International Journal of Management, IT & Engineering
Vol. 9 Issue 9, September 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Influence of Process Variables in Wire Cut Electric Discharge Machining on Surface Roughness of Al2285-MgO Composites

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ABSTRACT: This paperpresents the influence of process variables in wire cut electrical discharge machining process ofAluminum 2285-MgO composite material. Electro-discharge machining process can be controlled by variables likepulse on time (T_{ON}), pulse off time (T_{OFF}), servo voltage, wire speed, discharge current and servo feed have been investigated to reveal their impact on machining of aluminum 2285-MgO composite.Surface Roughness is an important parameter to characterize the machining efficiency. The pulse on time, pulse off time, and servo voltage were varied to study the effect of variation in surface roughness of composite material. The optimal set of process parameters has been predicted to obtain thegood surface roughness.

Keywords: WEDM, T_{ON}, T_{OFF}, SV, WF, SR, EDM, Ra

1. Introduction

Electric discharge machining is mostly used to machine high temperature resistant alloys materials and is hard tomachinebyconventional machining process. EDM can be utilized to machine complex geometries.Ashish Shrivatsa et al., [1] made an investigation on composite of Al2024 reinforced with SiC to study the effect of electric discharge machining for three levels of each parameters such as current,pulse on time and reinforcement percentage on surface finish and MRR.Surface finish and Metal Removal Rate (MRR) is one of the most prime requirements of customer and it is also a significant tool to

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reduce the cycle time of any machine operation as well as the overall cost of the production. Surface roughness increases with the increase in peak current, Surface roughness was increases with the increase in Pulse on time. Surface roughness was increased with the increase in % reinforcement. B. Naga Raju et al., [2]made an attempt to study the influence of process parameters like pulse-on time, pulse-off time and peak current on surface roughness of Aluminum Metal Matrix Composites (AMMC). The composite material containing aluminum alloy as matrix, 5 wt. % silicon carbide as reinforcement was produced by stir casting technique, higher peak current results in higher energy pulses which produces a greater depth crater and over cut. It leads to poor surface finish. The increase in pulse-on time decreases surface finish quality. Higher pulse-on time with fixed pulse duration results in higher energy discharge there by producing craters on the surface which leads to poor surface quality. Jangra, Jain and Grover [3] have machined hardened D3 tool steel using Zn-coated brass wire. Taguchi and gray relational analysis were employed. The results showed that pulse-on time is the most significant parameter affecting surface roughness. G. Ramesh et al., [4] investigated the Influence of Process Parameters in Wire Cut Electric Discharge Machining of Hybrid Al Metal Matrix Composites. In this study, the size and weight fraction of the reinforcement particles determines the surface roughness. Gradual increase in pulse time gives greater surface finish. From the response graphs it has been observed that the average Ra for Al7075 3% SiC 3%B4C was found to be 3.98 μm and average value for 7% SiC 3% B4C was 4.25 μm. It has been observed that the Ra value increases with increase in weight fraction of SiC and B4C particulates. The presence of reinforcement in the aluminum matrix resulted in higher roughness. Raman Sharma et al., [5] studied optimization of Process parameters of Al 6061 by using WEDM. The four process parameters like current (IP), pulse on time (Ton), pulse off time (Toff) and servo voltage (SV) have been considered in this study for optimal settings, for machining of the material. Two different optimal settings of process parameters were found for MRR and SR. The optimal predicted values for MRR and SR are 15.859 mm3/min and 3.563 μm. Two process parameters namely pulse-on time (Ton) and Peak current (IP) are found the most significant affecting the MRR and SR. Hasrimran Singh and Harmesh Kumar [6] performed the Experiments in Wire EDM on Al metal matrix Composites; Research work proves that WEDM is an adequate process to machine aluminum matrix composites with good surface finish and dimensional precision. Muthuraman et al [7] Performed experiments on (WC-CO) using different process parameters Pulse on time, Pulse off time, Ignition current, Wire feed and Dielectric pressure& to study their effect on surface roughness. DOE is used to study influence of Process variables on WEDM of Tungsten Carbide Cobalt Metal Matrix Composite. It was suggested that with increase in Pulse on time, Wire feed, then value of surface roughness increases but as increase in dielectric pressure takes place then surface roughness starts decreasing. A. Muniappan et al[8] made investigation on WEDM Process Parameters for Cutting Speed using

