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EDM machining of die steel EN8 and testing of surface roughness with varying parameters

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A B S T R A C T

EN 8 belongs to BS 970 standard and is an unalloyed medium carbon steel used for where some better then normal mild steel which is having carbon ranges from 0.3 to 0.6%. The surface roughness of die while machining on EDM machine depends upon the working parameters of the machine. These working parameters will give fine, super fine and coarse roughness surface on the work piece. The main methodology consists of gauging of these parameters and analyzing the surface roughness. For this the experiment has conducted on EDM machine and the surface roughness will be measured and analyzed. Concept of single variable at a time approach at a time will be used to find out the effect of input parameters on the Surface Roughness. A series of experiments would be conducted to study the effects of various machining parameters of EDM. In each experiment, one input variable would be varied while keeping all other input parameter at fixed value. Studies will be undertaken to observe the effect of selected parameters viz; discharge current, T-ON pulse on time, T-OFF pulse off time, wire feed, servo voltage, MRR and Surface Roughness.

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1. Introduction

The also known as spark machining, spark eroding, burning, die sinking, wire burning or wire erosion, is a manufacturing process whereby a desired shape is obtained by using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or "electrode," while the other is called the work piece-electrode, or "work piece." The process depends upon the tool and work piece not making actual contact. The EDM process is most widely used by the mold-making, tool, and dies industries, but is becoming a common method of making prototype and production parts, especially in the aerospace, automobile and electronics industries in which production quantities are relatively low. In low cost dies which are useful for making general components like plastic buttons and small clips the die need to be tested and can not be of plain carbon steel. Experimental work done to enhance the surface hardness and wear resistant of plain EN8 steel by flame hardening and to check how it behaves on Electrical discharge machining (EDM). The die sinking method of machining give performance on various process parameters such as discharge current, pulse on time, pulse off time, wire feed, servo voltage and MRR. According to these parameters the machining quality need to be assessed. The fine, super fine finishing and coarse roughness are end result of variation of these machining parameters [1–3].

2. Objective

The main objective of this work is to find a way for machining of work piece through EDM with optimum surface finish. There are many parameters in EDM die sinking that can be considered. Three level process parameter such as voltage (V), T-On pulse on time (μs), T-Off pulse OFF time (μs) and peak current (A) with two level of factor (High) and (Low) considered for this study. By controlling the chosen processes parameters the required surface roughness will be derive and the final result will be evaluate in order to get

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Fig. 1. Heat Treatment of EN8 alloy steel sample.

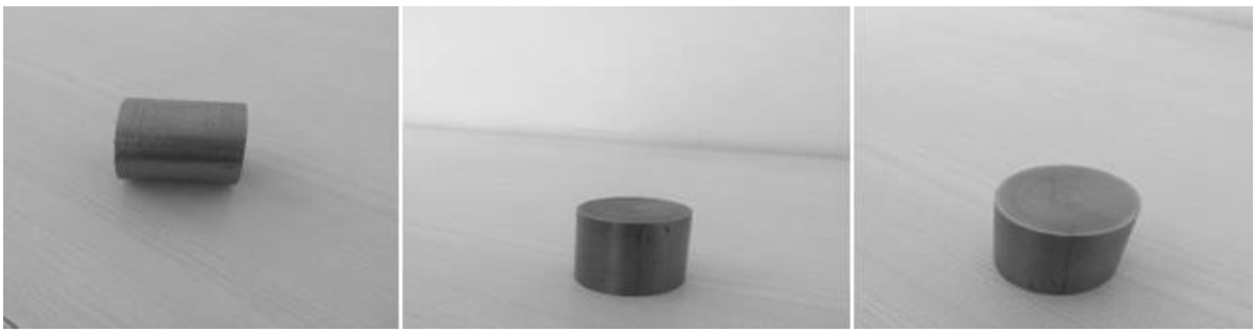

Fig. 2. Final work piece of EN8 alloy steel.

Fig. 3. Copper Electrode of EDM Machine.

Table 1
The chemical composition of EN8 and EN24 alloy steel.

Material	Carbon%	Silicon %	Manganese%	Sulphur%	Phosphorus%
EN8	0.36–0.44	0.1–0.4	0.6–0.1	0.05 max	0.05 max

Table 2
Dimensions of the copper electrode.

Total length of electrode	50 mm
Tool length	24 mm
Tool breadth	7 mm
Tool width	7 mm
Diameter of base cylinder	12.67 mm

the most significant machining parameter that influences fine surfaces roughness (see Figs. 1–3 and Tables 1 and 2).

- To produce a die of EN-8 tool steel by the process of die sinking EDM machine.
- To evaluate and compare the quality of the surface roughness that would be produced from the EDM machining EN-8 tool steel.
- To find significant parameter and optimum value of surfaces roughness from the surfaces quality evaluation.

3. Methodology

3.1. Selection of raw material

The workpiece materials which we have used in this research is EN-8. EN-8 is a medium strength steel that is suitable where good all-round performance is required. Achieving a fine finish is more difficult in the case of EN-8 because the material tends to 'rip', especially evident during fine pitch dry screw cutting. The objec-

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Fig. 4. Copper electrode adjusted in a Die sinking EDM machine.

tive of using this materials is because of the reason that the used material have good strength and we could define the parameters for other high strength material too (see Figs. 4 and 5).

The difference being the composition of Manganese, Sulphur and phosphorus in both the materials is the main reason for some of the difference in their properties. This variance in properties would let use determine the best way for optimizing the surface finish for different type of materials (see Table 3).

