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Effects of EDM Parameters on MRR & SR of automobile Chassis material by ANOVA

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Abstract—Electric Discharge Machining (EDM) is a unconventional machining process somewhere compound and complex shapes can be machined. Only electrically conductive materials can be machined by this method. It is accomplished of machining geometrically complex or hard materials, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. To observe the all results EN31 heavy vehicle chassis and D3 steel heavy vehicle chassis with respect to weight, stiffness and strength .These materials are being widely used in die and mould making industries, aerospace, aeronautics and nuclear industries. In this work D3steel is the material used for the machining purpose and Copper is used as an electrode. It is essential to consider most number of input parameters to get the better result. In this process Taguchi approach is used to create L27 orthogonal matrix. Experiments were conducted with the L27 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined. The purpose of ANOVA to see the individual effect of control factors on MRR and SR. In the present work, Optimization of MRR and SR on EDM conducted by using Taguchi and ANOVA.

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Keywords— Die sinking EDM machine, parameter MRR & SR, Taguchi's method, ANOVA.

1. Introduction and Literature Review

Electrical Discharge Machining (EDM) is a process of material removal using an accurately controlled electrical discharge (spark) through a small gap (approximately 10 to 50 microns) filled with dielectric fluid between an electrode and a workpiece. The hardness of the workpiece has no effect on the process.Electrically conductive material is removed by controlled erosion through a series of electric sparks of short duration and high current density between the electrode and the work piece, both the workpiece and tool is submerged in a dielectric bath, containing kerosene or distilled water. During this process thousands of sparks per second are generated, and each spark produces a tiny crater in the material along the cutting path by melting and vaporization. Generally the material is removed by erosion process. This process is not restricted by the physical and metallurgical properties of the work material as there is no physical contact due to high energy electro thermal erosion between the tool and the work piece. The objective of the present work is to find suitable process parameters to minimize the tool wear as a work piece steel and square copper electrode as a tool and dielectric flushing. The machining parameter selected are discharge current, pulse on time ,pulse off time , voltage , fluid pressure of the tool using Taguchi design approach analysing the responses MRR . The Taguchi's method is used to formulate the experimental layout, ANOVA method is used to analysis the effect of process parameters on the machining characteristics and find the optimal process parameters of Electric Discharge Machining. Optimization helps for finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. In this section, some selected research papers have been discussed related to Electrical Discharge Machining. The studies carried out in these papers are mainly concerned with the EDM parameters such as current, voltage, pulse on time, pulse off time and flushing pressure etc.K. J. Buhariwala and J. S. Hansen (1988) added that with the combination of ultrasonic vibration in the MRR and surface finish improved increased. The research work i.e. lower metal introduced rotary disc for grooving operation on titanium alloy. The rotary electrode was placed above the work material. The difficulty of debris problem was encountered removal rate and arching occurs due to the accumulation of debris particle between the electrode and work piece.K.W. Poh, P.H. Dayawansa (1999) Spark erosion with ultrasonic frequency using a DC power supply instead of the usual pulse power supply. The pulse discharge is produced by the relative motion between the tool and work piece simplifying the equipment and reducing its cost. It is easy to produce a combined technology which benefits from the virtues of compared the various performance measures of rotating electrode with the stationary electrode. The results concluded an improvement in MRR due to the better flushing action and sparking efficiency with little TWR but the surface finish was improved. Karaoglu, N. S. Kuralay (2002) optimized the cutting of Al2O3/6061Al composite using rotary EDM with a disk like electrode with Taguchi methodology. Taguchi methodology revealed that, in general electrical parameters (Peak Current, Pulse duration and gap voltage) affects the machining Performance are MRR, electrode wear rate & surface roughness more significantly than the non-electrical parameters speed of rotational disc. High MRR was found due to superior debris disposal effect of RDE. Jakub Šmiraus1, Michal Richt (2011) compared the effects of high and low frequency forced axial vibration of the electrode, rotation of the electrode and combinations of the methods (vibro-rotary) in respect of MRR, TWR & SQ in EDM die sinking and found that vibro-rotary increases MRR by up to 35% compared with vibration EDM and by up to 100% compared with rotary EDM in semi finishing.The objective of this experiment to estimate the material removal rate and tool wear rate by using DIN 1.2714 steel as a workpiece and copper as a tool.

2. Methodology

Taguchi's method is a powerful technique for the design of a high quality system. It provides not only, an efficient but also a systematic approach to optimize designs for performance and quality. Furthermore, Taguchi parameter design can reduce the fluctuation of system performance.

A. This experiment is governed by the following steps are:Select process parameters to be evaluated.

- Select the appropriate orthogonal array and assign these parameters to the orthogonal array.
- Perform the experiments based on the arrangement of the orthogonal array.
- Analyze the experimental results using the signal to noise(S/N) ratio and analysis of variance (ANOVA).