Surface methodology ,in this investigation the material used are 15 wt. % SiC(10%), Graphite(15%) particulates in Al 6061.The cast hybrid composite was machined on wire electrical discharge machine. The linear parameters Pulse on time, Pulse off time, peak current and control speed had significant effect on cutting speed. The optimum results are adopted in validation study and the results based on WEDM process responses can be effectively improved.Shiva Kant Tilekar et al [9] studied an effect of process parameters on Surface Roughness and kerf width of Al and MS are investigated, single objective Taguchi method is used for Process Parameters.In this study spark on time and the input current have statistically significant in case of Al and MS. Kumaret al., [10] developed a model for predicting the surface roughness of pure titanium in WEDM process using brass wire. Pulse-on time, pulse-off time, peak current, spark gap voltage, wire feed and wire tension were selected as process variables to find their effect on surface roughness using response surface methodology(RSM). Pulse-on time, pulse-off time, peak current and spark gap voltage were observed to be the most significant parameters with respect to surface finish. Saha et al., [11] have studied the surface roughness of tungsten carbide-cobalt (WC-Co) composite using uncoated brass wire against process parameters such as pulse on-time, pulse-off time, peak current, and capacitance. It was observed that surface roughness increases with the increase in the peak current and capacitance.

In Wire EDM, a constantly moving conductive material worked as an electrode and material is removed from the work piece by a progression of discrete sparks between the work piece and wire electrode isolated by a thin film of dielectric liquid. The dielectric fluid is constantly passed to the spark area to flush away the eroded material and it also works as a coolant. During the WEDM process, there is no immediate contact between the work piece and the wire. WEDM uses a constantly travelling wire electrode made of thin brass, molybdenum, copper or tungsten of diameter 0.05-0.50 mm, which is fit for accomplishing less corner radii. Wire EDM has high potential in recent times in the metal cutting industry for accomplishing a high dimensional accuracy, surface machining and forming contour elements of items or parts.Wire EDM method combines a thin wire as an electrode changes electrical energy to thermal for cutting of the materials. The schematic representation of WEDM cutting process is shown in Fig.1.

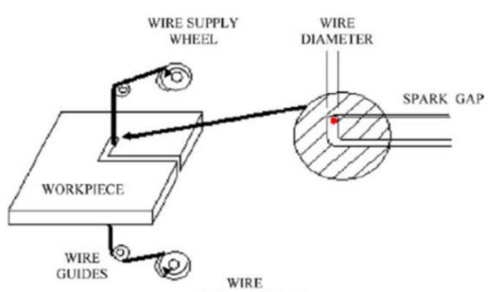

Fig.1: Schematic representation of wire EDM cutting process

2. Experimental Methodology

The experimental studies were performed on WEDM machine as shown in the Figure 2. Various input parameters varied during the experimentation are Pulse on time (T_{ON}), Pulse off time (T_{OFF}), Servo voltage (SV), and Wire feed (WF). The effects of these input parameters are studied on Surface Finish.

Fig. 2: WEDM machine

The different wire cut EDM machine settings of open circuit voltage, wire speed and dielectric flushing pressure were used in the experiments. During the experiments, two input variables; discharge current and servo feed were kept constant. In each experiment one input variable was varied while keeping all other input variables at some mean fixed value and the effect of change of the input variable on the output characteristic like material removal rate is studied and presented in this paper. The Brass wire with 0.25 mm diameter was used in the experiments. The work piece materials of Al2285 alloy and Al2285-MgOcomposite material of diameter 25mm and length 250 mm were used to evaluate the effects of machining parameters on Surface Roughnessand to identify the best optimal machining parameters for good surface finish. The various input parameters like Pulse on, Pulse off, servo voltage, wire feed were varied. The effects of these input parameters are studied on surface roughness using one factor at a time approach. The parameters were selected based on machine. Surface roughness is measured by Tally surf surfacemeasurement tester shown in fig 3. Measurements of Ra were repeated three times, and the average of the Ra was taken

Fig.3:Surface roughness measurement tester (Tally Surf)

3. Results and Discussions

The experiments are based on one factor experiment strategy. In this only one input parameter was varied while keeping all other input parameters are kept constant value. During this experimental procedure, three sets of experiments were performed. The results of the following were discussed below.