3.2. Preparation of samples

The initial samples of EN8 alloy steel are not fit for EDM machining. The mechanical process that took place to produce the final workpiece ready for EDM machining is as follows.

- Cutting a required amount of piece from the initial sample with a hex saw producing a sample with fixed dimensions and allowance.
- Hardening and oxidizing the material by heating it in a Hearth furnace with the use of coke, wood coal to 1073 K.
- Turning operation is applied upon the sample piece after hardening.
- Surface grinding and cylindrical grinding operations are performed and a smooth finished workpiece is obtained which could be then used for machining [4–6].

The dimension of final workpiece has a Diameter of $32^{+-0.005}$mm and the length is $25^{+-0.001}$mm.

3.3. Preparation of tool

The tool that we have used in this research is made of copper. The base is of cylindrical one and the front end of the tool has a rectangular face. Copper and copper alloys have better EDM wear resistance than brass. We use the copper electrode as it would give a fine finish as compared to electrode of other materials [7,8].

3.4. Final testing

The size and dimensional accuracy of the die and the hole produced in the die of EN8 alloy steel are observed and analyzed by metrological operations. The surface roughness testing would be done in two ways for higher precision of the result [9,10]. One would be the manual inspection and calculation and other would be the spectroscopy method which would give us a high quality high precision result. After machining a surface roughness tester MITUTOYO SJ 210 series is used to obtain Ra, Rb and Rz values. MRR is calculated by the ratio of metal removed in single spark vs cycle time [11–13].

Table 3
Specifications of SZNC-EDM.

SR.No.	Description	Unit	S-50-6040
1	Work Tank Dimensions	MM	900 × 600 × 400
2	Table Size	MM	600 X 400
3	X-Axis Travel With Ball Screw.	MM	325
4	Y-Axis Travel With Ball Screw.	MM	225
5	Z-Axis Travel With Ball Screw.	MM	250
6	Table assembly construction	MM	With LM Guides
7	Maximum Job Height	MM	250
8	Maximum Job Weight	KG	800
9	Day Light	MM	600
10	No. Of Filters	NO	3
11	Dielectric tank capacity	LITRES	400

Table 5
Surface Roughness Observation.

Slot No.	Ra (μm)	Rb (μm)	Rz (μm)
1	9.790	12.188	50.906
2	7.069	13.672	68.909
3	5.795	7.069	30.795

Table 4
Parameters Set.

Slot No.	T-ON (Pulse on time in seconds)	T-OFF (Pulse Off time in seconds)	Current (A)	Voltage (V)	Time Taken
1	10	20	10	45	1 min and 50 s
2	15	15	20	45	1 min and 37 s
3	15	30	20	45	58 s

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Table 6
EWR v/s MRR EWR – Electrode Wear Rate MRR – Metal Removal Rate.

EWR	3.9	3.5	4.7	3.5	4.1	5.9	7.4	5.7	5.8	7.2	12.9	11.6	10.9	13.8	10.2
MRR	14.00	14.53	14.608	15.66	16.16	17.80	18.26	18.86	18.87	19.56	20.96	23.37	26.42	28.99	29.03

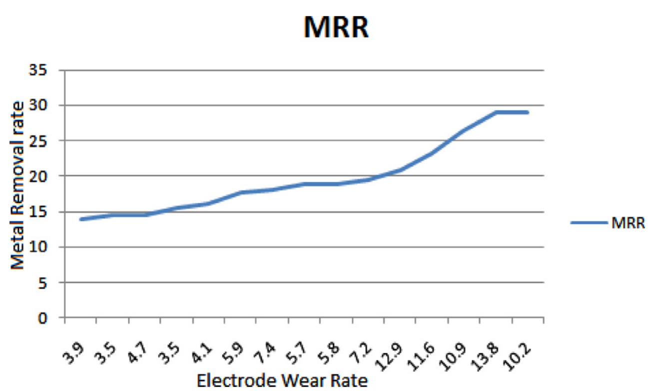

Fig. 5. Relation between EWR and MRR.

4. Implementation

4.1. Tools required

- EDM Machine and its accessories
- Specimen
- Surface Roughness Tester MITUTOYO SJ 210
- Work piece material of EN-8
- Copper electrode

4.2. Parameters set

See Table 4

4.3. Surface Roughness Observation

See Tables 5 and 6, Fig. 5.

5. Results and conclusion

A study of the surface integrity of EN-8 tool steel workpiece in die sinking EDM is presented in this paper. Die sink EDM was conducted on a SAVITA S-50-6040, 7*7*50 mm copper piece as the electrode in distilled water as dielectric fluid. The EDM Machining has low MRR but it has its own implication with parameters. The low MRR machining always needed to set output of good surface finishing and low surface roughness. The experiment conducted in varying operational parameters to check the surface roughness value for EN8 die material. According to the results if T-On (Pulse On time – The duration on which pulse is applied in form of voltage) and T-Off (Pulse off time) with values 10–20, 15–15 and 20–30 with set current and voltage not much varying in nature but the Rz value is changing drastically. This is not because of material properties and its observed where the same value to process parameters the time taken for machining is playing an important role for machining quality, surface finishing and surface roughness. According to the data collected it can be concluded that if we are taking more time for machining on EDM where low MRR is observed the more time taken more the Rz value and less time taken for machining less the Rz value. The EWR Electrode wear rate is in proportion to the MRR for higher values of process parameters.

CRediT authorship contribution statement

Anurag Joshi: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Amit Kumar Saraf:** Resources, Software, Supervision, Validation. **Ravi Kumar Goyal:** Supervision, Validation, Visualization.

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