Effect of Process Parameters in Wire Cut Electric Discharge Machining of Al2285-Mgo Metal Matrix Composites

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ABSTRACT: This paper deals with the machining characteristics of wire cut electrical discharge machining process in Aluminum 2285-MgO composite material. Di-electric used for experiment was De-ionized water. The effects of various process parameters of wire cut electrical discharge machining like pulse 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 material removal rate of aluminum 2285-MgO composite.The optimal set of process parameters has been predicted to maximize the material removal rate.

Keywords: WEDM, T_{ON}, T_{OFF}, SV, WF, MRR

Introduction

Non-traditional machining processes have been developed since World War II, in which forms of energy other than mechanical energy are utilized. The need for developing most of the process was the search for a better alternative method of machining complex shapes, higher removal of metal from inaccessible places on difficult to machine materials irrespective of hardness limitation. Electro discharge machining process has been proven as an alternative process for machining complex and intricate shapes from all type of conductive materials in which electrical energy is used to cut the material to final shape and size [1-3]. Kumar and Kumar [4] made investigation on material removal rate and over cut in WEDM process of pure titanium using brass electrode were modeled and analyzed through response surface methodology. Dimensional analysis is used to develop the semi empirical model and developed model has been validated by comparing the predictions of the model with the experimental values of MRR and a good agreement between the two has been obtained. It was found the error between experimental and predicted values at the optimal combination level of input parameter settings for material removal rate and overcut lies within 6.95 and 6.32 %, respectively. Saha et al. [5] have studied 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. Jangra, Jain and Grover [6] 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. Kumaret.al [7] 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. During WEDM of pure titanium, wire feed and wire tension were found to be insignificant to the output i.e. SR. Yan et al. [8] proposed a novel pulse generator for machining of polycrystalline diamond (PCD) using tungsten wire as electrode. The results indicated that higher open voltage produces higher peak current and hence surface roughness increases with increase in open voltage. Sharma et al. [9] performed experiments on high strength low alloy steel using brass wire as electrode to investigate influence of process parameters on material removal rate (MRR) and surface finish (SF). Optimal process parameters were achieved through Response Surface Methodology (RSM). It was found that surface roughness increases with increase in pulse-on time and peak current. Lodhi and Agarwal [10] optimized the machining conditions on AISI D3 steel using zinc-coated brass wire. Pulse-on-time, pulse off-time, peak current, and wire feed were varied to study the surface roughness. It was reported that the surface roughness was greatly influenced by current. Similar observations were observed by many researchers [11-15].

The schematic representation of the Wire cutting electrical discharge machining process is shown in Figure 1. Wire cut electrical discharge machining is a specialized thermal machining process capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the main stream machining processes. Presently, Wire cut electrical discharge machining is a widely used in the aerospace and automotive industries for high-precision machining of all types of conductive materials such as metals, metallic alloys,graphite, or even some ceramic materials of any hardness.