3.1Effect of Servo voltage on the Surface Roughness

The variation of Ra onServo voltage of wire cut EDMwhen Pulse On=1μs and Pulse off=14 μs, wire speed=5m/min, servo feed=5m/min, input power=17 amps shown in Fig. 3.

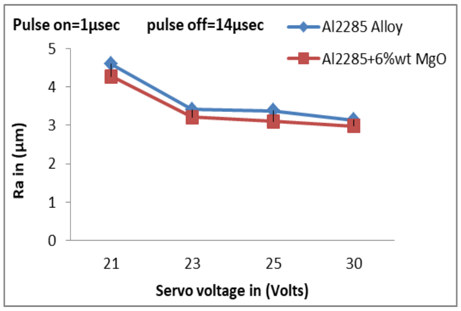

Fig.3: Variation of Ra onServo voltage of wire cut EDM

3.2 Effect of Servo voltage on the Surface Roughness

variation of Ra on servo voltage of wire cut EDM when Pulse On=1μs and Pulse off=17 μs wire speed=5m/min, servo feed=5m/min, input power=17 amps shown in Fig: 4 From the fig 3 and 4, the graph shows that Surface Roughness decreases with increase in the servo voltage (V) and also Surface Roughness is higher at low voltage and lower at highest voltage the surface Roughness of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The Ra decreases as the servo voltage increases. The Ra of Al2285+MgO decreases by 6% at 23 servo voltage as compared to Al 2285 alloy. The Ra decreases by 28% at the servo voltage increases from 21v to 30v for Al2285 alloy.

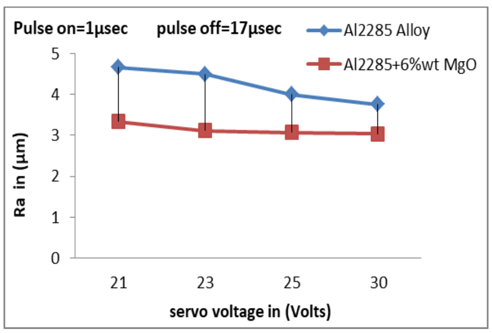

Fig 4: Variation of Ra on Servo voltage of wire cut EDM

3.3 The effect of Pulse on time on the Surface Roughness

The variation of Ra on pulse ON of wire cut EDMwhenpulse off=14μs, servo voltage=21 v wire speed=5m/min, servo feed=5m/min, input power=17 amps shown in Fig: 5

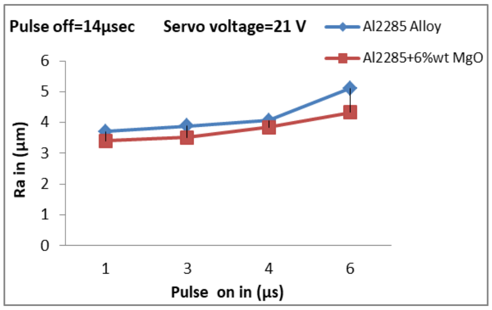

Fig. 5: Variation of Ra on Pulse ON of wire cut EDM

3.4 The effect of Pulse on time on the Surface Roughness

The variation of Ra on pulse ON of wire cut EDMwhenpulse off=14μs, servo voltage=30 v wire speed=5m/min, servo feed=5m/min, input power=17 amps shown in Fig. 6. From the fig 5 and 6, the graph shows that Surface Roughness increases with increase in the Pulse On time and also Surface Roughness is lesser at lowest Pulse on time and higher at highest pulse on time. From the above Fig. 5 and Fig. 6, graph reveals that the Surface Roughness of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The Ra increases as the pulse on time increases. The Ra of Al2285+MgO increases by 8.5% at 3μs pulse on as compared to Al 2285 alloy. The Ra increases by 20% at the pulse on increases from1μs to 6μs for Al2285 alloy.

