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STUDY AND EVALUATION OF SURFACE ROUGHNESS AND MRR OF EN24 STEEL TOOL IN EDM PROCESS

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ABSTRACT:
Electrical discharge machining is one of the first non-traditional manufacturing, commonly used in industry for the production of rare profiles of components with an acceptable precision. In this paper the model of material removal rate, electrode wear rate, and surface roughness by the reaction technique of the surface has been attempted in the sinking EDM cycle. The optimization took place in two stages using a provisional assessment criterion and a box-Behnken method consisting of three variables and three rates for the calculation of critical experimental conditions. Pulse on time, pulse off time, and peak current were changed during the tests, while a copper electrode having tubular cross section was employed to machine through holes on EN 24 steel alloy work piece. The results of analysis of variance indicated that the proposed mathematical models obtained can adequately describe the performances within the limits of factors being studied. The experimental and predicted values were in a good agreement. Surface topography is revealed with the help of scanning electron microscope micrographs.

1.0 INTRODUCTION

Electrical discharge machining also known as EDM has been proven as an alternative process for machining complex and intricate shapes from the conductive ceramic composition. It is a non-conventional machining method. In electrical discharge machining process electrical energy is used to cut the material to final shape and size. Efforts are made to utilize the whole energy by applying it at the exact spot where the operation needs to be carried out. It is generally used for machining of very tough and brittle electrically conducting material. In this experiment EN24 steel is used as work piece and copper is used as tool. EN series is a popular steel tool. There are three input variable parameters used which are current, pulse time and duty cycle. Taguchi method is used to create L9 orthogonal array of input variables

PRINCIPLES OF EDM

Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape. The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the workpiece. This removes (erodes) very tiny pieces of metal from the workpiece at a controlled rate.

Figure: Experimental setup

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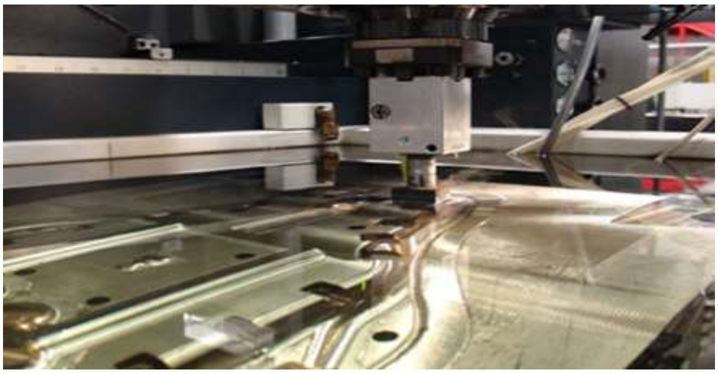

Figure: the surface by discharge machining

ADVANTAGES OF EDM

- Complex shapes can be machined which is difficult in conventional cutting tools.
- In EDM process no cutting force generated as there is no contact between workpiece and electrode so it permit the production of small and fragile surfaces.
- Extremely hard material can be machined without deformation
- Any types of conductive material can be machined
- Burr free edges can be produced
- Intricate details and very high surface finish can be obtained
- Fine holes can be drilled easily

Boujelbene et al. [1] carried out experiment on two electrical discharge machines to obtain high surface finish and other machining aspects. By doing experiment they found out increasing discharge energy, impulse the MRR increases and surface becomes rougher and white layer thickness increases. This happens because of more melting and recasting of material. They also found that if the degree of induce stream exceeds the maximum tensile stress of material cracking will occur.

Hwa-Teng Lee et al. [2] have done experiments and found out that the value of MRR and surface roughness increases with increasing the values of pulse current but after certain value the MRR and SR reduces due to expansion of electric plasma. The pulse current affects the surface crack density while the pulse on duration influences the degree of crack opening. The residual stress induced by hole drilling increases with increasing values of pulse current and pulse on time.

