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Control system for Mirco - EDM

T Kaveya*[1] and Vijay Kumar Pal*[2]

[1]Department of Mechanical engineering, SRM Institute of science and Technology, Kattankulathur – 603203, India
[2]Department of Mechanical engineering, SRM Institute of science and Technology, Kattankulathur – 603203, India

*Corresponding Author: kaveya.kt@gmail.com[1] vijaykumarpal.r@ktr.srmuniv.ac.in[2]

Abstract. Micro-Electrical Discharge Machining (EDMs) is a manufacturing process in which the desired shape of the work-piece is obtained by electrical discharge. The removal of the material from the surface of the work-piece occurs by rapid current discharges occurring between two electrodes separated by dielectric medium and subjected to an electric voltage. The spark is generated between the electrodes when the voltage applied is high enough to breakdown the dielectric. As a result of this the material is removed from the surface of the work-piece. Generally, Micro-EDM operates on flat surfaces. In this paper, a controller is designed for Micro-EDM to operate on a cylindrical work-piece. The parameters to be controlled are the speed of the motors which will control the electrode and the work-piece, the spark generated and the discharge gap. A PID controller will be implemented to control the entire system. Each parameter will have its own PID controller. The controller will be designed and simulated using MATLAB/SimuLink software.

1. INTRODUCTION

1.1. MICRO EDM
Electrical discharge machining is a manufacturing process which uses electrical discharge (sparks) to remove the material of the workpiece in order to obtain the desired shape. The tool and the work-piece act as anode and cathode respectively. The material removal process takes place due to the electrical sparks that occurs between the two electrodes separated by di-electric medium that is subjected to electric voltage. The material removed, are then cooled and re-solidified in the di-electric medium resulting in hundreds of spherical debris particles which will be flushed away from the gap by the flow of dielectric medium. The Micro EDM works on the same principle as the EDM. The main difference between the Micro EDM and a conventional EDM is the size of the plasma channel radius, that arises during the spark, is smaller than the electrode in the conventional EDM, whereas the radius is comparable to the electrode size in a Micro EDM. The radius of the plasma channel can be modified by the pulse duration as the channel radius is directly proportional to the time. Increase in time will increase the size of the plasma channel. The electrode wear for each discharge is proportionally higher in the Micro EDM compared to the conventional EDM[8]. The removal rate per spark is controlled by limiting the maximum peak energy in a Mirco EDM[5]. The shape of the electrode is chosen equivalent to the gap size and the dielectric

medium will be chosen in order to obtain precise machining[8]. The gap width should be maintained in order to avoid short circuiting of electrodes[6]. A high voltage is required to break down the dielectric strength. The control of the manufacturing process plays an important role.

There are two types of EDM machine:

1. Die Sink
2. Wire EDM

Die Sink machines are also known as Cavity type EDM or Volume EDM. This type consists of an electrode and a workpiece immersed in an insulating medium such as oil, kerosene, etc. The working process of the EDM is explained above. The sparks, that occur due to the interaction between the electrode and the workpiece, usually strikes one at a time.

The wire EDM is also known as the wire cut EDM and wire cutting EDM. In this type, a thin single strand metal wire acts as an electrode which is fed through the workpiece immersed in a tank of dielectric medium. The dielectric medium used very often is a de-ionized water. This type of machine is commonly used to cut plates of 300mm thickness and punch, and manufacture tools and dies from hard metals.

2. SPECIFICATIONS

Table 1. Specifications

SPECIFICATIONS	DETAILS
Motors	2(DC motors) Stepper motor (1)
Sensors	Quad encoder
Weight of lead screw x base(g)	400g
Weight of the lead screw y base(g)	240g
Microcontroller	Arduino Mega
Electrode	Copper (50g)

3. WORKING

Three motors are used for controlling the motion of the tool and the work-piece. Two DC motors and one stepper motor is used in the mechanism. The motors are chosen based on the requirements of the application.

The quadrature encoder that is in-built in the motor will be used to find the number of rotations of the motor. This output will be used as a feedback to control the position of the motor. The pitch of the lead screw used in the mechanism is 1.7mm. The system will be controlled using a PID controller .