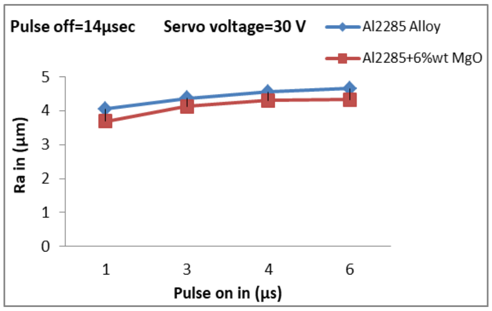

Fig. 6: Variation of Ra on Pulse ON of wire cut EDM

3.5 The effect of Pulse off time on the Surface Roughness

The variation of Ra on pulse off of wire cut EDMwhenpulse on=4μs, servo voltage25 v wire speed=5m/min, servo feed=5m/min, input power=17 amps Shown in Fig. 6.

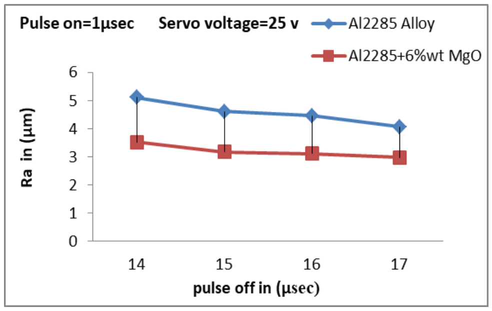

Fig. 7: Variation of Ra on Pulse off of wire cut EDM

3.6 The effect of pulse off time on the surface roughness

The variation of Ra on pulse off of wire cut EDM whenpulse on=6µs, servo voltage25 v wire speed=5m/min, servo feed=5m/min, input power=17 amps Shown in Fig: 6. From the fig 7 and 8, the graph shows that Surface Roughness decreases with increase in the Pulse Off time and also Surface Roughness is higher at lowest Pulse off time and lesser at highest pulse on time. From the above Fig. 7 and Fig. 8, reveals that the Surface Roughness of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The Ra decreases as the pulse off time increases. The Ra of Al2285+MgO decreases by 7% at 15 pulses off time as compared to Al 2285 alloy. The Ra decreases by 20% at the servo voltage increases from 14µs to 17µs for Al2285 alloy

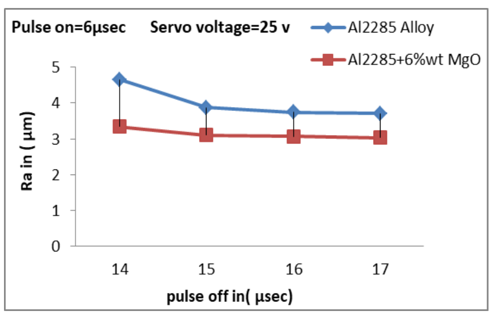

Fig.8: Variation of Ra on Pulse off of wire cut EDM

Conclusions

The concluding findings of the experimentation are,

- Surface Roughness of both the Al2285 alloy and Al2285+ 6 wt. % MgOcompositematerial decreases with the increasein the servo voltage and pulse off time
- Surface Roughness of the Al2285 alloy and Al2285+ 6 wt. % MgOcomposite material increases with increases in Pulse on time (T_{ON}) and the Pulse on time parameter has direct effect on the Surface Roughness.
- The Surface Roughness of Al2285 alloy and Al2285+ 6 wt. % MgO directly increases with increase in Pulse on time (T_{ON}) and decreases with increase in Pulse off time (T_{OFF}) and Servo voltage (SV).

It can be concluded that the better surface roughness is found to be, Pulse off time and servo voltage which are considered to be the optimum process parameters for WEDM of Al2285+ 6 wt. % MgO composite materials.

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