K.M. Patel et al. [3] investigated the machining characteristics, Surface integrity and material removal mechanism of Al_2O_3-SiCw-Tic with EDM. They concluded that the surface roughness and recast layer increases with current and pulse on time. The material removes because of dissociation melting and evaporation and to some extent oxidization and decomposition at lower current and thermal spelling at higher current.

3.0 METHODOLOGY

It is a conventional machining method. In electrical discharge machining process electrical energy is used to cut the material to final shape and size. Effort is made to utilize the whole energy by applying it to exact spot where the operation needs to b carried out. There is no mechanical pressure existing between the work piece and electrode and there is no contact between them. Any type of conductive material can be machined by using EDM irrespective of the hardness or toughness of material. When a potential difference is applied between two conductors emerge in a dielectric medium the fluid will ionized

SELECTION OF MATERIAL

The steel tool EN-18 is one of the famous steels of the EN Series. Carbon mixture and alloys are EN steels. During the World War, the EN Series arrived and is the product of British standard steels (BS970). Generally carbon, magnesium, silicone, sulfure, phosphate, chromium , nickel and molybdenum are included in this steel.

EN24 MATERIAL PROPERTIES:

EN24 is a very high strength steel alloy which is supplied hardened and tempered. The grade is a nickel chromium molybdenum combination - this offers high tensile steel strength, with good ductility and wear resistance characteristics. With relatively good impact properties at low temperatures, EN24 is also suitable for a variety of elevated temperature applications

Table: Chemical composition of En24

Size mm	Tensile Strength N/mm^2	Yield Stress N/mm^2	Elongation	Impact Izod J	Impact KCV J	Hardness HB
63 to 150	850-1000	680 Min	13%	54	50	248/302
150 to 250	850-1000	654 Min	13%	40	35	248/302

Selection of tool:

Various types of materials may be used as an EDM process tool, such as steel, brass aluminium alloy, silver alloy, etc. Copper shape is 21 mm in diameter cylindrical

Figure: Copper tool

Evaluation of Surface Roughness:

Surface roughness is the measure or is often referred to as roughness for surface hardness. The row is µm. It is possible to define vertical variation of the surface from the ideal one. The rough surface is supposed to be elevated, if the variation is greater, and if the deviations are lower, it will be level. Usually, surface roughness is measured using a lightweight profilometer model of talysurf.

Machining Parameter	Unit	Levels		
		1	2	3
Discharge Current	A	1	5	9
Pulse on time	µs	100	500	1000
Duty Cycle (Tau)	%	50	65	85

4.0 RESULT AND DISCUSSION

The quality of a machined surface is becoming more and more important to satisfy the increasing demands of sophisticated component, longevity and reliability. Die steel and OHNS steel has wide range of physical and Mechanical properties which are available in the Indian market depending on their Carbon percentage. As per that EN-24 increase of number indicates lower the carbon %. OHNS steel is also the same strength as EN-24 Liao et al. had given details about electrical discharge machining (EDM) as a well-established non-conventional machining option for manufacturing electrically conductive and geometrically complex or hard material parts an appreciable number of elements diffused from the electrode to the work-piece and vice versa

Expt. no.	Pulse time I (A)	Pulse time T_{on} (µs)	Duty Cycle T_{au} (%)	MRR (mm^3/min)	Surface Roughness (µm)
1	1	100	50	0.24221	3.8
2	1	500	65	0.21685	7.13
3	1	1000	85	0.10205	6.13
4	5	100	65	2.03954	7.4
5	5	500	85	2.00242	8.26
6	5	1000	50	0.89272	7.13
7	9	100	85	5.76275	7.8
8	9	500	50	5.58673	12.67
9	9	1000	65	5.38266	12.33

From the above design matrix, I have conducted the nine experiments from EDM machine with machining time 10 min. taken for each experiment. The impact on the work piece by machining process is shown in the below figure