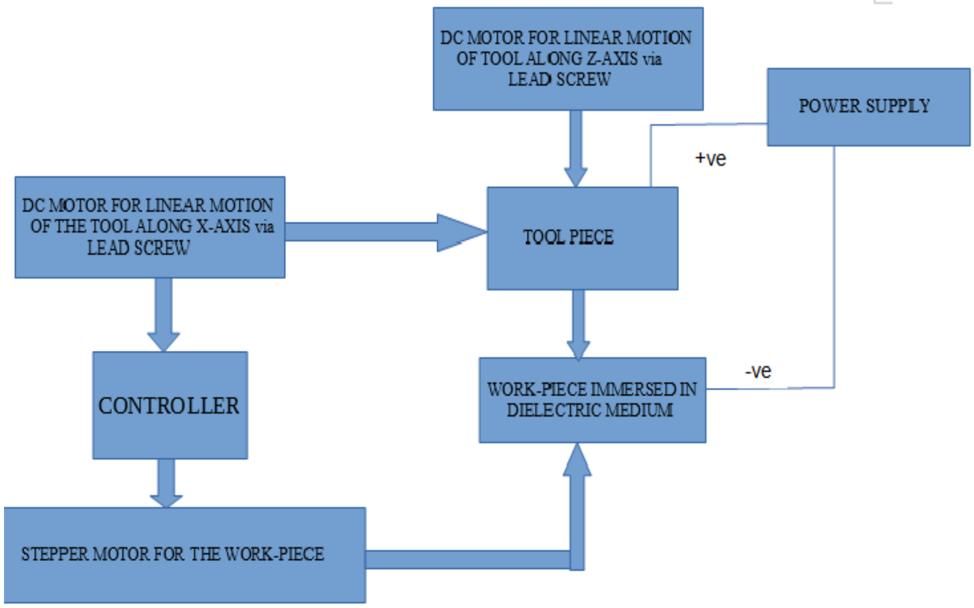

Figure 1. Block diagram of the proposed Micro EDM design

4.TRANSFER FUNCTION

Transfer function of a DC motor is given by :

$$P(s) = \frac{\theta(s)}{V(s)} = \frac{K}{(Js+b)\,(Ls+R) + K^2} \quad \frac{rad/sec}{V} \qquad (1)$$

Where,

K- emf constant
J – Moment of inertia
L-Electrical inductance
R- Electrical resistance

