Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 52(3) (2018) 1-3
DOI:

A Comparative Study on the Effect of Ultrasonic Vibration on Aluminum Surface Properties in Electrical Discharge Alloying

H. Eivazi bagheri[1], H. Gorji [1*] , M. R. Shabgard[2], S. Nourouzi [2]

[1] Department of Mechanical Engineering, Noshirvani University of Technology, Babol, Iran
[2] Department of Mechanical Engineering, University of Tabriz, Tabriz, Iran

ABSTRACT: In this paper, considering the importance of surface integrity, effect of ultrasonic vibration of the Monel 400 electrode with a frequency of 20 kHz on the output parameters of the aluminum surface properties (surface hardness and wear resistance, thickness of the surface layer, the depth of copper and nickel diffusion to the aluminum surface and surface roughness) by the method of electrical discharge surface alloying has been studied. Based on the results of the scanning electron microscope images, the surface layer thickness in the combination of ultrasonic vibration with the electrical discharge alloying process is more than the non-vibration mode. Therefore, increasing the thickness of this layer increases the surface wear resistance. Also, the micro hardness test results show that surface hardness of the aluminum has increased to 450 Vickers after the combination of ultrasonic vibration with the alloying process. According to the results of energy dispersive X-ray analysis, the diffusion depth of alloying elements (copper and nickel) is higher in ultrasonic electrical discharge alloying, So that the surface layer thickness is up to 50 microns. Also, based on the results of surface roughness measuring, ultrasonic vibrations reduce the aluminum surface roughness after surface alloying.

Review History:

Received:
Revised:
Accepted:
Available Online:

Keywords:

Surface alloying
Electrical discharge
Ultrasonic vibration
Aluminum, Monel 400

1- Introduction

The advancement of technology has made the need for metal materials with better surface properties. Therefore with the development of materials science, materials with new structures and special functions have been considered by researchers. Aluminum alloys due to their unique properties such as high strength to weight ratio, good weld ability, excellent formability, fairly well corrosion resistance, are used in a variety of structures, aerospace and marine industries, electronic equipments , etc [1,2]. Compared with other metals such as steel, the most noticeable weaknesses of aluminum are low hardness, low wear resistance. Therefore, considering the low physical and mechanical properties, the ability to use aluminum alloys despite the stated benefits also has some limitations. But a significant characteristic of aluminum is the formation of intermetallic compounds with other elements such as Fe, Ni, Co, Cr, Ti and Cu. Therefore, in recent research, the creation of intermetallic aluminum compounds with these elements is interest [3-6].

Although, the method of electrical discharge is a material removal process, but tried to use this method for surface operations. Research results show that the surface layer after a machining operation is a high-speed cooled, which the depth of this layer depends on the energy and the pulses of duration. Below this layer, there is a layer affected by machining, with its chemical composition has been changed and phase changes can be seen. Therefore, the composition of the recast layer by materials in the dielectric or electrodes is an effective way to improve the surface quality. Electrical Discharge Alloying (EDA) is performed by selecting suitable materials with the aim of increasing the surface hardness, increasing wear resistance, increasing the corrosion resistance [7, 8].

*Corresponding author's email: hamidgorji@nit.ac.ir

2- Methodology

In experiments, aluminum was selected as workpiece materials with the purity of 99.98% and the tool material was selected of Monel 400. In order to prepare the aluminum specimens, the cutting, turning and grinding were carried out on the raw material and 32 cylindrical aluminum with the dimensions of 12×14mm^2. Also, in order to prepare 32 cylindrical electrodes, cutting, machining and grinding were done on Monel 400. Fig. 1 shows the aluminum workpiece and the Monel electrode.

