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EFFECT OF EDM PROCESS PARAMETERS ON SURFACE ROUGHNESS USING AISI D2 MATERIAL

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ABSTRACT

Electrical discharge machining (EDM) is a widely used process in the mould / die and aerospace industries. It is a process for shaping hard metals and forming deep and complex-shaped holes by arc erosion in all kinds of electro-conductive materials. The objective of this research is to study the influence of operating parameters of EDM of AISI D2 on the machining characteristics. This study investigates the influence of EDM parameters on Surface Roughness while machining of AISI D2 material. The parameters considered are pulse-on time (Ton), pulse off time (Toff) discharge current (D.C.). The experiments were performed on the die-sinking EDM machine fitted with a copper electrode. The experiments planned, conducted and analyzed using Taguchi method. It is found that the surface roughness is mainly influenced by (D.C.); where as other factors have very less effect on surface roughness.

KEYWORDS— EDM, AISI D2, Surface Roughness, Taguchi**.**

INTRODUCTION

EDM has been substituting traditional machining operations. Now today EDM is a popular machining operation in several manufacturing productions all over the world's countries. Most of the traditional machining process such as drilling, grinding and milling, etc. are failed to machine geometrically complex or difficult shape and size. Those materials are easily machined by EDM non-traditional machining process which leads to broadly utilized as die in addition to mold assembly industries, making aeronautical parts and nuclear instruments at the minimum cost. Electric Discharge Machining has also established its presence touched on the different subject areas such as make use of sporting things, medicinal and clinical instruments as well as motorized research and development regions.
Electrical Discharge Machining is a most basic nontraditional machining process, where material is removed by thermal energy of spark occurring by means of repeated sequences of electrical ejections between the small gap of an electrode and a work piece. EDM is commonly used for machining of electrically conductive hard metals and alloys in automotive, aerospace and die making industries. EDM process is removing undesirable material in the form of debris and produce shape of the tool surface as of a metal portion by means of a recurring electrical ejection stuck between tool i.e. cathode and the work piece i.e. anode material in the existence of dielectric liquid. In this machining process work piece is called the anode because it is connected with positive terminal and electrode is connected with negative terminal i.e. called cathode. Dielectric fluid may be EDM Oil, kerosene, transformer oil, distilled water, etc.

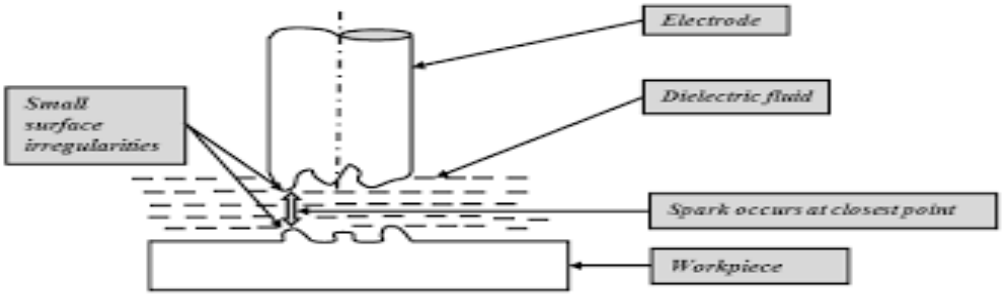

Fig: 1 Working Principle of EDM

In this machining method the metallic particle is removed as of the work piece owed to controlled wearing away action by means of repeatedly occurring spark ejection with the help of discharge current applied by power supply taking place in small gap in the range of 10 –125μm between the tool and work piece.
The below fig.2 shows the mechanical as well as electrical control system and electrical path for Electric Discharge Machining. A small break is kept among the tool and work piece through a servo control arrangement in which the tool in attached. Both the electrode and work piece stay immersed in a dielectric liquid.

