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Parameter optimization of Electro Discharge Machine of AISI 304 Steel by using Taguchi Method.

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ABSTRACT

Electrical discharge machining (EDM) is one of the non-traditional machining processes, based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. The optimization of the parameters of the EDM machining has been carried out by using the taguchi's method for design of experiments (DOE). In recent years many ways has been found for improving the MRR of the WORK PIECE. Taguchi method has been used for design of experiments with three input parameters and their three levels using L9 array. In the research nine experiment had been done along with copper tool material as well as AISI 304L material had been used as a work piece. The dielectric used is kerosene diluted with water. The main objective of the research is the analysis to optimize the process parameters of EDM with the help of taguchi method and using Minitab software in terms of MMR. The different parameters considered while carrying out the experiments on EDM would be the current, Ton, Toff, Time required, Depth of cut etc,. The research findings show that the copper having high material removal rate with respect to other material such as aluminum, gun metal, brass, etc.

1. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. EDM is mainly used to machine difficult to machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive. Spark erosion Machining is a process based on the disintegration of the dielectric and current conduction between the Job and work piece by an electrical discharge occurring between them. This process is also called as Electro Discharge Machining/Electro Erosion Process/Electro Spark Machining. In this method the Job and the work piece (which act as electrodes) are separated by a certain gap filled with a dielectric medium. A pre-set pulse is applied across the Job and work piece. Depending upon the micro irregularities of Tool and Work piece surfaces, and presence of carbon and metal particles, the dielectric is broken down at several points producing, the dielectric is broken down at several points producing ionized columns which allow a focused stream of electrons to flow and produces compression shock waves and there is an intense increase in the local temperature. Due to the combined effect of these two particles of metal are thrown out, very much similar to the boiling out of water. As erosion progresses the gap changes and that gap is continuously maintained by the servomechanism.

2. LITERATURE REVIEW

Vishnu D Asal et al. conducted experiment [1] on Process parameters of EDM by using the ANOVA method. In this experiment, two level of current, tool material, and spark gap are kept as the main variable. They use the material of S.S.304 as the work piece and copper and brass as the tool electrode and also DEF-92 as dielectric fluid. The design of experiment is used to design the EDM experiments. The various tool of DOE are used to analyze the final result of the experiment with the help of graphs in research. The analysis is being done with the help of mini-tab 15 software. ANOVS is performed to identify the statistical significance of parameters. They conclude that Material Removal Rate process accounting for over 88.31 percent main effects of the total variability. The MRR is maximum achieved when tool material is Copper, current is higher level (17 amp), and spark gap volts is set as low (5 volts). The TWR is achieved maximum at the tool is Copper, current is higher level (17 amp), and spark gap voltage is low level (5 volts). For surface roughness is minimum at the current is at low level (9 amp) and spark gap voltage at low level (5 volts). It also noticed that tool material does not show any effect on surface roughness. Chandramouli S et al. conducted [2] investigating EDM process parameters by using the Taguchi method and select the optimum result from that. The effect of various process parameteron machining performance is investigated by the Taguchi method. They use the input parameters as current, pulse time on, and pulse time off and the other side of Material removal rate (MRR), Tool wear rate (TWR), and surface roughness (SR). The taguchi method is used to formulate the experimental layout, ANOVA method is used to analysis the effect of input parameters on machining characteristics and find the optimum process parameters. They conclude that for getting optimum MRR the set of process parameters are current is high level (24 amp), pulse time on is low level (10 µs) and pulse off time is high level (50 µs). The TWR is decreasing with increase in pulse time on and it increase with pulse time off increase. The optimum set of surface roughness is current is low level (6 amp), pulse time on is low level (10 µs), and pulse time off is high level (50 µs). Raghuraman S et al. Performed [3] on mild steel IS 2026 by using the taguchi method. In this paper the input process parameters such as current, pulse time ON, pulse time OFF and the other side of the output parameters selected as Material removal rate, tool wear rate and the surface roughness of the work piece material. They used the work piece material as mild steel 2026 and the electrode as copper. In this paper the main objective of to find the maximum MRR and select the best process parameters. For this getting result they use the Taguchi DOE and use the L_9 orthogonal array and analysis on them. The confirmation experiments were carried out to validate the optimal results. Thus, the machining parameters for EDM were optimized for achieving the combined objectives of higher rate of material removal, lower wear rate on tool, and lower surface roughness on the work material considered in this work. The obtained results show the taguchi Gray relational Analysis is being technique to optimize the machining parameters for EDM process. M. atheswaran et al. Performed [4] on Taguchi method of DOE. They use the numbers of method as orthogonal array, the signal-to-noise (S/N) ratio, and analysis of variance (ANOVA). In this experiment they study the performance characteristics in machining operations of titanium material using copper electrode as machine tool. In machining the process parameters use as current, pulse time ON, pulse time OFF are studied in favor of getting optimum surface roughness property. Through this study they not only get the optimum process parameters, but also the main machining parameters that affect the machining performance in EDM process can be found. Vishal J Nadpara et al. performed [5] on AISI D3 tool steel using graphite electrode of 10 mm diameter. The process parameters are taken on the basis of Taguchi Method. The objective of the paper is to optimize the process parameters of machining in high. Medium and low wear factors through duty cycle. In this paper they use the input process parameters as current, duty cycle and pulse time ON and the opposite side the output process parameters as MRR and EWR. In this they also used as taguchi method for getting the optimum result of selecting the best process parameters. MohdAmriLajis et al. implemented [6] of taguchi method on the EDM which having Tungsten Carbide as work piece. They use as tool electrode as tungsten Carbide and also they then applied taguchi method on the numbers of experiments. The taguchi method is used to formulate the experimental layout, to analyze the effect of ech parameters on the machining process and they predict the optimal choice for EDM parameters such as current, Ton, Voltage, and interval time. This all parameters have significant influence on MRR, EWR, and SR. in this paper they also use the ANOVA method for finding the optimal and residual value for the MRR. Nilesh M. Vohra optimizing [7] of various parameters which are affected on different types of machining characteristics of EDM. The objective of this paper is to investigate the optimum cutting parameters for a work piece of SS 304 & tool material use as copper, aluminum and brass combination on fuzzy logic control based EDM. This experiment was accomplished by Taguchi Method. In this paper they use process parameters are Current, spark gap voltage, Ton, and Toff. And at the other side of output they use MRR, TWR, and SR. In the paper they conclude that the Gap voltage has highest effect on MRR.

