*i*Journals: International Journal of Social Relevance & Concern (IJSRC)
ISSN-2347-9698
Volume 9 Issue 4 April 2021

Experimental Investigation of Aluminum Electrode on Surface Roughness in Electrical Discharge Machining of Titanium

Vuong Thi Nhu Yen[1]; Phan Thanh Chuong[1]; Le Thi Phuong Thanh[2]

Technical-economics college, Thai Nguyen, Vietnam[1]; 2Hanoi University of Industry, No. 298, Cau Dien Street, Bac Tu Liem District, Hanoi [2]

E-mail: thanhchuong.com@gmail.com [3]

ABSTRACT

In the paper, the surface roughness of the EDM machined surface with aluminum electrodes was evaluated. Aluminum (Al) electrode has been used for the study on machining Titanium (Ti). Current (I), voltage (Vg) and pulse on time (Ton) have been used as technology parameters under Taguchi method with regression model and optimal technology parameters. It was found as I and Vg are the parameters could strongly affect surface quality. The optimal technological parameters with coated and uncoated electrodes were found as I = 10 A, Ton = 500 µs and Vg = 40 V.

Keywords: EDM, taguchi, electrode.

1. INTRODUCTION

Titanium and its alloys are widely used in various fields including aerospace, nuclear, medical, etc.It is highly difficult to process such materials with traditional machining methods due to the higher strength.Electrical discharge machining (EDM) is commonly used to process this group of materials.In EDM, the machining surface quality and the machining productivity is not high [1]. Many technical solutions have been implemented to improve the machining efficiency of EDM including optimization of technological parameters, new electrode material or electrode surface layer and vibration in EDM.It has shown that the utilization of coated electrodes EDM is a great promising solution to improve machining productivity and quality.It can reduce the wear of tool electrode and production costs. However, research works on EDM using new electrode materials are mainly focused with powder metallurgical electrodes. The usage of the coating electrodes are still very little.In addition, the physical and mechanical properties of the material layer of the electrode surface will directly affect the spark formation process to enhance the machining productivity and quality.Hence it is necessary to clarify the effectiveness of using coated electrodes in EDM process.

A lot of research results were performed to evaluate the machinability of the electrode in EDM [2]. Many types of electrode materials (Al, Cu, Cu-W and brass) have been investigated in tool steel machiningby EDM [3]. The Cu-W could produce lowersurface roughness (Ra) in EDM [4]. The machining capacity with Cu-W electrode is also higher than Cu and brasselectrodes [5]. It was inferred that the formation of larger residual tensile stress in EDM process with conventional electrodes [6].The electrode material used in EDM will affect the structure of the white layer on the machined surface layer consisting of austenite and residual stress [7,8]. The different electrode materials are used in EDM to modify the surface

quality [9].The Ra and morphology of the machining surface are strongly influenced by the change of electrode material in EDM [10]. Recent studies have used powder metallurgical electrodes in EDM to improve machining efficiency with improved surface quality [11].The TiC composite electrode can produce better surface than Cu-W electrode [12]. The powder metallurgical electrode can produce alloy layer with better surface quality and hardness[13]. The composite electrodes in EDM can be fabricated with 3D printing [14]. However, it should be required that the composition of the composite mixture of the electrode material should be correct since it will directly affect the surface quality and machinability in EDM [15].

The surface roughness in EDM is an indicator directly related to the choice of the further finishing method and its machining cost. Hence a research attempt is very necessaryto improve surface quality in EDM.The number of studies regarding coating electrodes and the coating materials used are still very limited. In this study, the effect of technological parameters on Ra in EDM using uncoated and AlCrNi coatedAl electrode.The regression model development in Taguchi has identified the regression equation of the Ra.The efficiency of the coating electrode to improve the SR and the quality of the machining surface at the optimum condition are also analyzed.

2. EXPERIMENTAL METHODOLOGY

The machining experiments were performed on CNC type Electro Discharge Machine manufactured by Electronics India Private Limitedfor machining Ti. The process variables were chosen based on low, medium and high level of process parameter available at machine. All experiments were systematically planned with four level based on Taguchi method. The levels of process parameters in this study described in the Table 1. Since the work deals with three factors and four levels, L16 orthogonal array (OA) was selected in the present study to evaluate quality measure of Ra. Surface roughness of machined workpiece surface was measured by contact type surface roughness tester (Taylor Hobson machine) with the cutoff length of 0.8mm.

