Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

ANALYSIS OF MATERIAL REMOVAL RATE IN ELECTRICAL DISCHARGE MACHINING (EDM) BY TAGUCHI METHOD

Rahul Kaduskar[1] Nidhi Panchal[2] Dhruv Joshi[3] Anshi Singh[4] Prof. Chetan Solanki[5]
[5]Assistant Professor

[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Gujarat Technological University Institute of Technology and Management Universe

Abstract— *Electrical discharge machining (EDM) is an unconventional machining process that uses the concept of controlled spark discharges which increases the temperature of the surface of work-piece and results into the removal of material from work-piece. EDM is used to machine materials which are hard in nature and have very high strength. There is no direct contact between the tool and work-piece, hence there is no mechanical energy involved in this process. The objective of experiment is in increasing the Material Removal Rate (MRR) by optimizing the working parameters of EDM machine. The work piece used here is Inconel 601- a nickel-chromium alloy having high resistance to high temperature oxidation. Graphite which has high temperature strength and good thermal and electrical conductivity is used as an electrode. Kerosene is used as a dielectric because of its good insulation and cooling properties. The 3 working parameters to be optimized are Peak current, Supply voltage and Arc Gap. The design of experiment was done by Taguchi method with the help of Minitab software. The findings were such that MRR found to be increasing with the increase in current and voltage whereas MRR is found to be decreasing with the increase in Arc gap. The final findings have been showcased by graphs generated with the help of Minitab software.*

Key words: *EDM, Material removal rate (MRR), Inconel, Die-sinker EDM, Taguchi Method, Minitab.*

I. INTRODUCTION

EDM is the process of machining electrically conductive materials by precisely controlled sparks. This process is capable of producing complex and intricate shapes. It can machine hard materials which cannot be easily machined by conventional machines, hence it finds wide acceptance in industries. The foundation of electric discharge machining can be traced in 1770s when English physicist Joseph Priestley discovered the erosive effect of Electric discharges. However, the electric discharge has been exploited for constructive purpose in the year of 1943 at Moscow University by Lazarenko. The Lazarenko EDM system used resistance- capacitance type of power supply which was used at EDM machines in 1950s and later served as model for further development in EDM. Electric Discharge Machining is a non-traditional machining process. It is an electro-thermal process which does not involve direct contact between tool and work-piece. Here, electrical energy is used to generate sparks which removes material of work-piece due to their thermal energy. It is widely used in manufacturing of tools and dies, surgical instruments, aerospace components, automotive parts etc. EDM can also machine three dimensional complex micro components and microstructures from metallic substrate and semiconductor substrate and can machine small hole easily. It has been effectively used in machining hard, high strength and temperature resistance materials. Thus, the comprehensive study of the effects of EDM process parameters on the performance characteristics such as material removal rate, surface roughness, electrode wear rate is of great significance.

Different researchers use different process parameters to analyze & optimize performance characteristics of EDM.
Schematic diagram of EDM machine

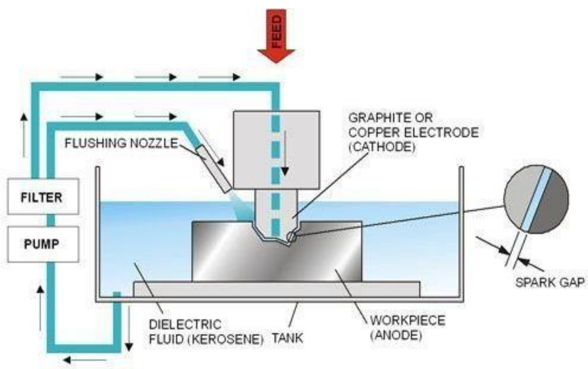


FIG. 1: ELECTRIC DISCHARGE MACHINING

II. MECHANISM IN MRR

The mechanism of material removal of EDM process is the conversion of electrical energy into thermal energy. During the process of machining the sparks are produced between work piece and tool. Each spark produces a tiny crater and crater formation leads to the erosion of the work piece material. Material Removal Mechanism is the process of transformation of material elements between the work-piece and electrode. The transformation is transported in solid, liquid or gaseous state, and then alloyed with the contacting surface by undergoing a phase reaction.

III. PROCESS PARAMETERS

A. *Pulse-On Time:*

It is the time during which the machining takes place. Material removal is directly proportional to the energy applied during the pulse-on time. The length of pulse-on time controls that energy. The material removal rate increase with pulse on time but after certain time it starts decreasing.