3. METHODOLOGY

The selection of the material and work piece on the basis of reviewed research paper and the selected tool is copper and work piece material is AISI 304L stainless steel. According to the taguchi method of experimental design the experiment has been done with 9 experimental run. The input parameter is current, Ton and Toff and output parameter is MRR. The researcher has selected the three level of input parameter. The parameters are current, Ton and Toff and the level of parameters are (12, 12, 14), (5, 6, 7), (9, 8, 7) respectively.
Material removal rate (MRR) and Signal to noise ratio is calculated as following

$$MRR = \frac{[(\text{weight before machining}) - (\text{weight after machining})]}{[(\text{time duration}) \times (\text{material density})]}$$

For this experiment S/N ratio, is taken as the "**Larger is Better**" so the equation to find out signal to noise ratio is,
$S/N = -10 * \log (\Sigma (1/Y^2)/n)$

Fig. 1. Tool and work material

Fig.2 Electrode setup

In addition to the above table, Mini-Tab software has been utilized for finding the signal to noise ratio and also means for most affecting parameters. The all solution of signal to noise ratio and means value are shown below.

4. RESULT AND DISCUSSION

The finding of the research is obtained using minitab 17 software. The S-N ratio for each and every experiment is taken as "Larger is Better" condition. Weigh of the workpiece material is taken before and after the machining on EDM and with help of weigh and desity, material removal rate is obtained. The Effect of input parameters on the output parameter is recorded in the table The nine experiments done on the electro discharge machine based on the taguchi method and summarized in the following table.

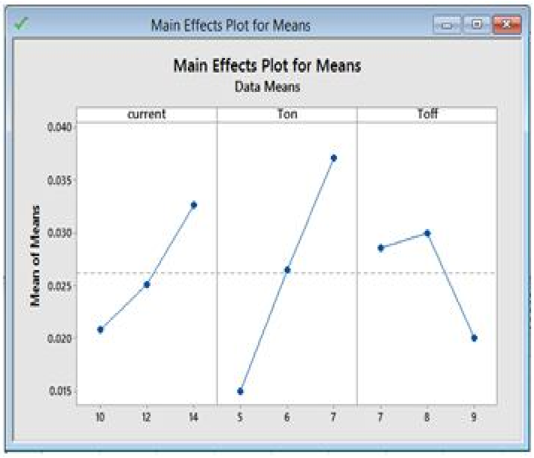
Experiment no	Process Parameters			Weight before(gm)	Weight after(gm)	Time taken(min)	MRR(cm^3/min)
	Current (A)	Ton(µs)	Toff(µs)				
1	10	5	9	327.50	322.90	89.31	0.00643
2	10	6	8	334.38	328.92	24.00	0.02843
3	10	7	7	336.32	330.73	25.22	0.027706
4	12	5	8	327.10	323.41	41.10	0.01122
5	12	6	7	348.19	343.96	17.30	0.03056
6	12	7	9	314.80	310.73	15.20	0.03347
7	14	5	7	308.93	305.55	15.40	0.02743
8	14	6	9	325.81	322.39	21.02	0.02033
9	14	7	8	335.90	331.81	10.21	0.05007