Table 1. Experimental results from the present study

Input process parameters			Surface roughness	S/N of Ra
Current	T_{on}	Gap Voltage		
10	100	40	6.664	-16.4747
10	500	45	6.683	-16.4994
10	1000	50	6.691	-16.5098
10	1500	55	6.815	-16.6693
20	500	40	7.781	-17.8207
20	100	45	8.325	-18.4077
20	1500	50	8.662	-18.7524
20	1000	55	8.981	-19.0665
30	1000	40	9.116	-19.1961
30	1500	45	9.203	-19.2786
30	100	50	9.412	-19.4736
30	500	55	9.665	-19.7040
40	1500	40	9.706	-19.7408
40	1000	45	9.783	-19.8094
40	500	50	10.112	-20.0967
40	100	55	10.391	-20.3331

3. RESULTS AND DISCUSSION

3.1 Analysis of variance (ANOVA)

The ANOVA analysis of Ra results to find influence of parameters on quality indicators in EDM is shown in Table 2 and Figure 2. I (F = 161.13) and Vg (F = 6.19) had a significant effect on Ra in EDM with Al electrode, and Ton (F = 0.28) had a negligible effect on Ra. Based on the values of the fisher coefficient (F), I is the most significant effect (F is largest), followed by Vg and Ton (F is minimum), respectively. The percentage distribution of the influence of the technological parameters on Ra for both types of

electrode materials is quite similar. The percentage of distribution of the influence of I is the largest (95%), it's of Vg (3.65%) and Ton is very small (0.16%).

Table 2. ANOVA of R_a using Aluminum electrode and AlCrNi coated electrode

Source	DF	SS	MS	F-Value	P-Value	Contribution%
I	3	24.3974	8.13246	161.13	0	95
V_g	3	0.9366	0.3122	6.19	0.029	3.64
T_{on}	3	0.0426	0.0142	0.28	0.837	0.16
Error	6	0.3028	0.05047	-	-	0.01
Total	15	25.6794	-	-	-	-