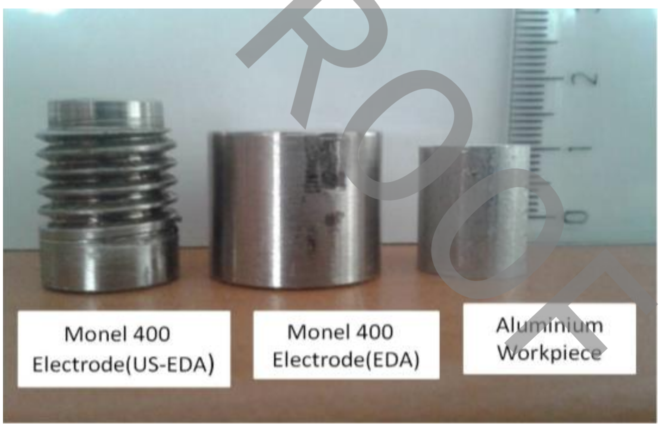
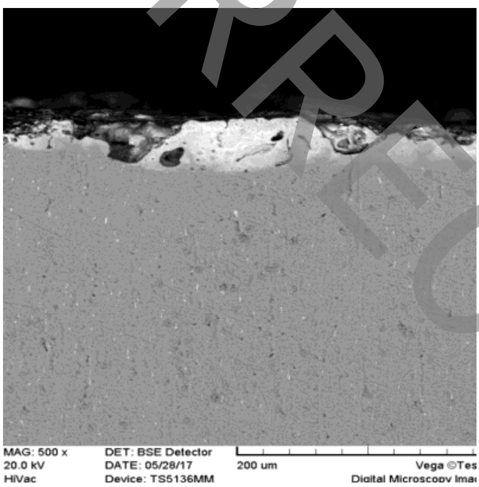


Fig. 1. Monel electrode and aluminum workpiece

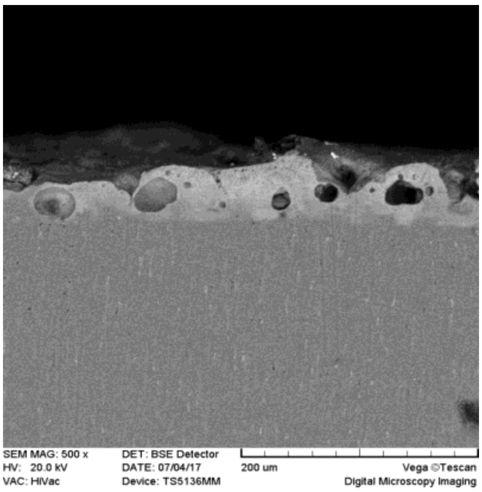
Table 1. Experimental test conditions

Parameters	Conditions
Dielectric fluid	Kerosene oil
Pulse on-time, µs	50,100,200,400
Voltage, V	160
Pulse current, A	12,16,24,32
Pulse of time, µs	800
Tool Polarity	Negative

All samples were machined by the use of die sinking Electrical Discharge Machining (EDM) machine (CNC-Charmilles Roboform 200) with an iso-pulse generator. Each test was performed for 20 minutes. In order to create the same conditions for flushing during all experiments, the normal submerged flushing method was used. Table 1 provides input parameters and test conditions.



(a)



(b)

Fig. 2. Scanning electron microscope micrograph showing cross-section of EDA-ed workpiece
a) Without ultrasonic vibration, b) With ultrasonic vibration

3- Results and Discussion

3-1- The effect of ultrasonic vibration on the surface layer thickness

Fig. 2 shows the created layers after the surface alloying through EDA process. According to this Fig., with adding ultrasonic vibration, the average thickness of the alloyed layer increases.

3-2- The effect of ultrasonic vibration on the surface hardness

Fig. 3 shows the effect of ultrasonic vibration, on the aluminum surface hardness. According to these Fig., the aluminum surface hardness in the combined mode of the electric discharge and ultrasonic vibration is 30% higher than the average value.

3-3- The effect of ultrasonic vibration on the surface wear resistance

Fig. 4 shows the effect of ultrasonic vibration, on the aluminum surface wear resistance. As it is seen, with improvement of surface properties by electric discharge method, the weight loss of the aluminum sample is much lower compared to the base metal, and the application of ultrasonic vibrations improves the surface wear resistance.

4- Conclusions

1. Ultrasonic vibration with increasing material removal rate from the Monel 400 electrode increases the diffusion depth of copper and nickel to the aluminum surface.