Table.4.1Experimental Result

In addition to the above table, Mini-Tab software has been utilized for finding the signal to noise ratio and also means for most affecting parameters. The all solution of signal to noise ratio and means value are shown below.

Level	Current	Ton	Toff
1	0.02086	0.01503	0.02857
2	0.02508	0.02644	0.02991
3	0.03261	0.03708	0.00983
Delta	0.01175	0.02206	0.00983
Rank	2	1	3

Table.4.2 Response table for means of MRR



Graph.1. Main effect plot for Means

From the above response table for means of MRR it has been claimed that the Ton parameter has the greatest effect on the MRR and the same has been proved from the graph of main effect plot for means. It has also been observed from the following table that the optimum parameter set for the MRR is Current-14, Ton-7, Toff-8.

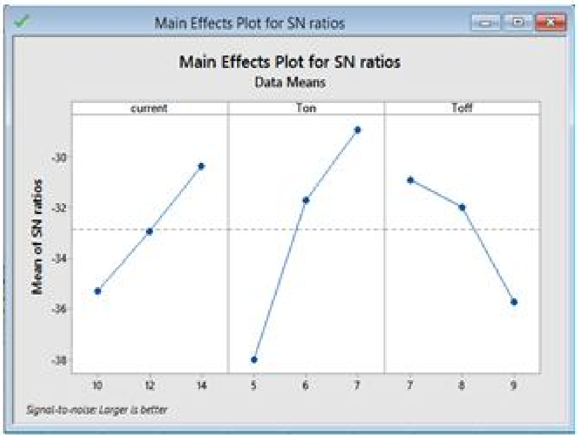
current	Ton	Toff	MRR	SNRA1	MEAN1		PSNRA1	PMEAN1
10	5	9	0.006430	-43.8358	0.006430		-24.4100	0.0458916
10	6	8	0.028430	-30.9245	0.028430			
10	7	7	0.027706	-31.1485	0.027706			
12	5	8	0.011220	-39.0001	0.011220			
12	6	7	0.030560	-30.2969	0.030560			
12	7	9	0.033470	-29.5069	0.033470			
14	5	7	0.027430	-31.2355	0.027430			
14	6	9	0.020330	-33.8373	0.020330			
14	7	8	0.050070	-26.0084	0.050070	OPTIMUM SET OF PARAMETERS		

Table. 4.3 Final result table from Mini-Tab

The response table and graph of S-N ratio support the above result that Ton has the greatest effect on the MRR.

Level	Current	Ton	Toff
1	-35.30	-38.69	-30.89
2	-32.93	-31.69	-31.98
3	-30.36	-28.89	-35.73
Delta	4.94	9.14	4.83
Rank	2	1	3

Table. 4.4 Response table for S/N ratio of MRR



Graph 2. Main effect plot for SN ratio

From all the above detailed analysis of various process parameters of EDM process, it has been concluded that. The "Ton" parameter has the greatest effect on the output parameter MRR. Optimum parameters of input factors as follows:Current = 14 A, T_{on} = 7 µs, T_{off} = 8 µs If the current is higher than the Material Removal Rate is grater with respect to the Toff time. It has also been proved that copper having high material removal rate with respect to other material like as aluminum, gun metal, brass, etc.

5. FUTURE SCOPE

Various theoretical models describing material removal mechanism have been proposed by the researchers from time to time. Still a lot of in-depth study is required to better understanding and development of the EDM process. Future scope which would express this research is some non-electrical parameters like electrode rotation and work piece rotation while machining improve the flushing conditions and thus may improve MRR.Performance of water based dielectric is yet to be investigated for machining materials like composites and carbides. Selection of different types of electrode would also change in MRR, TWR, And Surface roughness. It may also be used the hybrid Electric Discharge Machine such as Abrasive and Dielectric mixture EDM, Magnetic EDM, etc.

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