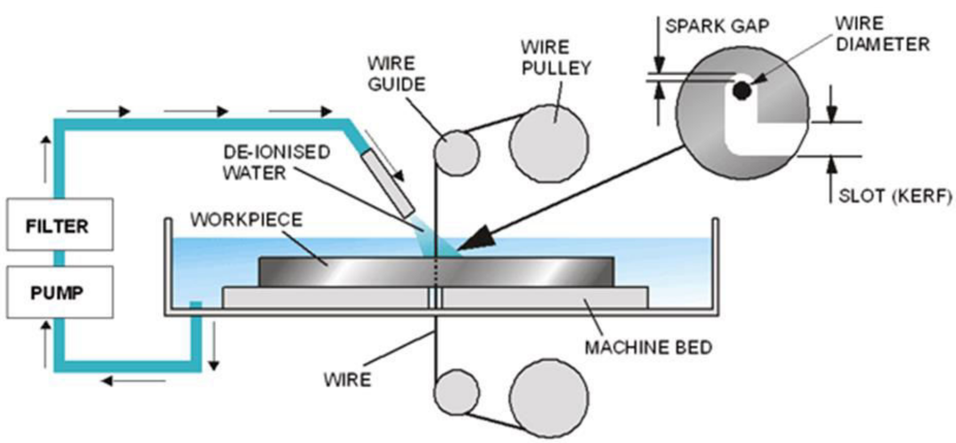

Fig.1: Schematic representation of wire EDM cutting process

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 material removal rate. The units of some input parameters such as pulse on time, pulse off time,servo feed, wire feed etc. are taken as per the machine setting.

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 material removal rate and to identify the best optimal machining parameters for higher MRR with good surface finish.

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.

3.1The effect of Servo voltage on the material removal rate

Fig. 3 illustrates the variation of MRR for different servo voltage at pulse on of 1µs,pulse off: 14 µs, wire speed=5m/min, servo feed=5m/min, input power=17 amps.The material removal rate decreases as the servo voltage increases. The material removal rate in Al2285 alloy is higher compared to Al2285+6 wt. % MgO composites for all the servo voltages.

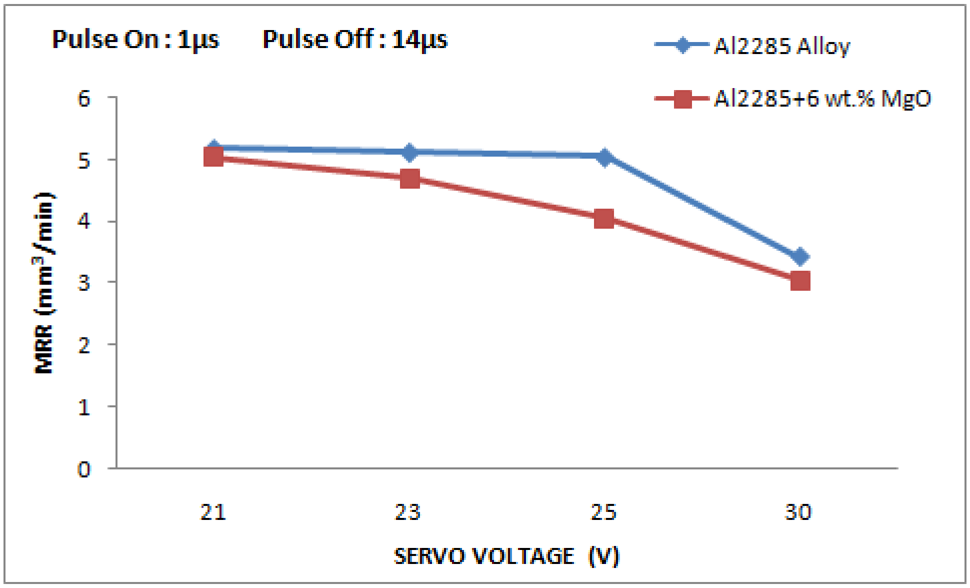

Fig.3: Variation of MRR onServo voltage of wire cut EDM

Fig. 4 illustrates the variation of MRR for different servo voltage at pulse on=1µs, pulse off=17 µs, wire speed=5m/min, servo feed=5m/min, input power=17 amps. In the above Fig 3 and Fig 4,graph reveals that the material removal rate of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The MRR decreases as the servo voltage increases. The MRR of Al2285+MgO decreases by 10% at 23 servo voltage as compared to Al 2285 alloy. The MRR decreases by 34% at the servo voltage increases from 21v to 30v for Al2285 alloy.

