EXPERIMENTAL INVESTIGATION OF EDM PROCESS PARAMETERS ON HIGH CARBON HIGH CHROMIUM STEEL WITH GRAPHITE

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ABSTRACT`

Electrical spark machining is an advance machining process primarily used for hard metals which are not possible by conventional machine. In die Sinking EDM process, two metal parts are submerged in an insulating liquid and are connected to a source of current which is switched on and off automatically. The analysis of process parameters on responses has been done by conducting a set of experiments on high carbon-chromium steel with graphite as tool electrodes and high carbon oil as the dielectric medium. Central composite design was used for conducting the experiment and developing empirical models for MRR, surface roughness and EWR with the help of Minitab software. Pulse on time is most significant factor over other machining parameters for electrode wear rate with graphite tool.

Keywords: *Electro Discharge Machining (EDM) process, Electrode Wear Rate (EWR), Material Removal Rate (MRR), Machining, Surface Roughness.*

1.Introduction

Electro-Discharge Machining (EDM) is an electro-thermal non-conventional machining Process, in which electrical energy is used to create electrical spark between two electrode and material removal mainly occurs by applied number series electrical discharge between work piece and tool [1,2].Sameh S. Habib is discussed comprehensive mathematical model for correlating the interactive and higher order influences of various electrical discharge machining parameters through response surface methodology (RSM), using relevant experimental data as obtained through experimentation. The proposed models have been tested for accuracy through the analysis of variance (ANOVA) [2].S. Assarzadeh, M. Ghoreishi developed a model and optimize process parameters in Electro-Discharge Machining (EDM) of tungsten carbide-cobalt composite (ISO grade: K10) using cylindrical copper tool electrodes in planning machining mode based on statistical techniques [3]. Neeraj Sharma, Rajesh Khanna, Rahuldev Gupta are study is to investigate the effect of parameters on metal removal rate for WEDM using HSLA as work-piece and brass wire as electrode for machining. HSLA used in cranes, trucks, bridges, roller coasters cars and other structures that are designed to handle large amounts of stress. In this work it is observed that metal removal rate and surface roughness increases with increase in pulse on time and peak current. Wire mechanical tension has no significant effect on surface roughness and metal removal rate [4].P. Kuppan & A. Rajadurai & S. Narayanan show the experimental investigation of small deep hole drilling of Inconel 718 using the EDM process. Some parameters such a pulse on-time, peak current, duty factor and electrode speed were chosen to study the characteristics of machining [5].Kuntal Maji and Dilip Kumar P ratihar was attempt made to model input-output relationships of an electrical discharge machining process based on the experimental data (collected according to a central composite design) using multiple regression analysis [6]. In this work, the study is focused on the studied of process parameters on responses of die-sinking EDM of high carbon high chromium steel by usingGraphite electrodes. This was done using the techniques of surface response methodology (CCD) for conducting series of experiment and analysis of variance (ANOVA) has been done for analysis the data with the help of Minitab.

2.Experimental detail

2.1 Experimental Set-Up

This experimental work was done on die-sinking Electric Discharge Machine at MANIT Bhopal, with constant servo-head and tool electrode used as a positive polarity and work piece used as a negative polarity during experimental time. High carbon EDM oil was used as dielectric medium. Discharge current was allowed in various steps in positive mode of terminal between two electrodes.

