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Parametric Optimization of Electro Discharge Machining Processes

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ABSTRACT

This project involves the multi-objective optimization of process parameters of Electrical Discharge Machining for obtaining minimum surface roughness, minimum tool wear rate and maximum material removal rate. The important machining parameters were selected as peak current, gap voltage and puls on time. Experiments were conducted by selecting different operating levels for the three parameters according to Taguchi's Design of Experiments. The multi-objective optimization was performed using Grey Relation Analysis to determine the optimal solution. The Gray Relation Grade values were then analyzed using Analysis of Variance to determine the most contributing input parameters.

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I. INTRODUCTION

Electrical discharge machining is basically a non-conventional material removal process. This process is widely used to produce dies, punches and moulds, finishing parts for aerospace and automotive industry and surgical components. This process can be successfully employed to machine electrically conductive work pieces irrespective of their hardness, shape and toughness. During EDM process, the electrode shape is mirrored in the work piece. The electrode dimensions are determined in such a way, that spark gap between the surfaces of electrode and work piece are auto generated between piece and electrode. Higher gap between electrode and work piece is required so as to remove the material at higher rate but this result in poor surface quality. The performance of the EDM process is highly dependent on the material and the design of the electrodes. The electrode has two parts, i.e. electrode tool and holder. Both these parts are often designed and manufactured into single piece. The simple electrodes are normally manufactured by conventional cutting methods, but machining, casting, electroforming or metal spraying may produce complicated shaped electrodes. In die-sinking electrical discharge machining process, in general, either fixed electrodes are used to produce die cavities or a rotary device works in conjunction with a CNC to control the electrode's path in various EDM profiling [5-7]. Manufacturing method of electrode also affects manufacturing time, cost and performance of EDM electrode in order to maintain quality.In present day's scenario, EDM is used as a standard technique for manufacturing production tooling out of hardened materials for production of dies and moulds. Due to rapid tool wear involved, many electrodes are often required for machining each cavity. Tool wear affects machining accuracy and demand for frequent tool replacement adding to around 50% of tooling cost. Alternatively use of rapid tooling technique minimizes the electrode development lead-time and reduces the tooling cost considerably. Therefore, design, development and manufacturing of EDM electrode play a very vital role in EDM technology. A lot of published EDM research work relates to parameter optimization for a particular work tool interface or to determine best tool material for a particular work material. Many innovative electrode material and designs have also been tried worldwide.

II. OBJECTIVE

1) To carry out a drilling operation of Hot die steel D3 workpiece by electric discharge machine.

2) To carry out a Taguchi L9 orthogonal array design of experiment.
3) To study the effect of variation of pulse-on time (T_{on}), peak current (I_p), and gap voltage (V_g) on material removal rate (MRR), electrode wear rate (EWR), and Material removal rate (MRR) of the drilled holes.
4) To carry out a statistical analysis (ANOVA test and regression analysis) on the collected data to find out the effect of variation of machining parameters on response factors.
5) To find out the optimum set of input parameter by using Taguchi Method.
6) To take final experiment of optimum set (verification).

III. LITERATURE REVIEW

[1] Mr. C. Bhaskar Reddy sir's review on Electro Discharge Machining has been commonly applied for machining and micro machining of parts with intricate shapes. Main advantage of process is relatively low machining speed as compare to other conventional machining process due to its thermal machining technique

[2] Mr. S. R. nipanikar sir's research paper the EDM process is only useful on electrically conductive materials. The disadvantage of this process is it can't be employed on electrically or magnetically nonconductive materials.

[3] Mr. Anand pandey & Mr. shankar Singh sir's, review on current research trends in variants of Electro Discharge Machining. They found out that present manufacturing industry is facing challenges. To meet these challenges, non-conventional machining processes are being employed to achieve higher MRR and better surface finish & Greater dimensional accuracy with less tool wear

[4] Mr. Sushil Kumar Choudhary sir's, study on Use of powder mix in electrolyte provides mirror like surface finish, increase which MRR & no stresses are produced in work piece. Proper work piece and powder combination must be used for better results.

