

Investigations of Effect of Rotary EDM Electrode on Machining Performance of Al6061 Alloy

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Abstract. Electric Discharge Machining is an essential process which is being used for machining desired shape using electrical discharges which creates sparks. There will be electrodes subjected to electric voltage and which are separated by a dielectric liquid. Removing of material will be due to the continuous and rapid current discharges between two electrodes.. The spark is very carefully controlled and localized so that it only affects the surface of the material. Usually in order to prevent the defects which are arising due to the conventional machining, the Electric Discharge Machining (EDM) machining is preferred. Also intricate and complicated shapes can be machined effectively by use of Electric Discharge Machining (EDM). The EDM process usually does not affect the heat treat below the surface. This research work focus on the design and fabrication of rotary EDM tool for machining Al6061 alloy and investigation of effect of rotary tool on surface finish, material removal rate and tool wear rate. Also the effect of machining parameters of EDM such as pulse on & off time, current on material Removal Rate (MRR), Surface Roughness (SR) and Electrode wear rate (EWR) have studied. Al6061 alloy can be used for marine and offshore applications by reinforcing some other elements. The investigations have revealed that MRR(material removal rate), surface roughness (Ra) have been improved with the reduction in the tool wear rate (TWR) when the tool is rotating instead of stationary. It was clear that as rotary speed of the tool is increasing the material removal rate is increasing with the reduction of surface finish and tool wear rate.

1. Introduction

In Electrical Discharge machine (EDM), material is removed from the electrically conductive material by discharge of spark [8]. Electrical discharge machining removes material from work piece by spark erosion process [10]. Electric field provides the spark path and material is being removed. Also the insulation between electrode and work piece to be considered for ionization.

The Shape, position and status of the electrode plays a major role in the performance, material removal rate and work piece shape. The desired output parameters can be obtained by controlling the area in which spark erosion should take place [15]. In this research work, a rotary EDM tool has been designed and fabricated to provide rotation to the tool [4]. The work piece will be fixed and the tool will be made to rotate. Investigations have been made to study the effect of rotary speed on material removal rate (MRR), surface roughness (Ra) and tool wear rate (TWR) [1]. Material for machining has been taken as Al6061 alloy. Aluminium matrix composites (AMMCs) are suitable materials for fabrication of large structures, aircraft components and automotive components [6, 11]. These applications required machining of smaller and component with intricate shapes. Hence there is a need for developing an advanced EDM system [9].



2. Experimentation

A rotary EDM tool was designed and fabricated to evaluate the effect of rotary tool on material removal rate(MRR), Surface Roughness(Ra) and Tool wear Rate (TWR) which are highly influencing the EDM machining [7] of Al6061alloy. Copper was used as tool material. The Electrical Discharge Machine MMT Vidyunt EM 150 is provided with the rotary tool setup to rotate the tool [13].

In order to make the copper electrode tool to rotate, a sprocket-chain mechanism was used as shown in Figure 1. Motor is fixed to a support, which can move up and down according to the movement of tool head. In order to control the speed of the motor a dimmer setup is used. The normal speed of the motor is 6000 rpm and it is reduced to the required speeds 0-300 rpm by use of chain drive.