B. Experimental design

1) Step1- Process parameters selection*:* Process parameters and their ranges were determined by the research paper. The parameters are identified for the test such as current, pulse-on time, pulse off time, flushing pressure, gap voltage.

2) Step 2- Orthogonal array selection*:* To select an appropriate orthogonal array for the experiments, on the basis of parameter selection and its levels. Here we have five parameters and three levels are selected.

3) Step 3- Conduct the experiment and Recording of responses*:* Twenty seven experimental runs were conducted as per the Taguchi's L27 orthogonal array. The test runs were carried out at random to avoid a systematic error creeping into the experimental procedure.

It is done by taking mean of S/N ratio of TWR for Different levels (Level 1,2 and 3) of various parameters such as voltage , current ,pulse on time , pulse off time, flushing pressure.Find out Delta for Different parameters:[Delta = { (S/N mean) max - (S/N mean) min }]To find rank of respected Parameter, give Higher rank to the parameter which have larger delta. The parameter with larger delta among all, significantly affect the material removal rate of cupper which needed more attention to control among other parameters.

4) Step 4- Analysis using ANOVA*:* The analysis of variance (ANOVA) is used to discuss the relative importance of all control factors on the machined material quality and also to determine which control factor has the most significant effect. Analysis of variance (ANOVA) is employed to find the optimal process parameter levels and to analyze the effect of these parameters on metal removal rate values and electrode wear rate.

3. Experimentation

A. Experimental set up

The experiments were conducted using the Electric Discharge Machine, model ELECTRONICA 35 ZNC (die sinking type) .The EDM consists of the following parts Dielectric reservoir, pump and circulation system, power generator and control unit working tank with work holding device , X-Y working table , the tool holder, the servo system for feeding the tool. Before experimentation, the work piece top and bottom faces were ground to a good surface finish using a surface grinding machine .The work piece was held on the machine table using a specially designed fixture as shown in fig. The work piece and tool were connected to the negative and positive terminals of the power supply, respectively. The dielectric fluid used here is kerosene. The time taken for machining was recorded. The experiments were conducted in the order of L27 orthogonal array. At the end of each experiment, the work piece was removed from the machine, washed, dried and weighed on an electronic balance..

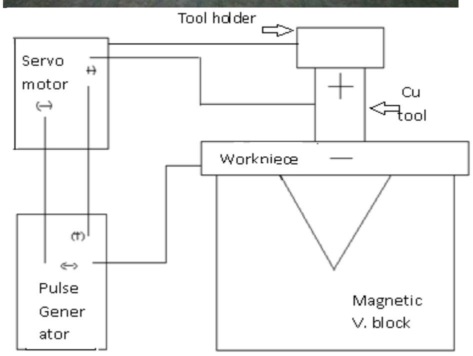


Fig.1 Block diagram for Die sinking electro discharge machining

B. Selection of work piece

- *D3* steel is an important tool and dies material, mainly because of its high strength

4. Experimental Result and discussion

(a) Analysis of Variance (ANOVA)

The results are further analyzed with Analysis of variance (ANOVA) and the F-ratio test is performed to check the adequacy of the model .The results of the ANOVA for MRR, and SR are shown From the ANOVA table it is again analysed that significance level of α=0.05, i.e. for the confidence level of 95% .It has been acceptable that P value less than 0.05 is indicated that the performance of the parameter statistically significant and more than 0.05 less significant to the model. Also it is found that the R^2 value for the MRR, SR are 0.98, 0.96 and 0.98 respectively that significant the R^2 value is closed to 1 which is desirable. The predicted R^2 is in reasonable agreement with the adjusted R^2.

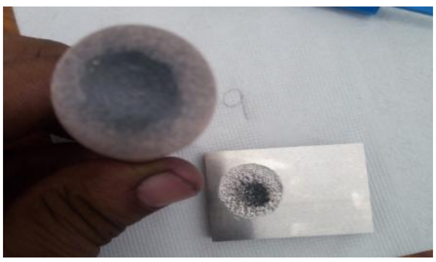
(b) Second order Mathematical Model

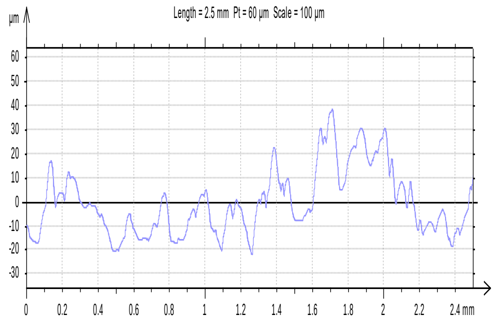
The empirical mathematical relation of the response parameters are defined in terms of process parameter. In this case the model is quadratic in nature involving linear and quadratic interactions of process variables.The mathematical model equation commonly represented by a function (Ø) i.e. R=Ø (T_{on}, I_p, F_p) where