ANALYSIS AND DISCUSSION OF MRR

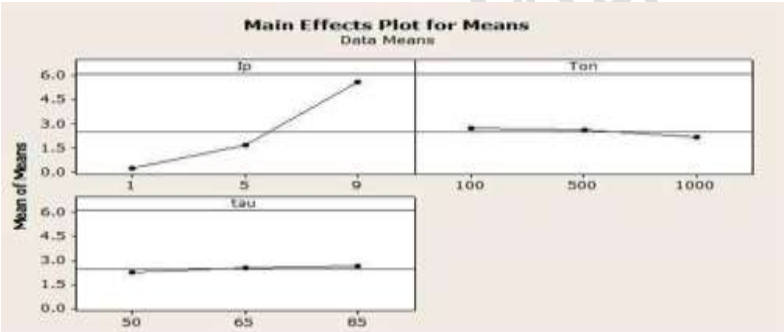

Figure: Main Effects Plot for MRR

- The MRR decreases with the rise in the Ip interest. The value change average for MRR is higher than the Ip spectrum (5A to 9A) (1A to 5A).
- The MRR marginally decreases as I increase the sound values from 100µ to 500µs. The MRR value decreases more quickly as the value rises from the 500µs to the 1000µs.
- MRR is rising from 50% to 65% as the rate of service increases. Yet MRR rises are very small after 65 percent.

Table: Estimated Model Coefficients for MRR

Term	Coef.	SR Coef.	T	P
Constant	2.46944	0.08983	27.490	0.001
Ip 1	-2.28240	0.12704	-17.966	0.003
Ip 5	-0.82455	0.12704	-6.490	0.023
T_{on} 100	0.21206	0.12704	1.699	0.237
T_{on} 500	o.13157	0.12704	1.063	0.409
T_{au} 50	-0.22298	0.12704	-1.809	0.212
T_{au} 65	0.07691	0.12704	0.605	0.606

S = 0.2695 R-Sq = 99.7% R-Sq(adj) = 98.8%

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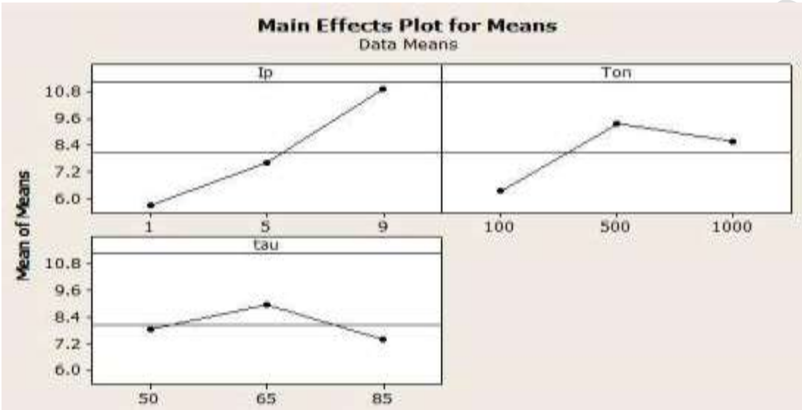
Table: Response Table for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Ip	2	46.6271	46.6271	23.3136	321.01	0.003
T_{on}	2	0.5411	0.5411	0.2705	3.73	0.212
T_{au}	2	0.2465	0.2465	0.1232	1.70	0.371
Residual Error	2	0.1453	0.1453	0.0726		
Total	8	47.5599				

It is observed in the ANOVA table that only Ip is important since the value of its P is smaller than 0.05. Ton and Tau 's value P is greater than 0.05. The most significant attribute is Ip, which is followed by Ton and Tau. The normal error range, S = 0.2695 And R^2 = 99.7%