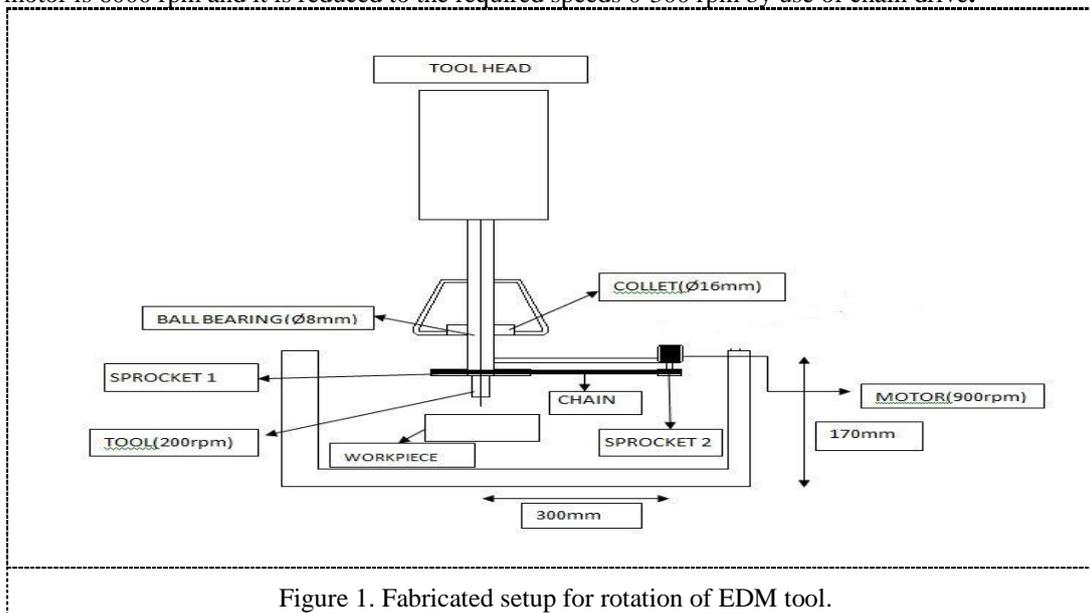


Figure 1. Fabricated setup for rotation of EDM tool.

Work piece to be machined and the electrode are first weighed before starting the experimentation. Work piece is fixed in the vice of the EDM and electrode is fitted on to the electrode holder. Then the machine is switched on and dielectric fluid kerosene is filled in to the tank. Settings are carried out to provide a appropriate gap / standoff distance between the electrode and work piece, required peak current, pulse on time and pulse off time [3]. After completing all the settings, machining process is started and time for machining is set as 35 minutes [3]. During the machining process, work piece and electrode is again weighed. Surface roughness of the machined surface is measured by Mitutoyo surface roughness tester. The same procedure is repeated by varying the parameters.

3. Results and Discussions

3.1. Effect of pulse off & ON time and rotary speed on surface finish

The results obtained from the experiments are more relevant to the results published by many researchers who have used various techniques. MRR was found to be increasing with increase in current and pulse ON-time [1]. It is also evident that from the Figure 2,3 the surface roughness value increases with increase in current , pulse ON-time and lesser rotation speed of electrode .If the current is high ,the thermal load increases on both electrodes and work piece[12] followed by higher amount of material being removed from both electrode and work piece. This causes more rough surface . When the electrode rotational speed increases, there will be vortex formation and which leads to uniform swiping action on the work piece and smooth machining.

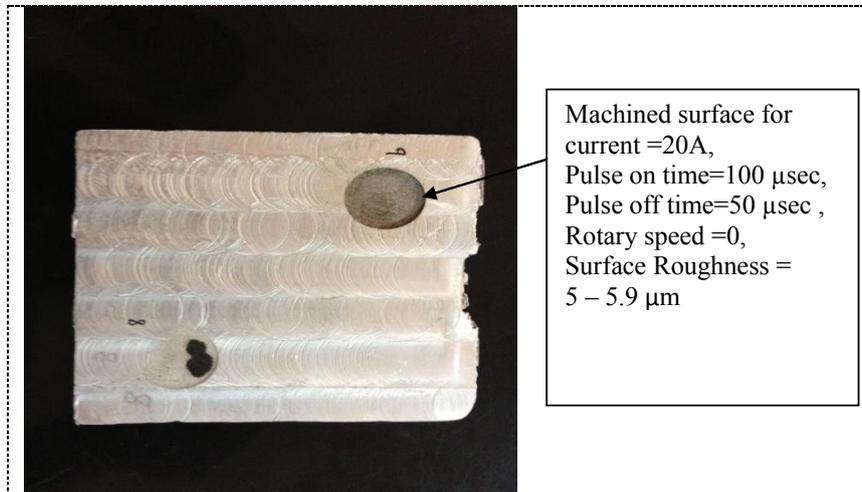


Figure 2. Surface of machined Al6061 alloy for the mentioned parameters.