B. *Peak Current:*

This is the most important parameter for machining any work material in EDM. It is measured in units of ampere. It is the amount of power used in discharge machining. Higher current will increase the pulse energy.

As the current increases the material removal rate also increases but it also affects the surface finish & electrode wear rate.

C. *Discharge Voltage:*

In the EDM, discharge voltage is related to the spark gap and breakdown strength of the dielectric. Before current can flow, the open gap voltage increases until it creates an ionization path through the dielectric.

Once the current starts to flow, voltage drops and stabilizes at the working gap level.

D. *Interval time:*

It is the time interval between the two consecutive sparks. If off time is too short, it will cause spark to be unstable. If interval time increases, material removal rate decreases.

E. *Arc Gap:*

It is distance between work-piece and the electrode during the process of EDM. It may be called as spark gap.

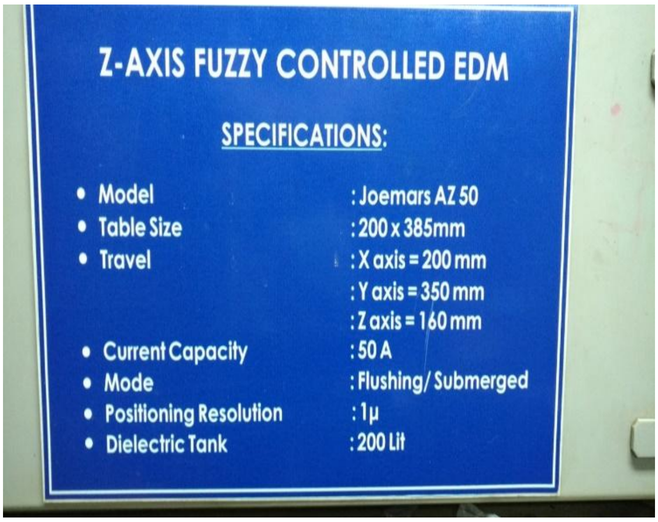
F. *Rotating speed of electrode:*

It is found that MRR and Surface roughness improves with rotary EDM due to effective flushing of eroded debris. Research on rotary electrode for EDM has been carried out for many years in order to analyze its effect on MRR and SR.

G. *Addition of electrical conductive particles in dielectric*

With addition of electrically conductive particles like Al or fine graphite powders in dielectric, both surface roughness and material removal rate improves.

IV. *DESIGN OF EXPERIMENT*



1) Mechanism of Process:

Controlled Erosion

2) Dielectric Fluid:

Kerosene

Properties of Dielectric required

2.1) Insulation: One important function of the dielectric is to insulate the work-piece from the electrode. The disruptive discharge must take place across a spark gap which is as narrow as possible. In this way efficiency and accuracy are improved.

2.2) Cooling: The spark has a temperature of 8,000-12,000° C when it punctures the work-piece and so the dielectric must cool both the electrode and the work-piece. Overheating of the electrode must be avoided, so that excessively high electrode wear cannot occur.

2.3) Ionization: As quickly as possible optimum conditions for the production of an electrical field must be created and then a spark path must be provided. After the impulse the spark path must be de-ionized quickly so that the next discharge can be made. The dielectric ought to constrict the spark path as much as possible, so that high energy density is achieved, which increases discharge efficiency at the same time.

3) Tool Material: Graphite

EDM electrode materials need to have properties that easily allow charge and yet resist the erosion that the EDM process encourages and stimulates in the metals it machines.

Alloys have properties which provide different advantages based on the needs of the application.

Figure 3

Graphite provides a cleaning action at low speeds. Carbon graphite was one of the first brush material grades developed and is found in many older motors and generators. It has an amorphous structure.

Graphite has the features of---

- High temperature strength
- Good thermal and electrical conductivity
- Low thermal expansion
- Appropriate machinability

4) *Work piece Material:*

Inconel 601 is a nickel-chromium alloy, that is highly resistant to oxidation. The alloy has good high temperature strength, and retains its ductility after long service exposure. Inconel 601 alloy has good hot corrosion resistance under oxidizing conditions. It find its application in manufacturing of industrial furnaces, heat-treating, petrochemical and other process equipment's and gas-turbine components. Inconel 601 has high melting temperature range.It ranges from 1320-1370 C. Dimension of the work-piece is 25 x 15 x 5 mm. And depth of cut for experiment is 0.5 mm.