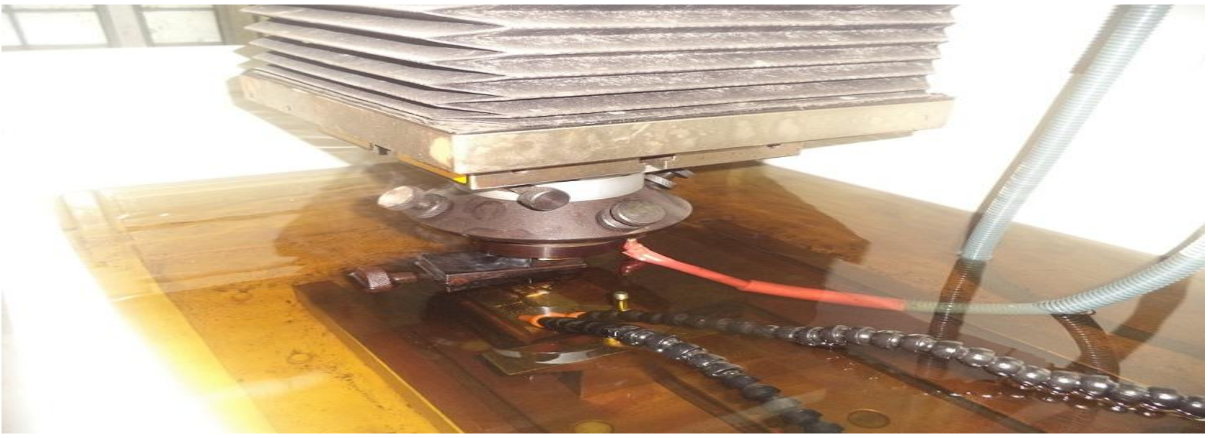

Fig.2.1 Experimental setup

2.2 Work Piece Selection

EDM are allow to machining of hard material component such as heat treated tool steels, composites, super alloys, ceramics, carbides and heat resistant steels. EDM are mostly used the higher carbon grades for such applications as stamping dies, metal cutting tools, etc. High carbon high chromium steel is taken as a work piece in this experiment. Steel material is a pre heated very slowly high tensile tool steel which offers ready machine ability in the hardened and tempered condition, therefore further heat treatment is not require. Fig 2.2 shows the work piece material in this work.

Fig. 2.2 Work Piece

Table – 2.1 Chemical composition of high carbon high chromium steel (%) [7]

C	Mn	Si	Co	Cr	Mo	V	P	Ni	Cu	S
1.4-1.6	0.60	0.60	1.0	11.00-13.00	7.00-1.20	1.10	0.03	0.30	0.25	0.03

Table –2.2 Process Parameters and Theirs Levels

Parameters (unit)	Notation	Levels /coded				
		-2	-1	0	1	2
Pulse on time (μs)	Ton	100	825	1550	2275	300
Duty cycle (%)	Dc	1	8.75	16.5	24.25	32
Current (amp.)	Ip	5	16.25	27.5	38.75	50
Voltage gap (volt)	Vg	10	37.5	65	92.5	120
Pressure (N)	F	0.1	0.2	0.3	0.4	0.5

3.Results And Discussion

In this study, model as well as experimental results of the responses have been analysed. Model analysis of the MRR, EWR and surface roughness was carried out in a line with the behaviour of the machining parameters on the responses. The analysis of variance is carried out on all the fitted models for a confidence level of 95%.

3.1 Material Removal Rate (Mrr):

Model fitted for material removal rate is represented by this equation and its variance analysis is given in Table 3.1

MRR = 63.54 – 0.03*Ton - 4.79*dc + 1.76*amp + 1.93*Vg – 133.92*press + 0.95*Ton*press + 0.04*dc*amp– 7.1399*dc*press + 2.1922*amp*Vg + 0.97*amp*press - 4.30*Vg*press

Table – 3.1 ANOVA for MRR using graphite

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	15	8651.6	8652	576.8	0.69	0.059
Linear	5	982.6	4296	859.8	1.03	0.432
Interaction	10	7668.9	7669	766.9	0.92	0.039
Residual Error	16	13327.8	13328	833.0	2.37	0.175
Lack of fit	11	11186.0	11186	1016.9		
Pure Error	5	2141.8	2142	428.4		
Total	31	21979.3				

R- sq= 76.89% , R- sq (adj) = 67.50

As per ANOVA results, Linear interaction fitted model is best fitted model for material removal rate using graphite tool because corresponding to that model P value is very low .The "Lack of Fit F-value" of 1016.9 implies that the lack of fit is significant relative to the pure error. It is not good for model because lack of fit is significant means there are such type of input process parameters which is much affected of model.

