiation, insultion, electrochemical maching

1. Introduction

The machining accuracy will be affected by stray current in precision electrochemical machining. The most effective way to improve is to coat the insulation layer on the electrode surface, so that current can only be accurately released from the desired area. Currently the precision and durable insulation on electrode for micro-structure machining still needs further study, the main factor is due to the gap of tens of microns only between the two poles in the micro electrochemical machining. The presence of a variety of physical and chemical impact effects, such as pulse voltage, resistance thermal, action thermal, high-pressure intense flush, etc., all will result in the destruction and peel of the insulation layer. So how in this harsh environment to strengthen the bonding force, insulation density and corrosion resistance, and extend the life of the electrodes and achieve accurate shape precision machining.

The micro arc oxidation (MAO), also called plasma electrolytic oxidation (PEO), is a novel surface engineering technique that can be used to form metallurgically bonded ceramics on some non-ferrous metals, widely employed for the surface modification of Ti, Al, Mg, etc. and its alloys to improve their wear, corrosion and thermal properties [1-4]. The MAO process is based on anodizing process with a high applied voltage and plasma discharge channels. The excellent adhesion of coating to the substrate, environmentally friendly processing, and ease of controlling.

This study is made a dense oxide insulation layer on the electrode in the production of aluminum micro-arc oxidation for electrochemical machining. Firstly this study adopted hot dip aluminizing method to explore the influence of the insulation layer coated as electrode substrate, then to promote aluminum into alumina insulation layer in micro-arc oxidation. The electrode tolerable voltage is tested in sodium chloride solution, and the cross-section and surface is observed in order to understand its characteristics changes. Finally DC and pulsed power is applied in different metal processing conditions requirements to know the processing performance and electrode life. This project expect to develop a long-life precision electrode insulation layer for electrochemical machining, reducing the stray electrochemical machining effects to achieve the improving the shape precision of the mold cavity.

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2. Process and test methods.

2.1. Experimental materials

The micro tool is made by sintering tungsten carbide (WC). The cobalt as the bonding metal (WC-Co) is used in the experiment. The original electrode dimension is 200 μm. Permutation the electro of the aluminum immersion plate in the order of cleaning with acetone, alkaline wash with 10 wt.% NaOH, acid pickling with 15 wt.% H_3PO_4, neutralize with 5 wt.% NaOH and undergo the seasoning treatment follow by the hot dip coating.

2.*2 Hot Dip Aluminizing process*

Aluminum is acted as solution in hot dip aluminum process, is poured into alumina crucible. Hot dip furnace is shown in Figure 1, and heated up to 750 ℃ to molten, but the air in contact with the aluminum surface of the molten liquid will form an oxide layer. The oxide layer will cause poor between electrode and molten aluminum during hot dip aluminizing processing. Before entering the aluminum piece molten, the oxide layer needs to be removed. Therefore, there are two parts for remove the oxide layer: (1) A layer of wet flux coating with the specimen surface to dry (ratio 10: 1 for flux and water). (2) Adding dry flux to remove the oxide layer on the molten aluminum surface. After the flux treatment, it can run hot dip aluminizing process. The parameter temperature of 750 ℃, dipping time of 1-5 minutes and the speed of rising and falling is 15 cm / min.

2.3 Micro-Arc Oxidation process

Micro-arc oxidation equipment includes power supply, stainless electrolytic tank, cooling systems. Before Micro arc oxidation, it is undergone a surface treatment. After been cleaned ultrasonically in deionized water for 10 min, they are rinsed in acetone, and dried immediately in flowing air. The electrode is perpendicularly put into the center of the stainless electrolytic bath and is steeped in the 150×150×150 mm receptacle. The process is shown in Figure 2. The process is undergone after placing the electrode. The controlling parameters of micro-arc oxidation are constant current, constant voltage and different oxidation time. The micro-arc parameters are voltage of 400 V and the oxidation time of 5~25 minutes. The micro-arc parameters are shown in table 1.

Table 1 Micro-arc process parameters.

Parameter	Value
Electrode	Tungsten carbide tool
Processing time(min)	5, 10, 15, 20, 25
Electrolyte concentration	10 g/L $Na_2Al_2O_4$ +1 g/L KOH
Electrolyte temperature(℃)	5
Power supply voltage(V)	350, 375, 400,425, 450

2.4 Voltage tolerable capability

The current is energized to achieve the electrochemical machining effect, so the insulating layer of the cathode tool needs to be tolerable to voltage during the process from collapsing. Therefore, electrolysis reaction is used to achieve the effect in this study. By operating electrolytic method, the resistance voltage of insulated electrode can be successfully determined, shown as figure 3. The stainless steel is adopted as anode and MAO oxidize layer electrode as cathode. The electrolyte is sodium chloride aqueous solution of 15 wt.%. Energizing it with constant-voltage continuously until the cathode becomes boiling and the drop off. The first step for the testing of voltage tolerable period is to find out the breakthrough voltage of the insulation layer. Continue energizing the current but lower 0.2 V until it boils then calculate the time. In order to examine the voltage easily by tilting the oxidize layer during electrolysis, which will benefit the observation of the bubbles during the breakthrough on the insulation layer.

Figure 1 Hot dip furnace.

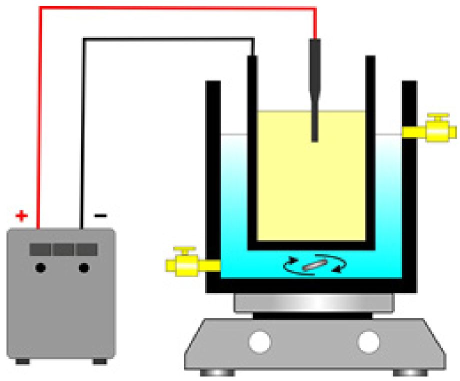

Figure 2 Schematic diagram of the MAO process.