RANGE OF PROCESS PARAMETERS

SR NO.	PROCESS PARAMETERS	RANGE
1	CURRENT	5-60 A
2	VOLTAGE	30-200V
3	ARC GAP	10-120 micrometer

4.5 VALUES OF PARAMETERS TAKEN CONSTANT

PARAMETERS	*VALUES*
ON TIME	38 SEC
OFF TIME	40 SEC
SERVO SENSOR	7
FLUSHING HEIGHT	16
WORKING TIME	10
ARC SENSOR	1
ELECTRODE POLARITY	1

V: RESEARCH METHODOLOGY: TAGUCHI

- Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer.
- Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning.

The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varied; it allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources.

Taguchi design method is to identify the parameter settings which render the quality of the product or process robust to unavoidable variations in external noise.

The experimental analysis using Taguchi method can be done using MiniTAB17 Software.

STEPS INVOLVED IN TAGUCHI METHOD

STEP 1: Formulation of problem

STEP 2: Identification of control factors, noise factors and signal factors (if any). Control factors are the one which can be controlled under normal production condition. Signal factors are those which affect the mean performance of the process.

STEP 3: Selection of factor levels, possible interaction and degrees of freedom associated with each factor and interaction effects.

STEP 4: Design of an appropriate orthogonal array (OA).

STEP 5: Preparation of the experiment

STEP 6: Running of experiment with appropriate data collection.

STEP 7: Statistical analysis and interpretation of experimental results.

STEP 8: Undertaking a confirmatory run of the experiment

VI: RESULTS AND OBSERVATION TABLE

GRAPH GENERATED BY MINITAB17 SOFTWARE

This graph shows the variation between various process parameters namely current, voltage and arc gap with respect to Material removal rate in EDM.

As we can see that with increase in Voltage and Current, MRR increases. But MRR is inversely proportional to Arc gap.

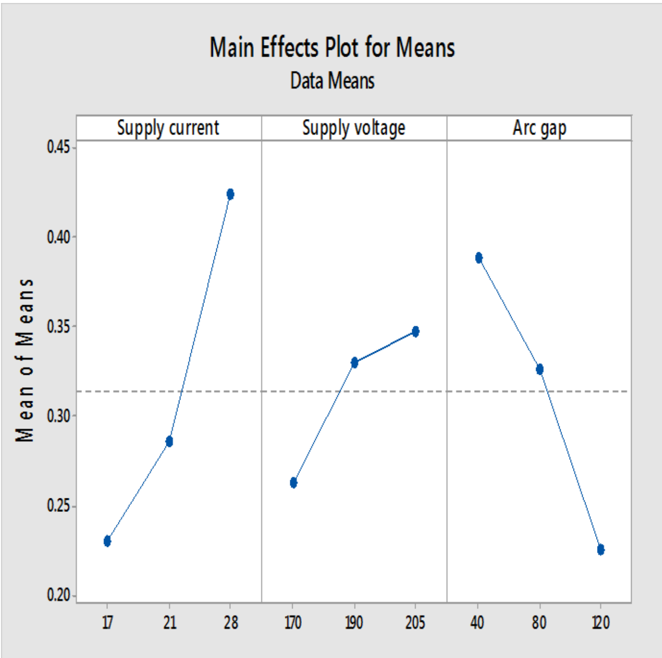
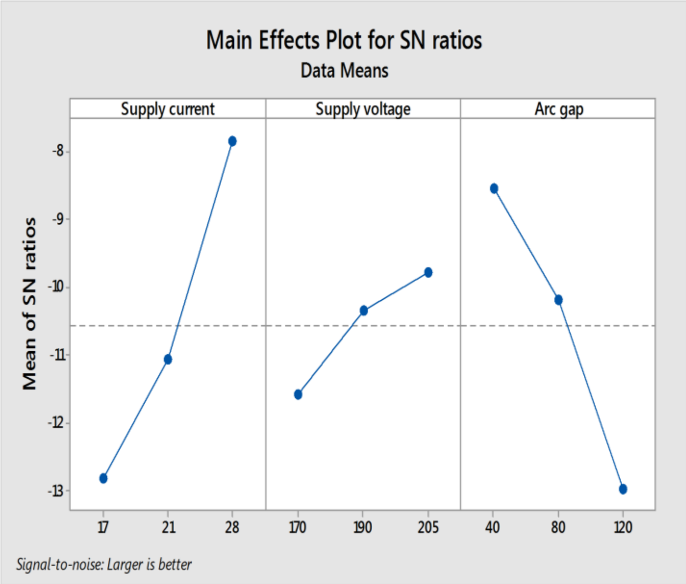