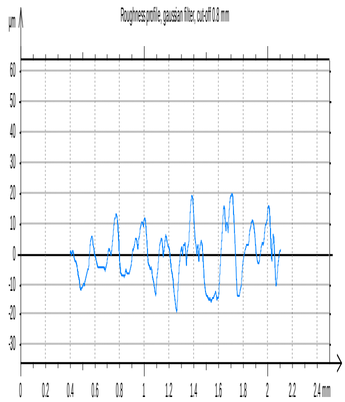
R is defined as the response.

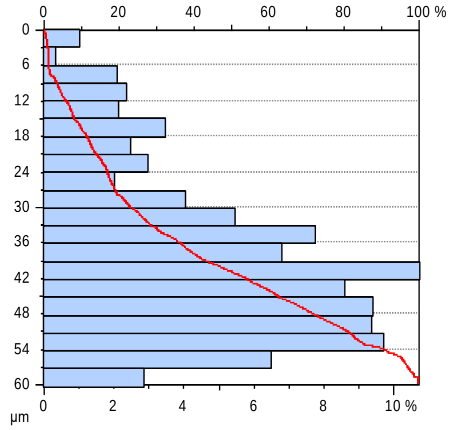
T_{on} is representing pulse on time

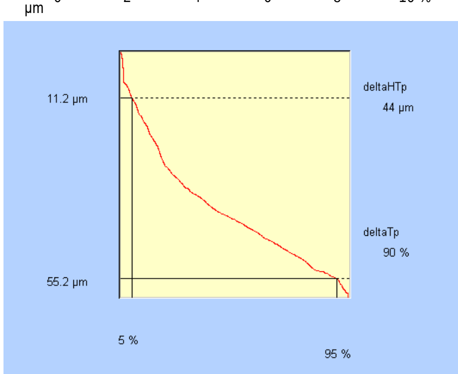
I_p is represent the peak current

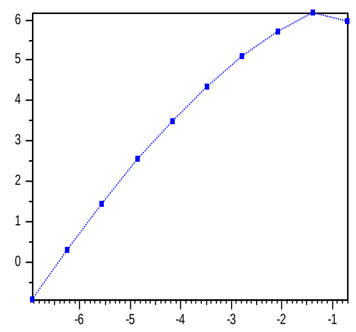




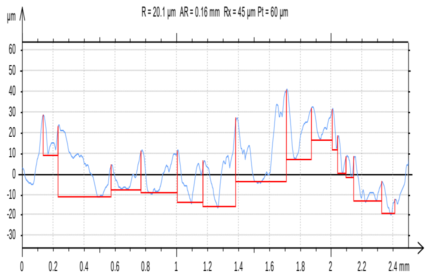




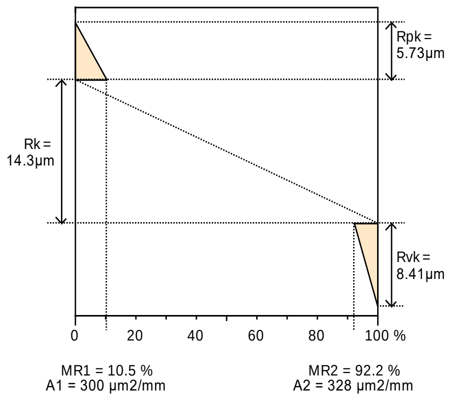


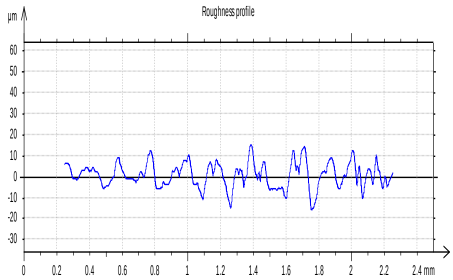


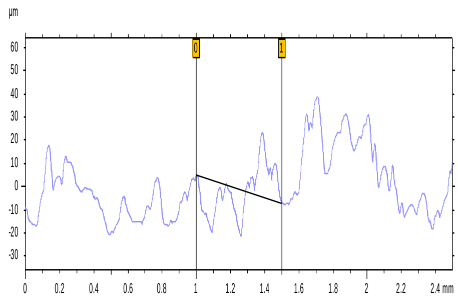
Fractal dimension: 1.22



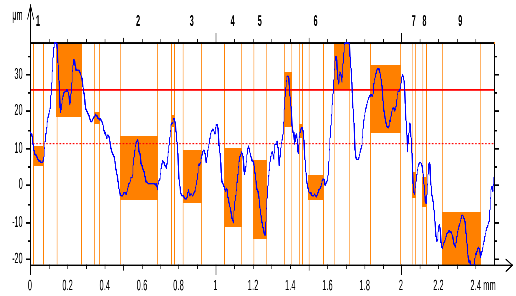
Rk parameters, double filtering, 0.25mm.