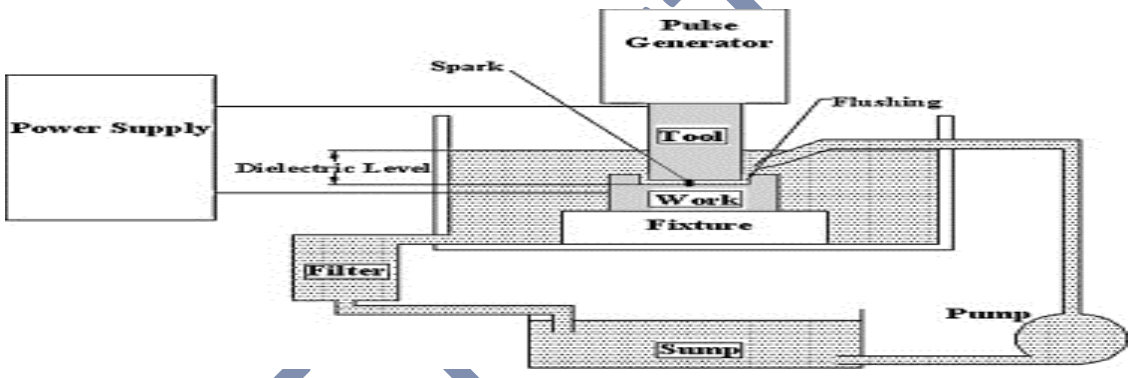

Fig 2: Schematic Setup of EDM

LITERATURE REVIEW

Yusuf Keskin · H. Selc¸uk Halkacı · Mevl ¨ut Kizil(1) investigated the effects of machining parameters on the Surface Roughness values of machined components by EDM experimentally. It is apparent that the Surface Roughness has an increasing trend with an increase in the discharge duration. This is mainly due to more discharge **energy** released during this time and expanding the discharge channel.
A. M. Nikalje & A. Kumar & K. V. Sai Srinadh (2) studied MDN 300 steel using Taguchi method. Maraging steel (MDN 300) exhibits high levels of strength and hardness. Optimization of performance measures is essential for effective machining. In this paper, Taguchi method, used to determine the influence of process parameters and optimization of electrical discharge machining (EDM) performance measures on MDN 300 steel, has been discussed. The process performance criteria such as material removal rate (MRR), tool wear rate (TWR), and Surface Roughness (SR) were evaluated. Discharge current, pulse on time, and pulse off time have been considered the main factors affecting EDM performance. Surface morphological study indicates that at higher discharge current and longer pulse on duration gives rougher surface characteristics with more craters, globules of debris, and micro cracks than that of lower discharge current and lower pulse on duration.
Ravinder Kataria, Jatinder Kumar(3) studied AISI 01 Tool Steel. The effect of several process parameters such as tool nose radius, speed, feed and depth of cut on the machining performance of turning operation has been studied using AISI O1 tool steel as a work material. The machining characteristics that are being studied are material removal rate (MRR) and Surface Roughness (SR) of machined surface. Taguchi method is utilized for single response optimization.
Anup B. Patel, Krunal Shah, Divyang(4) have done Experimental Analysis and Optimization of Process Parameter in WEDM for Aluminum-6082 and found that Surface Roughness is affected by the combination of wire tension and

pulse width, with both having maximum values highest is the roughness and with both having minimum value minimum is the roughness.

N. Tosun, C. Cogun, and A. Inan1(5) studied the variation of workpiece Surface Roughness with varying pulse duration, open circuit voltage, wire speed and dielectric fluid pressure was experimentally in Wire Electrical Discharge Machining (WEDM). Brass wire with 0.25 mm diameter and SAE 4140 steel with 10 mm thickness were used as tool and workpiece materials in the experiments, respectively. It is found experimentally that the increasing pulse duration, open circuit voltage and wire speed, increase the Surface Roughness whereas the increasing dielectric fluid pressure decreases the surface roughness. The variation of workpiece Surface Roughness with machining parameters is modelled by using a power function. The level of importance of the machining parameters on the workpiece Surface Roughness is determined by using analysis of variance (ANOVA).

R. Ramakrishnan , L. karunamoorthy(6) studied the effect of various machining parameter such as pulse on time, wire tension, delay time, wire feed speed, and ignition current intensity has been studied though machining of heat-treated tool steel. It was identified that the pulse on time and ignition current intensity have influenced more than the other parameters considered in this study.Moreover the multiple performance characteristics such as material removal rate, surface roughness, and wire wear ratio for the WEDM process can be improved concurrently.

Yan-Cherng Lin & Ho-Shiun Lee(7) focused their attention on the effects of the novel process of magnetic-force-assisted EDM, and the optimizing machining parameters associated with multiple performance characteristics of magnetic-force-assisted EDM was determined using gray relational analysis. They observed that the topography of the machined surface was smoother than that of conventional EDM. Moreover, the thickness of recast layer and the surface cracks on the machined surface were significantly reduced in the magnetic-force-assisted EDM process. The machining parameters of magnetic-force-assisted EDM could be optimized for multiple performance characteristics. Moreover, MRR, EWR, and SR were greatly improved when the machining parameters were set at the optimal levels.