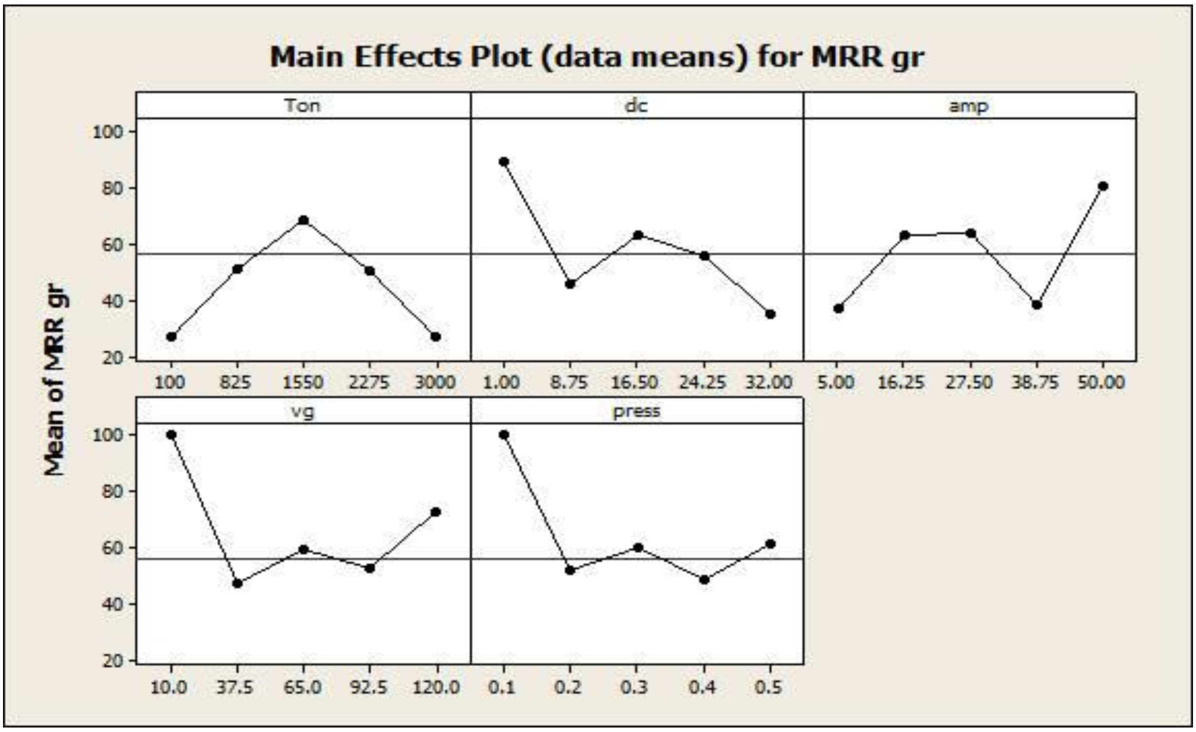

Fig.3.1 Main Effects Plot For MRR Gr

Figure 3.1 show the effect of pulse on time (T_{on}), duty cycle (dc), discharge current (I_d), voltage gap (V_g) and pressure on material removal rate using graphite as a tool electrode. First graph in this figure show the effect of pulse on time on MRR, so from first graph I can say that first of all MRR increase with pulse on time up to 1550 after than decrease the MRR with increase the pulse on time to 3000. Second graph of this figure represent the effect of duty cycle on MRR and in this case material removal decrease up-to 1.0 to 8.75 after than it increase between 8.75 -16.50 and then finally decrease up to final point. Third graph is show discharge current on MRR, first of all increase the MRR with discharge current up to 16.25 after then approximately constant from 16.25 to 27.50 than decrease the MRR to 38.75 and finally increase the material removal rate throughout. Graph fourth and fifth show the variation of voltage gap and pressure on material removal rate respectively and these two process parameters are affected in same nature on material removal rate (MRR).

3.2 Surface Roughness:

Model fitted for surface roughness is represented this equation and its variance analysis is given in Table 3.2

Ra = 5.26+ 0.5861*dc- 0.15*amp + 0.02*Vg – 3.86*press- 0.0012*Ton*press+ 0.02*dc*amp - 2.4452*dc*press– 0.7711*amp*press+ 0.49*Vg*press

Table – 3.2 ANOVA for Surface Roughness gr

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	20	224.02	224.02	11.201	2.74	0.44
Linear	5	23.97	12.90	2.580	0.63	0.68
Square	5	20.09	20.09	4.018	0.98	0.47
Interaction	10	179.96	179.96	17.996	4.40	0.011
Residual Error	11	44.95	44.95	4.087		
Lack of fit	6	26.56	26.56	4.427	1.2	0.429
Pure Error	5	18.39	18.39	3.678		
Total	31	268.98				

R-Sq = 83.3% R-Sq(adj) = 52.9%

According to ANOVA results, Linear interaction fitted model is best fitted model for material removal rate using graphite tool because corresponding to that model P value is very low .The "Lack of Fit F-value" of 4.427 implies that the lack of fit is not significant relative to the pure error. It is good for model because lack of fit is not significant means there are no such type of input process parameters which is much affected of model.