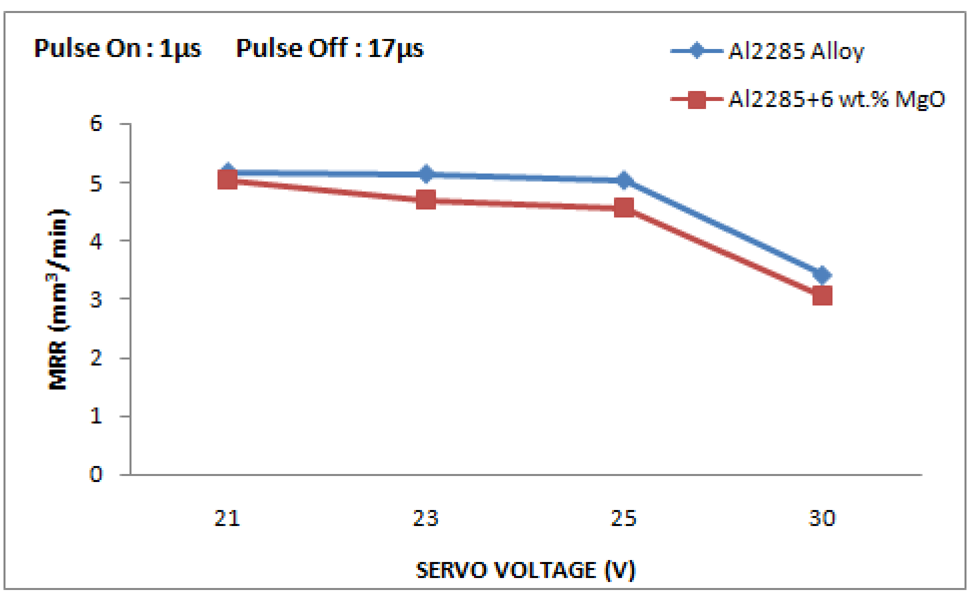

Fig 4: Variation of MRR on Servo voltage of wire cut EDM

3.2 Effect of pulse on timeon materialremoval rate

Fig. 5illustrates the variation of MRR for different pulse on time at pulse off=14µs, servo voltage=21 v wire speed=5m/min, servo feed=5m/min, input power=17 amps. The material removal rate increases as the pulse on time increases. The material removal rate in Al2285 alloy is higher compared to Al2285+6 wt. % MgO composites for all the pulse on times.