[5] Mr. Raghuraman s. & Mr. Santosh S. Sir's,investigate the optimal set of process parameters such as current, pulse ON and OFF time in Electrical Discharge Machining (EDM) process to identify the variations in three performance characteristics such as rate of material removal, wear rate on tool, and surface roughness value on the work material for machining Mild Steel IS2026 using copper electrode. Based on the experiments conducted on L9 orthogonal array.

[6] Mr. chadharmauli sir's & Mr. shrinivas Balaraj sir's, investigate the optimalprocess parameters of Electric Discharge Machining on RENE80nickel super alloy material with aluminum as a tool electrode. Theeffect of various process parameters on machining performance isinvestigated in this study. The input parameters considered are current,pulse on time and pulse off time are used for experimental work andtheir effect on Material Removal Rate, Tool Wear Rate and SurfaceRoughness. The Taguchi method is used to formulate the experiment.

IV. WORKING PRINCIPLE OF EDM

EDM is a thermoelectric process in which heat energy of spark is used to remove material from the work piece. The work piece and the tool should be made of electrically conductive material. A spark is produced between the two electrodes (tool and work piece) and its location is determined by the narrowest gap between the two. Duration of each spark is very short. The entire cycle time is usually few micro-seconds (μs). The frequency of sparking may be as high as thousands of sparks per second. The area over which a spark is effective is also very small. Temperature of the area under the spark is very high. As a result, the spark energy is capable of partly melting and partly vaporizing material from the localized area on both the electrodes, i.e. the work piece and tool. The material is removed in the form of craters, which spread over the entire surface of the work piece. Finally, the cavity produced in the work piece is approximately the replica of the tool.

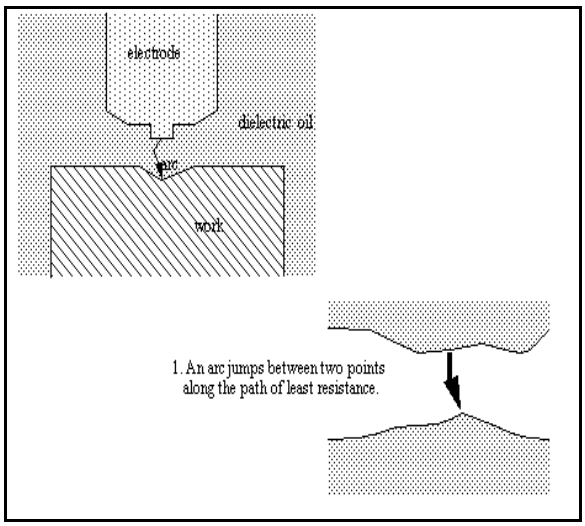

Fig. 1 Step 1 of EDM Process

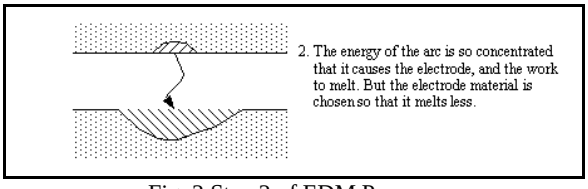

Fig. 2 Step 2 of EDM Process

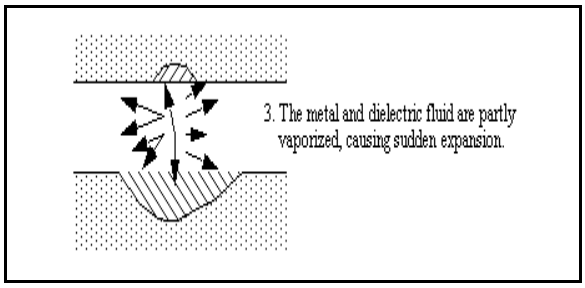

Fig. 3 Step 3 of EDM Process

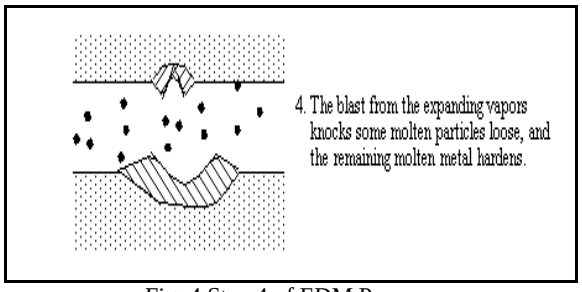

Fig. 4 Step 4 of EDM Process

V. METHODOLOGY

The proposed work will be carried out with following steps.