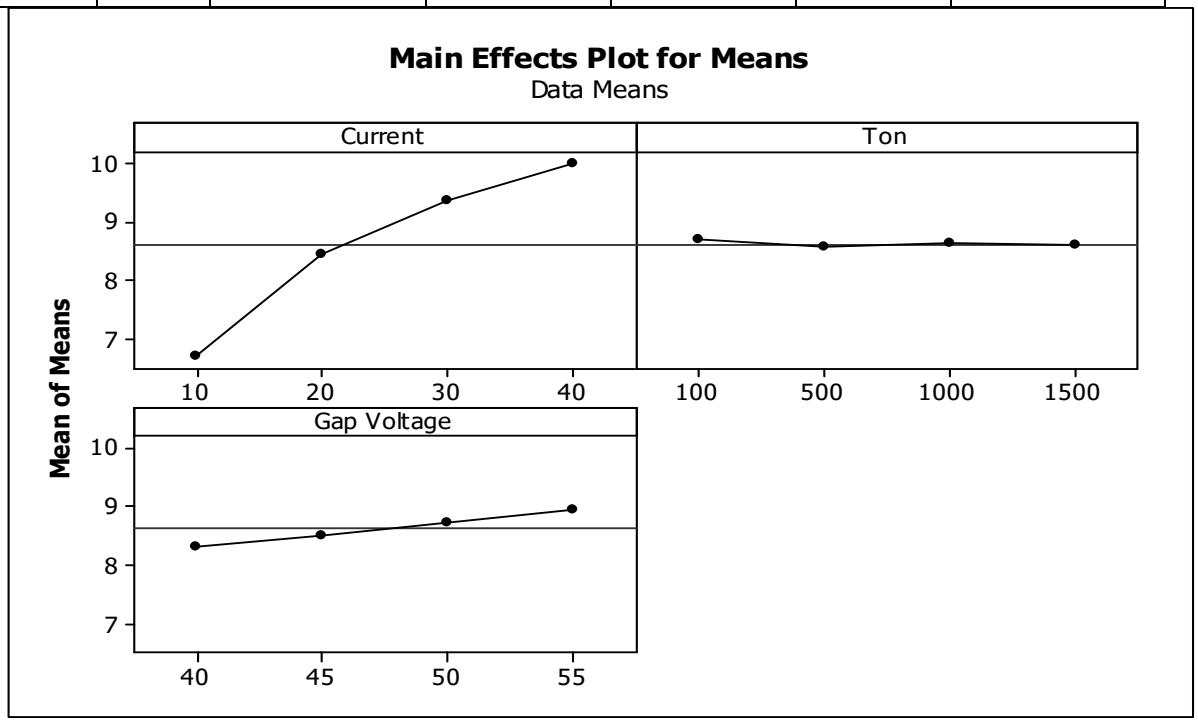

Fig 1: Main effects plot for Ra

3.2 Determination of the optimal technology parameters

The S / N coefficient is used to determine the optimal technology parameters. The S / N of the Ra is determined by "smaller is better" as shown in Fig. 3. It has been shown that the optimum technological parameters in EDM using Al electrode is the identical as o I = 10 A, Ton = 500 µs and Vg = 40 V. The optimal values for both Ra could be determined as follows Ra = 6.698 µm. A confirmation experiment at optimum conditions was performed and found as Ra = 6.476 µm. It was inferred that the error between the calculated method and experimental error was 7.2%.

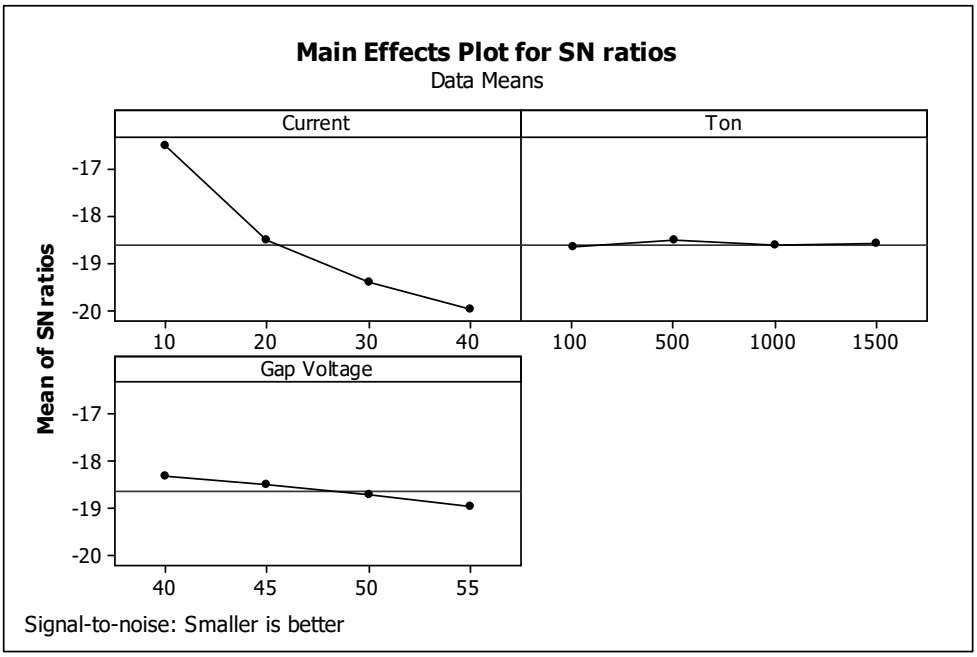

Fig 3: S / N ratio analysis of R_a

.

4. CONCLUSIONS:

In the present study, Ra of the EDM machined surface with Al electrodes was evaluated. Al electrode has been used for the study on machining Ti by EDM. From the detailed investigation, the following conclusions were drawn.

- The optimal technological parameters was found as I = 10 A, Ton = 500 µs and Vg = 40 V.
- I and Vg are the parameters could strongly affect surface quality.
- The comparison between calcular and the testing experiment shows good accuracy of 7.2%. Ra at optimum conditions as Ra = 6.476 µm.
- This has opened up research direction that can bring higher economic efficiency than powder metallurgical electrodes. At the same time, more clear research results are needed to comprehensively evaluate the economic and technical efficiency between coated and uncoated electrodes in EDM, which will contribute to developing this application into practice.

5. REFERENCES

[1]. Eng. Mona, A. Younis, Effect of Electrode Material on Electrical Discharge Machining of DIN 1.2379 and DIN 1.2080 Surface, J Material Sci Eng 1:111. doi:10.4172/2169-0022.1000111.