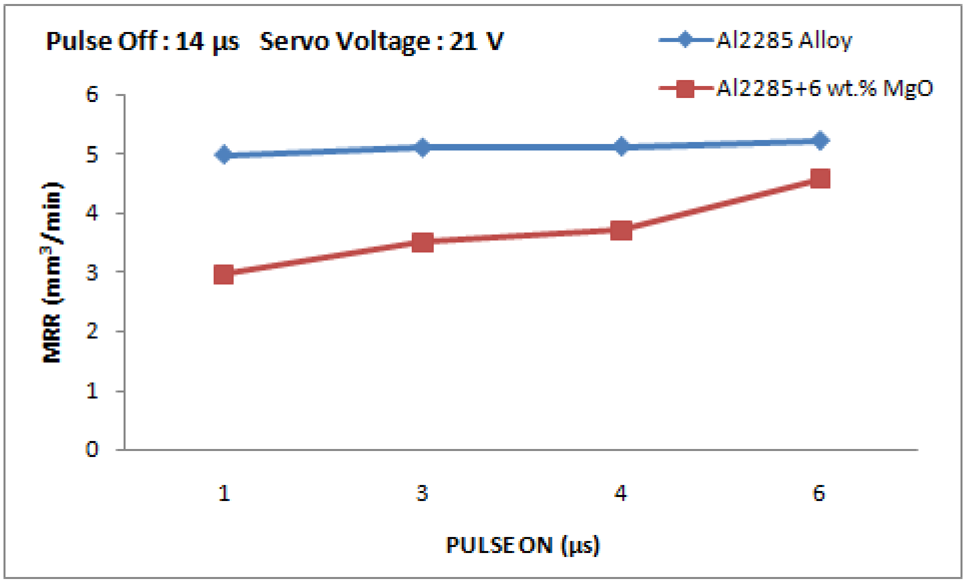

Fig. 5: Variation of MRR on Pulse ON of wire cut EDM

Fig. 6 illustrate the variation of MRR for different pulse on time at pulse off=14µs, servo voltage=30 v wire speed=5m/min, servo feed=5m/min, input power=17 amps. From the above Fig. 5 and Fig. 6, graph reveals that the material removal rate of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The MRR increases as the pulse on time increases. The MRR of Al2285+MgO increases by 10% at 3µs pulse on as compared to Al 2285 alloy. The MRR increases by 17% at the pulse on increases from1µs to 6µs for Al2285 alloy.

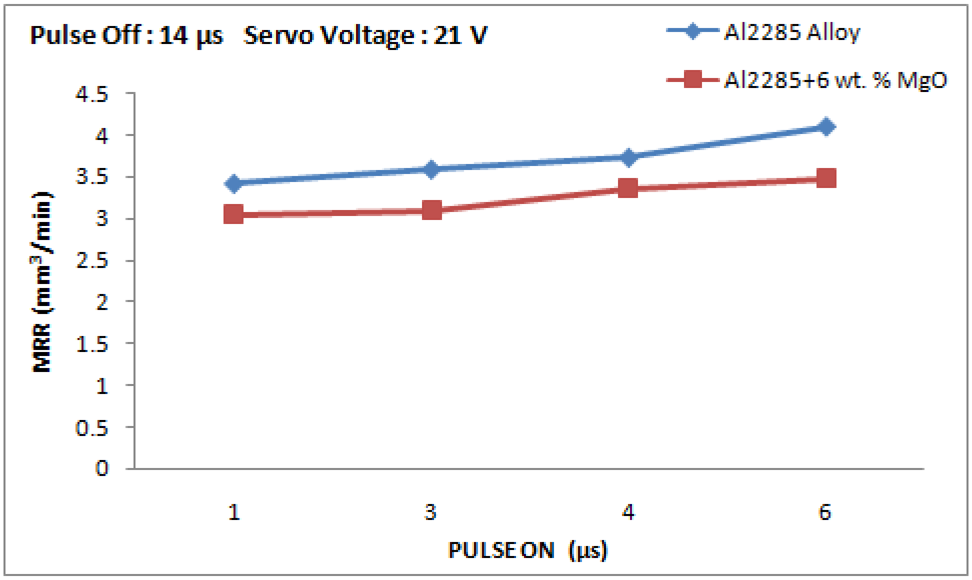

Fig. 6: Variation of MRR on Pulse ON of wire cut EDM

3.3 Effects of Pulse off time (T_{OFF}) on material removal rate

Fig. 7 illustrates the variation of MRR for different pulse off time at pulse on=4µs, servo voltage=25 v wire speed=5m/min, servo feed=5m/min, input power=17 amps. The material removal rate decreases as the pulse off time increases. The material removal rate in Al2285 alloy is higher compared to Al2285+6 wt. % MgO composites for all the pulse off times.