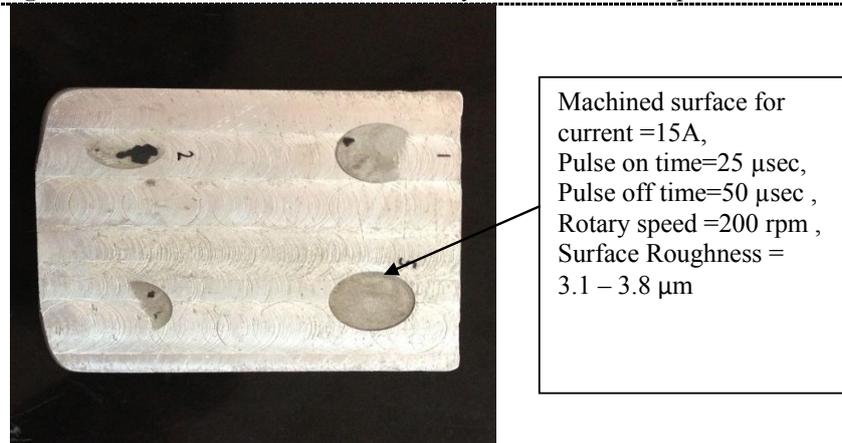


Figure 3. Surface of machined Al6061 alloy for the mentioned parameters.

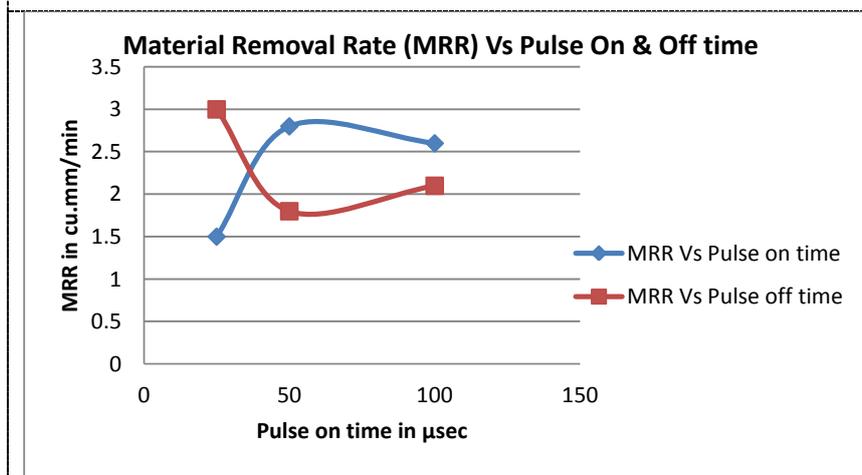


Figure 4. Material Removal Rate Vs Pulse on time & Pulse off time

3.2. Effect of pulse on time & Pulse off time on material removal rate (MRR)

From the Figure 4, it is very clear that, an increase of pulse on time [2] causes an increase in the metal removal rate. When the pulse on time increased, the heat flux will be retained for longer time, so more heat will be conducted to the work piece when the plasma channel expands. This will cause an increase in MRR. Also Figure 4 shows that, the MRR decreases non-linearly with the increase of pulse off time, but if the minimum value approaches, it has a potential to increase as it becomes stable in erosion