1. Identification of material.
2. Identification of process parameters.
3. Selection of process parameters.
4. Design of experiment.
5. Experimentation on EDM.
6. Testing of response parameters.
7. Optimization of process parameters.
8. R & D of different parameters.
9. Conclusion.

VI. DESIGN OF EXPERIMENT

The design of experiment (D.O.E.) chosen for the electric discharge machining of Hot Die steel was a Taguchi L9 orthogonal array, by carrying out a total number of 9 experiments along with 1 verification experiments (optional).

L9ORTHOGONAL ARRAY

In L9(3^4)array 9 rows represent the 9 experiment to be conducted with 4 columns at, 3 levels of the corresponding factor. The matrix form of these arrays is shown in table 3.1, where 1, 2, 3 in the table represents the level of each parameters.

Taguchi L9 Orthogonal Array Design Matrix

Experiment No.	Factor 1	Factor 2	Factor 3
E1	1	1	1
E2	1	2	2
E3	1	3	3
E4	2	1	2
E5	2	2	3
E6	2	3	1
E7	3	1	3
E8	3	2	1
E9	3	3	2

Level Values of Input Factors

Sr. No.	Factors	Levels		
		1	2	3
1.	T_{on} (µs)	100	150	200
2.	I_p (Amp)	5	10	15
3.	V_g (Volt)	50	55	60

SCOPE

Research may focus on the multi objective optimization of other manufacturing process. The standard optimization procedure can be developed and optimal results are to be validated. Most research work in Electro Discharge Machining relates to use of 3D form tool, different type of tools are yet to be tried. Copper electrode has frequently been used as electrode material in ultrasonic vibration assisted Electro Discharge Machining. Other different metallurgical electrode fluid needs to be investigated thoroughly.Performance of water based die electric is yet to be investigated for machining materials like Composite and Carbide.

DISCUSSION

EFFECT OF INPUT FACTORS ON MATERIAL REMOVAL RATE (MRR)

Peak current (I_p) have the largest contribution to the total sum of squares, i.e.67.53 %. Factor Gap voltage (Vg) has much less contribution to the total sum of squares, 10.33 %.

The larger contribution of a particular factor to the total sum of squares, the larger the ability is of that factor to influence material removal rate (MRR).

So peak current (I_p) have the maximum effect on material removal rate whereas pulse-on time (T_{on}) and Gap voltage (Vg) have less effect.

EFFECT OF INPUT FACTORS ON ELECTRODE WEAR RATE (EWR)

Gap voltage (Vg) has the largest contribution to the total sum of squares, i.e. 42.82 %. Factor Peak current (Ip) has very less contribution to the total sum of squares, i.e. 27.16 %. The larger contribution of a particular factor to the total sum of squares, the larger the ability is of that factor to influence electrode wear rate (EWR).

So factor Gap voltage (Vg) has the maximum effect on electrode wear rate .Whereas Peak current (Ip) have much less effect on electrode wear rate.

EFFECT OF INPUT FACTORS ON SURFACE ROUGHNESS

Peak Current (Ip) has the largest contribution to the total sum of squares, i.e. 79.89 %. Factor Gap voltage (Vg) has very less contribution to the total sum of squares, i.e. 7.11 %. The larger contribution of a particular factor to the total sum of squares, the larger the ability is of that factor to influence surface roughness (Ra).

So Peak current (Ip) has the maximum effect on surface roughness .Whereas gap voltage have much less effect on surface roughness.

VII. CONCLUSION

Experimentations be there accompanied according to Taguchi design method by using the machining set up and the solid tungsten carbide rod electrodes with side flushing. The control parameters are discharge current (Ip), pulse duration (Ton) and voltage (V). Experimentations were varied to complete 9 altered trials and the weights of the work piece for calculation of MRR and with the help of profilometer surface roughness (Ra) have been measured.

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