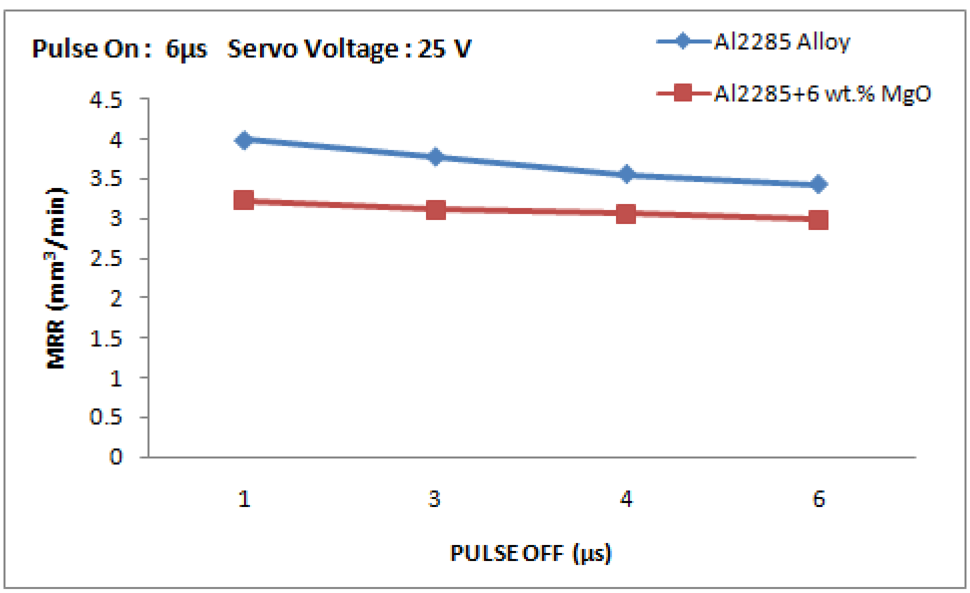

Fig. 7: Variation of MRR on Pulse off of wire cut EDM

Fig. 8 illustrates the variation of MRR for different pulse off time at pulse on=6µs, servo voltage=25v wire speed=5m/min, servo feed=5m/min, input power=17 amps. From the above Fig. 7 and Fig. 8, reveals that the material removal rate of composite Al 2285+6wt%MgO is lower than the Al2285 alloy. The MRR decreases as the pulse off time increases. The MRR of Al2285+MgO decreases by 10% at 15 pulses off time as compared to Al 2285 alloy. The MRR decreases by 14 % at the servo voltage increases from 14µs to 17µs for Al2285 alloy.

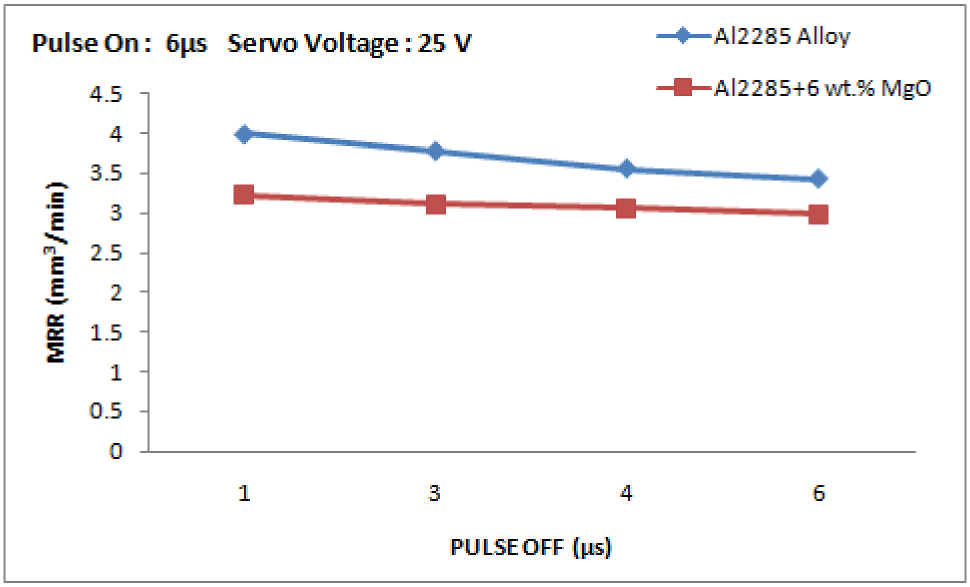

Fig.8: Variation of MRR on Pulse off of wire cut EDM

Conclusions

The concluding findings of the experimentation are,

- Material removal rate of both the Al2285 alloy and Al2285+ 6 wt. % MgOcomposite material decreases as the servo voltage increases.
- Material removal rate 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 material removal rate.
- The material removal rate decreases with the increase of Pulse off time.
- The material removal rate (MRR)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).

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