E. Aliakbari & H. Baseri (8) in their study determined , the optimal setting of the process parameters on rotary EDM. A total of three variables of peak current, pulse on time, and rotational speed of the tool with three types of electrode were considered as machining parameters. Then some experiments have been performed by using Taguchi's method to evaluate the effects of input parameters on material removal rate, electrode wear rate, surface roughness, and overcut. Moreover, the optimal setting of the parameters was determined through experiments planned, conducted, and analyzed using the Taguchi method.

J. Y. Kao & C. C. Tsao & S. S. Wang & C. Y. Hsu (9) In their paper, parameter of the electrical discharge machining process to Ti–6Al–4V alloy considering multiple performance characteristics using the Taguchi method and grey relational analysis was reported. Performance characteristics including the electrode wear ratio, material removal rate and Surface Roughness are chosen to evaluate the machining effects. The process parameters selected in this study were discharge current, open voltage, pulse duration and duty factor. The validation experiments shown an improved electrode wear ratio of 15%, material removal rate of 12% and Surface Roughness of 19% when the Taguchi method and grey relational analysis are used.

Venkata Rao & V. D. Kalyankar(10) observed in their review paper that the research on variety of materials was made using EDM process which includes large number of ceramics, composites, tool steels and various alloy steels including aluminum.

PROPOSED METHODOLOGY

In this research work, experiments are to be carried out on the Electrical Discharge Machine. The Tool electrode is a Cylinder of copper of 10 mm diameter and 50 mm height. AISI D2 steel was selected as workpiece with size- 100 x 100 x 10 mm (shape- Rectangle). Based on Literature survey parameters chosen as input parameters are Discharge current, pulse On time (Ton) and pulse Off time (Toff) with the Surface Roughness (Ra) as output parameter. Spark gap, Dielectric fluid and Voltage are the constant parameters. Machining Parameters and their Levels are shown below in Table: 1

Table 1: Machining Parameters

Machining Parameter	Symbol	Unit	Levels			
			Level 1	Level 2	Level 3	Level 4
Discharge Current (DC)	DC	A	3	8	12	14
Pulse On Time (Ton)	Ton	µs	12	14	15	18
Pulse Off Time (Toff)	Toff	µs	16	14	13	18

EXPERIMENTATION

The Experimentation is performed by operating on Electrical Discharge Machine (Die-Sinker Type), CHMER 50NZ whose polarization on Electrode be Positive and that of Work piece is Negative. Dielectric is Recycled EDM Oil.
The machine contains following measures-

1. Power Supply unit and CNC function
2. Leak proof tank along with tool fixing chuck.
3. Tool holding device
4. Servo control unit for vertical movement of the tool.

CONDUCT OF EXPERIMENT

Copper as tool material having 10 mm solid diameter and the die sinker EDM machine is used. EDM oil was used as dielectric fluid (Specific Gravity = 0.763, Freezing Point 94ºC) to perform experiment. Manual Side flushing was used to flush away the eroded material from the sparking zone. For a four level and three factors, total 16 trials are completed on Die sinking EDM. The results of these trials are tabulated as below in Table: 2

Table: 2 Results of Trials

Experiment	Discharge current(A)	Ton(micro sec)	Toff(micro sec)	Surf (Ra)
1	3	12	16	2.91
2	**3**	**14**	**14**	**2.13**
3	3	15	13	3.34
4	3	18	18	3.92
5	8	12	14	3
6	8	14	16	3.84
7	8	15	18	3.43
8	8	18	13	4.2
9	12	12	13	4.6
10	12	14	18	5.02
11	12	15	16	5.4
12	12	18	14	5.96
13	14	12	18	4.88
14	14	14	13	5.25
15	14	15	14	5.61
16	14	18	16	6.1

These experiments are conducted according to Taguchi Design method by using the machining set up with Solid Copper Electrode and manual side flushing. Experiments are varied to complete 16 altered trials with machining parameters like DC, Ton, Toff are varied to measure Surface Roughness.

CONCLUSION

The Experiment was performed to get optimum value of surface roughness. Discharge Current, Pulse on time and Pulse off time have been found to be influential parameters of Surface Roughness in EDM. The results are as below

1. **DISCHARGE CURRENT**

Observation from the present experiment is that the increase in Discharge Current increases the Surface Roughness. Minimum Surface Roughness is produced at 3A and maximum Surface Roughness is produced at 14A.

2. **PULSE ON TIME**

The pulse on time is another factor that shows the variation in Surface Roughness. Minimum Surface Roughness is produced at 14µs.

3. **PULSE OFF TIME**

The pulse off time is another factor that shows the variation in in surface roughness. Minimum Surface Roughness is produced at 14µs.

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