[2]. Fred L. Amorim, Walter L. Weingaertner, The Behavior of Graphite and Copper Electrodes on the Finish Die-Sinking Electrical Discharge Machining (EDM) of AISI P20 Tool Steel, J. of the Braz. Soc. of Mech. Sci. & Eng, 2007, Vol. XXIX, No. 4 / 366-371.

[3]. Naveen Beri, S. Maheshwari, C. Sharma, Anil Kumar, Performance Evaluation of Powder Metallurgy Electrode in Electrical Discharge Machining of AISI D2 Steel Using Taguchi Method, World Academy of Science, Engineering and Technology, International Journal of Mechanical and Mechatronics Engineering, Vol:2, No:2, 2008.

[4]. Rahul Mahajan, Hare Krishna, Ankit Kumar Singh, Ranjan Kr Ghadai, A Review on Copper

and its alloys used as electrode in EDM, IOP Conf. Series: Materials Science and Engineering 377 (2018) 012183 doi:10.1088/1757-899X/377/1/012183.

[5]. Jaber E. Abu Qudeiri, Aiman Zaiout, Abdel-Hamid I. Mourad, Mustufa Haider AbidI, Ahmed Elkaseer, Principles and Characteristics of Different EDM Processes in Machining Tool and Die Steels, Appl. Sci. 2020, 10, 2082; doi:10.3390/app10062082.

[6]. S. Dewangan , C. K. Biswas & S. Gangopadhyay (2014) Influence of Different Tool Electrode Materials on EDMed Surface Integrity of AISI P20 Tool Steel, Materials and Manufacturing Processes, 29:11-12, 1387-1394, DOI:10.1080/10426914.2014.930892.

[7]. Ranjith R., Tamilselvam P., Prakash T. & Chinnasamy C. (2019) Examinations concerning the electric discharge machining of AZ91/5B4CP composites utilizing distinctive electrode materials, Materials and Manufacturing Processes, 34:10, 1120-1128, DOI:10.1080/10426914.2019.1628258.

[8]. G.Sen, S.C.Mondal, Investigation of the effect of copper, brass and graphite electrode on electrical discharge machining of mild steel grade IS2062, 2nd International Conference on Mechanical Materials and Renewable Energy (ICMMRE 2019), AIP Conf. Proc. 2273, 050054-1–050054-7; https://doi.org/10.1063/5.0024672.

[9]. M.A. Moudood, A. Sabur, A. Lutfi, M.Y. Ali, I.H. Jaafar, Investigation of the machinability of non-conductive ZrO2 with different tool electrodes in EDM, International Journal of Automotive and Mechanical Engineering (IJAME), Volume 10, pp. 1866-1876, 2014.

[10]. M.P. Jahan, Y.S. Wong, M. Rahman, A study on the fine-finish die-sinking micro-EDM of tungsten carbide using different electrode materials, journal of materials processing technology 209 (2009) 3956–3967.

[11]. Shankar Singh, S. Maheshwari, P.C. Pandey, Some investigations into the electric discharge machining of hardened tool steel using different electrode materials, Journal of Materials Processing Technology 149 (2004) 272–277.

[12]. S.K. Ho, D.K. Aspinwall, W. Voice, Use of powder metallurgy (PM) compacted electrodes for electrical discharge surface alloying/modification of Ti–6Al–4V alloy, Journal of Materials Processing Technology 191 (2007) 123–126.

[13]. Abhinav Shard, Deepshikha, Vishal Gupta, M P Garg, Material Removal Rate during Powder Metallurgy Cu-Ti Electrodes in Electrical Discharge Machining of EN9 Steel, 3rd International Conference on Condensed Matter and Applied Physics (ICC-2019). AIP Conf. Proc. 2220, 060016-1–060016-5; https://doi.org/10.1063/5.0001826.

[14]. R.S. Pawar, S.B. Sharma, Development of EDM Electrode by Powder Metallurgy Process, Trends in Mechanical Engineering & Technology, Volume 3, Issue 2, (2013) 10-15.

[15]. Li Li, Y.S.Wong, J.Y.H. Fuh, L. Lu, EDM performance of TiCcopper-based sintered electrodes, Materials and Design 22 2001 669-678.