3.3. Effect of Rotational speed of EDM Tool on material removal rate (MRR) for Al6061alloy

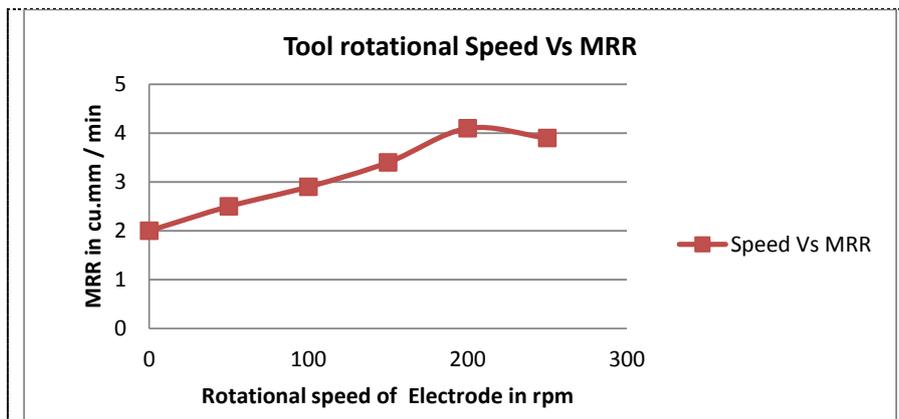


Figure 5. Material Removal Rate Vs Rotary Speed of Tool

The Figure 5 indicates that, the MRR increases linearly with the increase of rotary speed. It has been found that higher MRR is obtained due to the rotation of the tool. As the speed increases the pressure between the work piece and electrode increases. This creates more vortex, spread of heat flux and causes the increase of flow into the work piece [8]. Due to the above said reasons there is increase in the material removal rate (MRR) as the rotation speed of electrode increases. Also as the speed increase more than 220 rpm, it swipes the erosion action and the MRR is decreasing.

3.4. Effect of Rotational speed of EDM Tool on Wear Rate (EWR) for Al6061 alloy

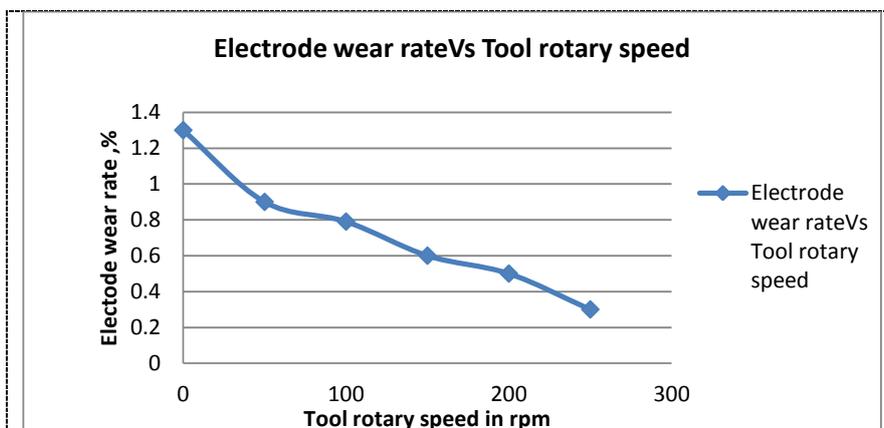


Figure 6. Electrode Wear Rate Vs Rotary speed

The literatures clearly shows that , if the tool is stationary ,due to more machining time ,the wear rate found to be more [14] .The Figure 6 shows that , electrode wear rate (EWR) [5] decreases slowly with the increase of rotary speed. This shows less amount of electrode gets removed with increase of tool rotation speed. This is due to the increase in MRR due to higher speed, which leads to lesser machining time .But when the speed of electrode decreases, the MRR also decreases and which leads to more electrode wear.

4. Conclusions

This research work focus on investigation of effect of rotary tool of electric discharge machine on rate of material removal (MRR), surface finish and electrode wear rate (EWR). Also design and development of a rotary tool setup with variable speed arrangement for an electrical discharge machine has been carried out to conduct various investigations. Investigations have been carried out to study the effect of EDM machining parameters such as current, pulse on time, and pulse off time, rotary speed of tool on material removal rate of work piece, surface roughness and wear rate of electrode. For investigations three factors, three levels were selected and used. The three levels of current are 10A, 15A and 20A. Three levels of pulse on time are 25, 50 and 100µsec. Three levels of pulse off time are 25, 50 and 100µsec. Three levels of rotary tool speed are 0,100 and 200rpm.

The measured output parameters such as material removal rate, rate of wear occurred on electrode and surface roughness are plotted against the input parameters like current, pulse on time, pulse off time and rotary speed using graphs.MRR was found to be increasing with the higher current and pulse on time 50 µsec and decreases beyond this level. The pulse off time to be limited to 25 µsec to obtain higher MRR. MRR increases with increase of rotary speed. However the rotary speed has to be limited to 220 rpm to obtain higher surface finish and material removal rate. Electrode wear rate is found to be decrease with increase of rotary speed of EDM tool .The surface roughness increasing with the increase in pulse on time and peak current during the machining of Al6061alloy. Also the surface roughness was increasing with increase of rotary speed.

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