Substituting the values of the motor in the transfer function (1) we get,

$$P(s) = \frac{0.5884}{1.059\, s^3 + 428.4\, s^2 + 1799\, s}$$

Simulating the transfer function we get,

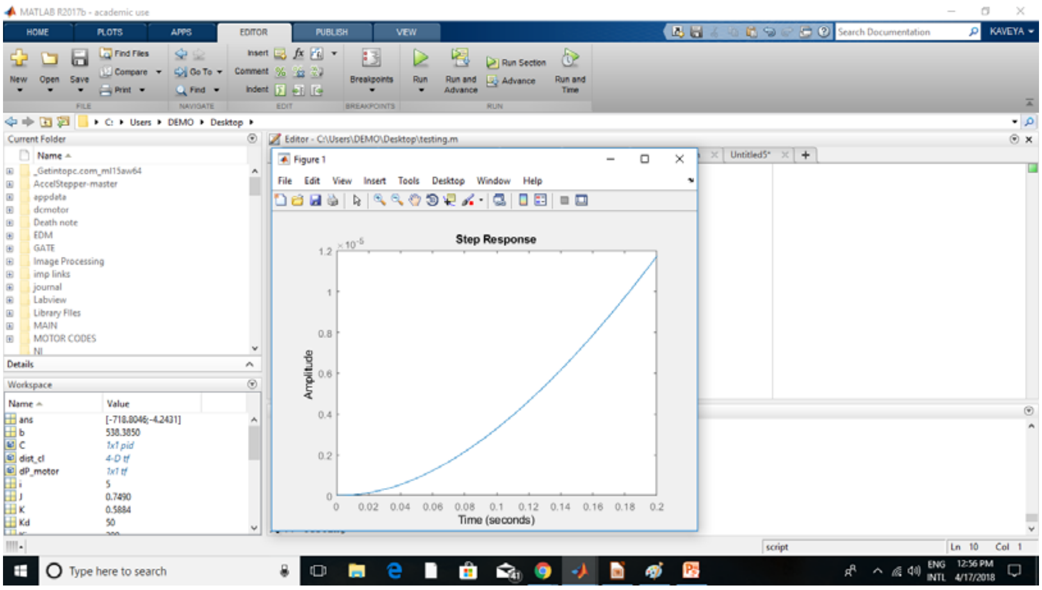

Figure 2. Open loop response

Stabilizing the system with a PID controller we get[1][3],

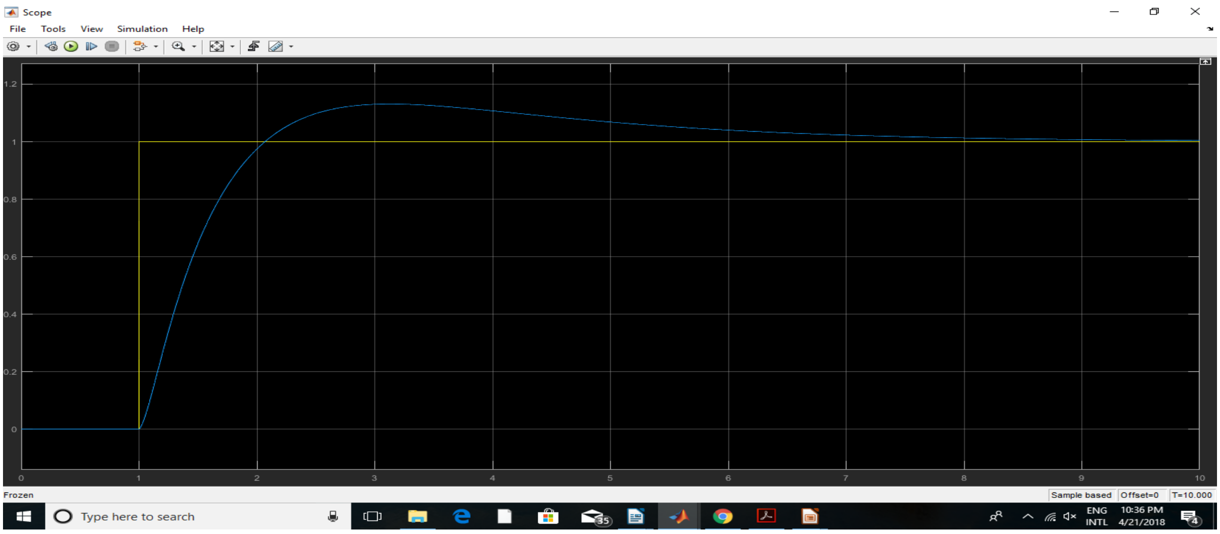

Figure 3. System response with K_p=400,K_I=300,K_D=0

5.EXPERIMENTAL RESULTS

Diameter of electrode = 4mm

Length of electrode = 6.9mm

Area= 86.70mm^2

Table 2. Experimental results

STAINLESS STEEL				**ALUMINUM**			
Diameter=20mm height=76mm				Diameter = 19mm Height=79mm			
Current	**Depth of cut**	**Machining Time**	**MRR**	**Current**	**Depth of cut**	**Machining Time**	**MRR**
6 Amps	2mm	4 min 17 sec	0.674	6 Amps	2 mm	4 min 42 sec	0.416

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	1mm	2 min 14 sec	0.647		1mm	2 min 39 sec	0.545
4 Amps	2mm	4 min 44 sec	0.610	4 Amps	2 mm	7 min 06 sec	0.407
	1mm	2 min 38 sec	0.548		1 mm	5 min 05 sec	0.286

Material Removal Rate (MRR):

$$MRR = \frac{\text{Electrode area} * \text{depth of cut Machining time}}{\text{Machining time}}$$

The above result proves that the MRR is higher when the current supplied is higher [5].

6. CONCLUSION

The experimental results prove that at low current the material removal rate is lesser than the MRR during the supply of high current. It also proves that the time taken to operate on aluminum is more than that of stainless steel. The position control of the tool was precisely controlled using a PID controller.

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