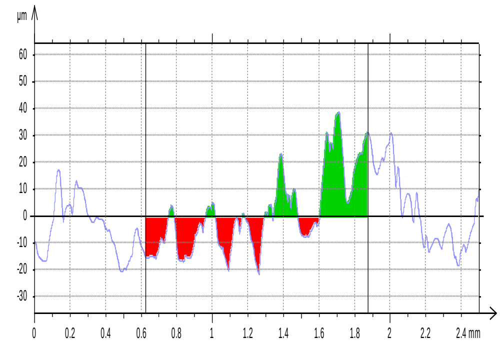




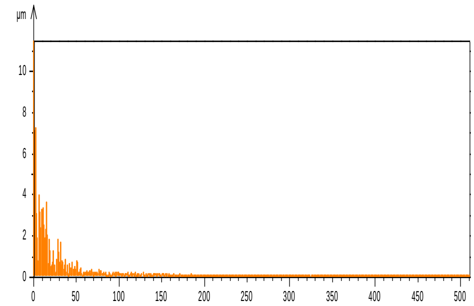
	0-1
Horizontal distance :	0.5 mm
Variation in height :	-12.1 µm



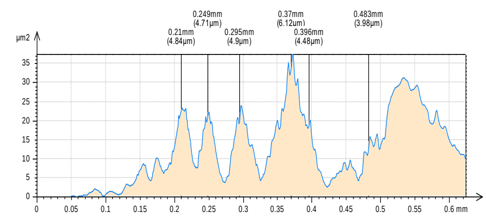
	1	2	3	4	5	6	7	8	9
Maximum depth	19.8 µm	28.8 µm	29.5 µm	35.9 µm	39.3 µm	28.9 µm	28.3 µm	30.6 µm	49.9 µm
Mean depth	18.7 µm	23.4 µm	25.9 µm	27.4 µm	31.4 µm	27.3 µm	26.5 µm	28.8 µm	41.1 µm
Width	0.051 mm	0.195 mm	0.102 mm	0.0905 mm	0.07 mm	0.078 mm	0.017 mm	0.019 mm	0.207 mm



Maximum depth :	20.5 µm	Area of the hole :	5855 µm2
Maximum height :	39.5 µm	Area outside :	8331 µm2



Wavelength # 1 : (2.5 mm)
Magnitude : 11.5 µm
Phase : -96.7° (-1.69 rad)



Zoom factor: x4 Nb iterations: 32 Smoothing: 11

Parameters calculated on the profile Profile

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* Parameters calculated by mean of all the
sampling lengthes.
* A microroughness filtering is used, with a ratio
of 2.5 µm.

Roughness Parameters, Gaussian filter, 0.8 mm

  Ra    = 6.79 µm
  Rz    = 32.6 µm
  Rq    = 8.16 µm
  Rp    = 16.9 µm
  Rv    = 15.8 µm
  Rt    = 38.6 µm
  Rsk   = 0.103
  Rku   = 2.78
  Rmr   = 1.3 %    (1 µm under the highest peak)
  Rdc   = 13.6 µm  (20%-80%)
  RSm   = 0.131 mm
  RDq   = 22 °
  RLq   = 0.133 mm
  RLo   = 7.68 %
  RzJIS = 23.7 µm
  R3z   = 27.9 µm
  RPc   = 7.65 pks/mm      (+/- 0.5 µm)
  Rc    = 17.8 µm
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5. Conclusions

The accumulation of SIC powder in the EDM oil a strongly increase in electrical conductivity and relatively trivial changes in thermal conductivity. This makes the D3 steel susceptible to machining by electrical discharge machining. The study of the surface roughness and MRR integrity of the D3 steel with 1 and 2 wt% CNT content after EDM reveals that the material removal mechanisms in both materials were melting/evaporation. A recast layer with a thickness of few microns in depth is formed in which the presence of C is detected. To observe the all results heavy vehicle chassis and steel heavy vehicle chassis with respect to weight, stiffness and strength. By employing a polymeric composite heavy vehicle chassis for the same load carrying capacity, there is a reduction in weight of 73%~80%, natural frequency of heavy vehicle chassis are 32%~54% higher than steel chassis and 66~78% stiffer than the steel chassis. Present used material for chassis is steel. From the results, it is observed that the polymeric composite heavy vehicle chassis is lighter and more economical than the conventional steel chassis with similar design specifications and MRR and SR also improved in this process.

6. References

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