A Review of Parameter Optimization of Electro Discharge Machine 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 this research we have used taguchi's method for design of experiments with three input parameters and their three levels using L9 orthogonal array. We have done 9 experiments with the tool material copper and work piece material AISI 304. The dielectric used is kerosene diluted with water. The objective of the analysis is to optimize the process parameters of EDM with the help of taguchi method and using Minitab software in terms of MMR.

Keywords:-EDM, MRR, TWR, Surface Roughness, Taguchi Method, DOE, Parameter analysis

I. Introduction To Die-Sinking EDM

In EDM, a potential difference is applied between the tool and work piece. Both the tool and the work material are to be conductors of electricity. The tool and the work material are immersed in a dielectric medium.A gap is maintained between the tool and the work piece. Depending upon the applied potential difference and the gap between the tool and work piece, an electric field would be established. If the work function or the bonding energy of the electrons is less, electrons would be emitted from the tool (assuming it to be connected to the negative terminal). Such emission of electrons are called or termed as cold emission. The "cold emitted" electrons are then accelerated towards the job through the dielectric medium. As they gain velocity and energy, and start moving towards the job, there would be collisions between the electrons and dielectric molecules. Such collision may result in ionization of the dielectric molecule depending upon the work function or ionization energy of the dielectric molecule and the energy of the electron. This cyclic process would increase the concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap. The concentration would be so high that the matter existing in that channel could be characterized as "plasma". The high speed electrons then impinge on the job and ions on the tool. The kinetic energy of the electrons and ions on impact with the surface of the job and tool respectively would be converted into thermal energy or heat flux. Such intense localized heat flux leads to extreme instantaneous confined rise in temperature which would be in excess of 10,000 C such localized extreme rise in temperature leads to material removal. Material removal occurs due to instant vaporization of the material as well as due to melting. Thus to summarize, the material removal in EDM mainly occurs due to formation of shock waves as the plasma channel collapse owing to discontinuation of applied potential difference

Fig. 1: Sparkonix EDM Setup [1]

II. Literature Review

In this paper few selected research paper related to Die-sinker EDM with effect of MRR, TWR, surface roughness (SR) and work piece material have been discussed.

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.

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 parameter on 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.

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

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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. Matheswaran 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.

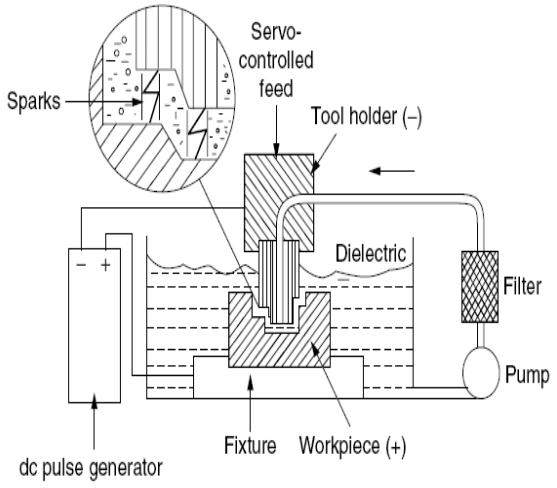

Fig. 2: Working principle of EDM [5]

Mohd Amri Lajis 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 each 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 whichare 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.

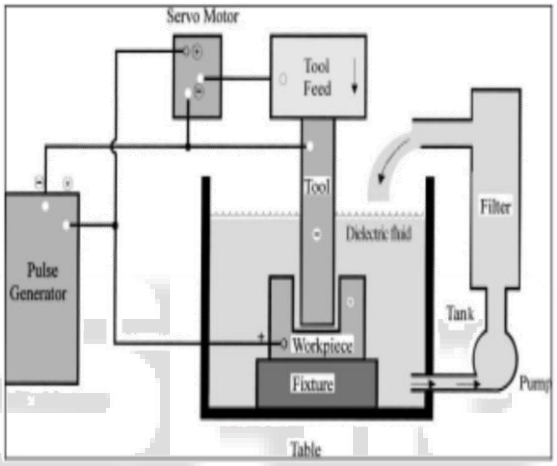

Fig. 3: Experimental setup [7]

S. P. Nipanikar et al. optimizing [8] of process parameters of EDM by the taguchi method. In this they used work piece material as AISI D3 steel material. The Taguchi method is used to formulate the experimental layout, to analyze effect of each parameter on the machining characteristics, and to predict the optimal choice for each EDM parameters such as current, gap voltage, and duty cycle and pulse time on. They use output parameters as MRR and EWR and Radial overcut. The Martial Removal Rate is mainly affected by peak current, and least affected by duty cycle. The EWR is mainly affected by peak current and least influenced by gap voltage. The peak current have maximum effect on radial over cut, and least affected by gap voltage.

D. C. Chen et al. [9] having the purpose of to find process parameters with the help of Taguchi method. The process parameters are used as current, pulse time on, duty cycle, the machining duration. In this paper they use several of method for finding the optimum parameters of EDM. The work piece material A6061-T6 aluminum alloy is used. They use the Taguchi and ANOVA method for finding Optimum result with the help of the Minitab software. The experimental investigations have considered four fundamental EDM parameters, namely the pulse current (PC), the pulse-on duration (ON), the duty cycle (DC), and the machining duration (MD). The optimum set of

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parameter are as, pulse time (1.5 A), pulse on duration (50 µs), duty cycle (20) and machining duration (500 ms). The surface roughness of the machined specimen determined primarily by the values assigned to the pulse current and duty cycle. The optimum parameter setting established for material process also in low surface roughness when applied to the machining of CuZn40 brass alloy specimens, and thus the general applicability of the Taguchi design solution is confirmed.

A. Aravindan et al. optimizing [10] the machining parameters of EDM by using the Robust Design. In this paper they use the Material EN 31 tool with copper as an electrode. MRR has been chosen to evaluate the machining effects. Parameters are selected in this paper current, pulse time on and pulse time off. Taguchi method is used to plan the experiment design L9 orthogonal array and to analyze the effect of each variable. They found that the current is mostly influenced by the peak current. They concludes that discharge current dominates the performance characteristics of the material removal rate, with almost 77.91% in contribution ratio followed by the pulse on time 17.17%. The optimized parameters for the pulse on time, pulse off time and current are 60, 7 and 15 respectively.

III. Conclusion

- From all the above detailed analysis of various process parameters of EDM process, the following points have been observed.
- It has been found that Ton has mostly significant effect on the MRR while the Toff has least effect on MRR.
- IF the current is higher than the Material Removal Rate is grater with respect to the Toff time.

It has also been found that the copper having high material removal rate with respect to some else material like as aluminum, gun metal, brass, etc.

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