Figure 7



OBSERVATION TABLE

SR NO.	CURRENT (A)	VOLTAGE (V)	SPARK GAP (micrometer)	MASS OF WP BEFORE MACHINING (g)	MASS OF WP AFTER MACHINING (g)	TIME (s)	MRR (g/min)
1	17	170	40	18.65	18.41	52.77	0.267
2	17	190	80	18.68	18.47	53.36	0.233
3	17	205	120	18.75	18.55	60.03	0.192
4	21	170	80	19.03	18.77	60.00	0.262
5	21	190	120	18.89	18.65	60.07	0.226
6	21	205	40	18.74	18.48	41.52	0.369
7	28	170	120	19.07	18.79	60.07	0.260
8	28	190	40	19.04	18.76	31.92	0.530
9	28	205	80	18.91	18.65	33.28	0.483

VII: CONCLUSION AND FUTURE SCOPE

- In this project we have optimized different process parameters like current, voltage and arc gap to get maximum material removal rate during EDM.
- From experimental observation table we can say that MRR is highest in trial 8 which is having 28 A current, 190V and 40 micrometer arc gap.
- We can conclude that both current and arc gap are the most significant control parameters to effect MRR.
- We have found that, with increase in current value, MRR increases.
- With increase in voltage value, MRR increases.
- With increase in arc gap, MRR decreases.

- Thus we can say that, current and voltage are directly proportional to MRR but arc gap is inversely proportional to MRR.

- By using various other process parameters and electrode and work piece material, further analysis of material removal rate in EDM can be done in future.

ACKNOWLEDGEMENT

The completion of this experiment would not have been possible without the supervision and guidance of **Prof.** CHETAN SOLANKI **(**Professor**,** Mechanical Engineering Department, I.T.M Universe, Vadodara).

REFERENCES

[1] Dr. Rajeev Kumar Garg, Mr. Kuldeep Ojha, “A review of tool electrode design for sinking EDM process”, ISBN 978-960-474-283-7

[2] Mohd Amri Lajis “The Implementation of Taguchi Method on EDM Process of Tungsten Carbide “European Journal of Scientific Research ISSN 1450- 216X Vol.26 No.4 (2009), sssssssspp.609-617

[3] Prof. S.R.Nipanikar “Parameter Optimization Of Electro Discharge Machining Of AISI D3 Steel Material By Using Taguchi Method” Journal of Engineering Research and Studies E-ISSN0976-7916.

[4] Production Technology Book by Dr. R.P Arora

[5] K.S.Banker , A.D. Oza , R.B. Dave “Performance Capabilities of EDM machining using Aluminium, Brass and Copper for AISI 304L Material” International Journal of Application or Innovation in Engineering & Management (IJAIEM) ISSN 2319 – 4847 Volume 2, Issue 8.

[6] BP Manual, Dielectric fluid for electro discharge machining, 1986

[7] HMT, “PRODUCTION TECHNOLOGY”, Tata McGraw Hill.

[8] Dinesh Kumar, Nibu Mathew, Naveen Beri, Anil Kumar “Study Of Material Removal Rate of Different Tool Materials during EDM of H11 Steel at Reverse Polarity” International Journal of Advanced Engineering Technology E-ISSN 0976-3945.

[9] CP Mohanty, J Sahu, SS Mahapatra. Thermal Structural Analysis of EDM Process,Proc. Eng.51(2013)508-513.

[10] Hitesh Prajapati, Hiren Prajapati, V A Patel. “Experimental investigation of performance of different electrode material in EDM for MRR and Surface Roughness” International Journal of Engineering Research and Application (IJERA) Volume 2 Issue 3, ISSN: 2248-9622.

[11] T Masuzawa, X X Cui, N. Taniguchi, Improved Jet flushing for EDM, Ann CIRP 41(1) (1992) 239-242.

[12] M Kuneida, T Masuzawa, A fundamental study on Horizontal EDM, Ann CIRP 37 (1) (1998) 187-190.

[13] J S Soni, G Chakraverti. Machining characterstics of titanium with Rotary EDM, Wear 171(1994) 51-58.