2. Aluminum surface hardness is higher in ultrasonic

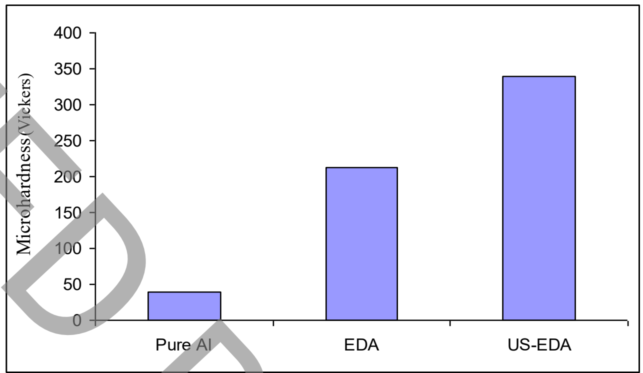


Fig. 3. Effects of ultrasonic vibrations on surface hardness

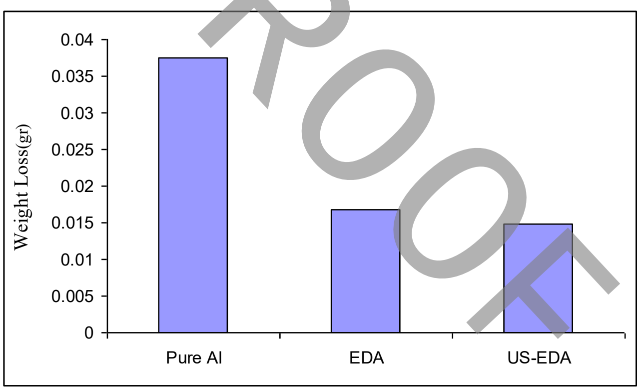


Fig. 4. Effects of ultrasonic vibrations on surface wear resistance

vibration mode, in which case the hardness of the surface has reached more than 450 V.

3. Ultrasonic vibration of the Monel electrode reduces the surface roughness of the aluminum in EDA process.

4. In using the US-EDA method, the surface wear resistance of the aluminum is more than EDA method.

References

[1] Fazel1, M., Garsivaz jazi1, M. R., Bahramzadeh, S., Bakhshi, S., 2014. "Influence of Gr and MoS2 Particles on High Temperature Tribological Properties of Ni-SiC Composite Coating". *Journal of Advance Materials Engineering (Esteghlal)*, 34(1), pp. 105-121(in persian).

[2] Azimi Abarghoui, S., Saatchi, A., Ebrahimi Kahrizsangi, R., 2013. "A New Method to Investigate Localized Corrosion on 2024, 7075 and 6061 Aluminium Alloys in the Sea-Like Atmosphere Environments". *New Material*, 4(13), pp.69-82(in persian).

[3] Alwafi, Y., Bidin, N., Hussin, R., Shkhawat, M., Gustiono, D., 2011. "Michrohardness Evaluation of Pure Aluminum Substrate after Laser Surface Alloying with Iron and Copper". *Journal of Materials Scince Engineering*, B(1), pp. 200-205.

[4] Popoola, A., Pityana, S., Fedotova, T., Popoola O., 2011. "Quantitative study of the hardness property of laser surface alloyed aluminium AA1200". *Journal of the Southern African Institute of Mining and Metallurgy*, 111, pp.335-344.

[5] Rambau, T. G., Popoola, A. P., Loto, C.A., Mathebula, T., Theron, M., 2013. "Tribological and Corrosion Characterization of Al/(Stellite-6+Zirconium) Laser Alloyed Composites". *International Journal of Electrochemical Science*, 8, pp. 5515-552.

[6] Jiru, W., Sankar, M. R., Dixit, U. S., 2015. "Surface Alloying of Aluminum with Copper using Co_2 Laser". *Laser based Manufacturing*, pp.107-116.

[7] Kumar, S., Singh, R., Singh, T. P., Sethi, B. L., 2009. "Surface modification by electrical discharge machining: A review". *Journal of Materials Processing Technology*, 209(8), pp. 3675-3687.

[8] Bleys, Ph., Kruth, J. P., Lauwers, B., Schacht, B., 2006. "Surface and sub-surface quality of steel after EDM". *Advanced Engineering Materials*, 8 (1), pp.15-25.