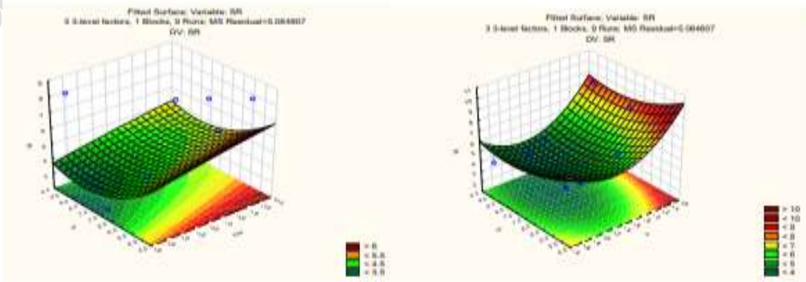


Graph: Main Effects Plot for SR

- The increase in Ip value increases surface roughness. SR increases at a good rate from 1A to 5A, but increases at a quick rate from 5A to 9A.
- Surface ruggedness increases with sounds from 100µs up to 500µs as the sound decreases from 500µs up to 1000µs.
- The Surface Roughness increases with the Tau increasing from 50% to 65%, while the value of SR decreases after 65% when I increase Tau up to 85%.

Surface plots:

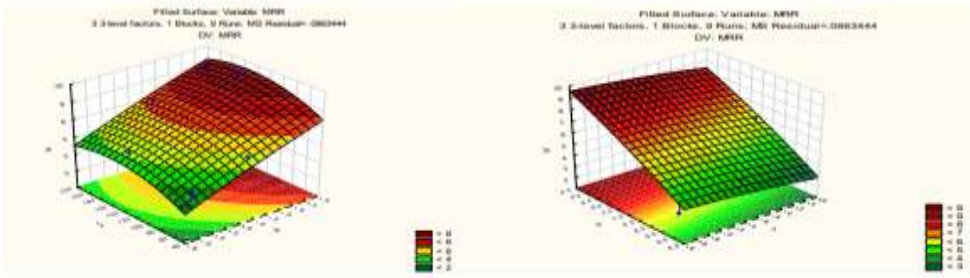
the three-dimensional surface plot of surface roughness (SR) against pulse on time (Ton) and discharge current (Ip), when the Ton increases SR increases and Figure) when Ip increases SR decreases. Similarly, when V increases, SR increases and when Ip increases SR has slightly increases shows the impact of voltage on the SR.



(a) (b)

Figure: Three -dimensional surface plots of the main effects of Ip, Ton and V

three-dimensional surface plot of MRR against pulse on time (Ton) & discharge current (Ip) and Ip & V respectively. However, Ip has greater impact on MRR as compared to Ton and V, in which MRR increases rapidly as the Ip increases.



(a) (b)

Figure:(a) & (b): Three-dimensional surface plots of the main effects of Ip, Ton and V

The conduction of experiment depends upon various parameters settings such as discharge current (Ip), pulse on time (Ton) and voltage (v) have been selected. Based on L9 orthogonal array by taguchi design was conducted and STATISTICA 9.0 software package was used for analysis of the experiment.

CONCLUSION

In this study of EDM process experiments were conducted considering variable parameters voltage and feed rate on EN-24 alloy steel by considering Taguchi design. Nine experiments were conducted to obtain high MRR and low surface roughness. Although I didn't get any factor as significant from ANOVA table, for both MRR and surface roughness, but by looking at the response table, it was quite clear that tool feed rate was effecting most to obtain high MRR and low surface roughness.

The experiments are performed using three vector parameters Ip, Ton and Tau in electric discharge, model ELECTRONICA – ELECTRAPLUSPS 500ZNC (the discharge type). The purpose of the experiment is to find the rating and surface ruggedness of the materials extracted and the results of these variables. The electrode used is copper and the steel En24 Device is a workpiece. This work uses Taguchi to construct an orthogonal sequence L9 and experiments are carried out accordingly. The following inference can be drawn from experiments:

- From the results of MRR we conclude that the discharge current is most significant or influencing factor then pulse on time and at last is voltage on the given input.
- MRR increased linearly with some extent of current and increases and decreases slightly with pulse on time. In case of surface roughness, the voltage is the effective parameter after that current and voltage are less effective on machined work piece.
- The value of Ton is lower than that of Tau. Ip is more important for MRR. Increases MRR not linearly as I raise Ip. As the sound raises the MRR marginally decreases and raises in Tau insignificantly.

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