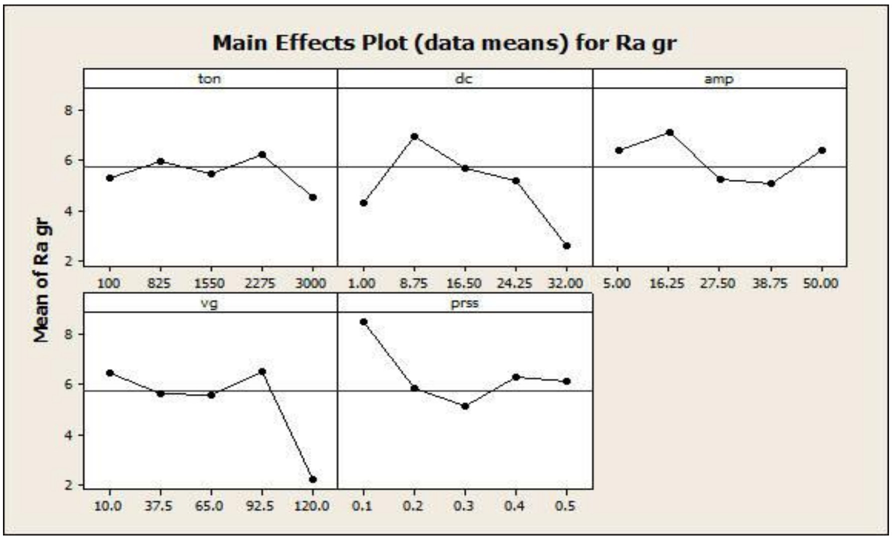

Fig.3.2 Main Effect Plot For Ra Gr

Figure 3.2 represent the effects of various process parameters such as pulse on time, duty cycle, discharge current, voltage gap and pressure on surface roughness using graphite as a tool electrode. From the figure I can say that pulse on time is not much affected throughout. Second graph of this figure represent the effect duty cycle on surface roughness, third, fourth, fifth graph in this figure are represents the variation of discharge current, voltage gap and pressure on surface roughness using graphite as a tool electrode. From this figure it is clear that duty cycle and pressure are most influencing parameters for surface roughness.

3.3 ELECTRODE WEAR RATE (EWR)

Model fitted for surface roughness is represented this equation and its variance analysis is given in Table 3.3

EWR = 1.64 - 0.22*dc +0.06*amp + 0.10*Vg – 7.81*press +0.79*dc*press + 0.02*amp*press -0.02*Vg*press

ANOVA based sequential sum of squares test was carried out to select the most appropriate model to be fitted MRR. Experimental result is shown in Table 4.11. Linear, two factor interaction; quadratic and cubic models were compared to see if addition of extra terms improved the fitting as indicated by the F value in the Fischer's F test [17]. With the help The F probability distribution curve, I can convert F value into P value. Significance model can be tested either by comparing the F value to a threshold F value or by comparing the corresponding p value to the threshold p value respectively to corresponding terms. P value depends on the confident level which was set here to 95%. In table 4.1.1 P value of linear model is very low as comparison to other model such as square and interaction hence linear model is best fitted model for material removal rate using copper electrode. If P value is less than 0.01 then corresponding to these factor are much significant and if P value vary between 0.01to 0.05 then it is significant factor and above the 0.05 of P value no significant factor.

Table – 3.3 ANOVA for EWR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	15	23.028	23.03	1.535	0.51	0.068
Linear	5	1.534	10.15	2.030	0.68	0.048
Interaction	10	21.494	21.49	2.149	0.72	0.099
Residual Error	16	48.034	48.04	3.002		
Lack of fit	11	36.456	36.64	3.134	1.43	0.364
Pure Error	5	11.579	11.58	2.316		
Total	31	71.063				

R-Sq = 83.3% R-Sq(adj) = 52.9%

Linear fitted model is best fitted model for electrode wear rate using graphite tool because corresponding to that model P value is very low .The "Lack of Fit F-value" of 3.134 implies that the lack of fit is not significant relative to pure error. It is good for model as lack of fit is significant means there are type of input process parameters which is much affected of model.

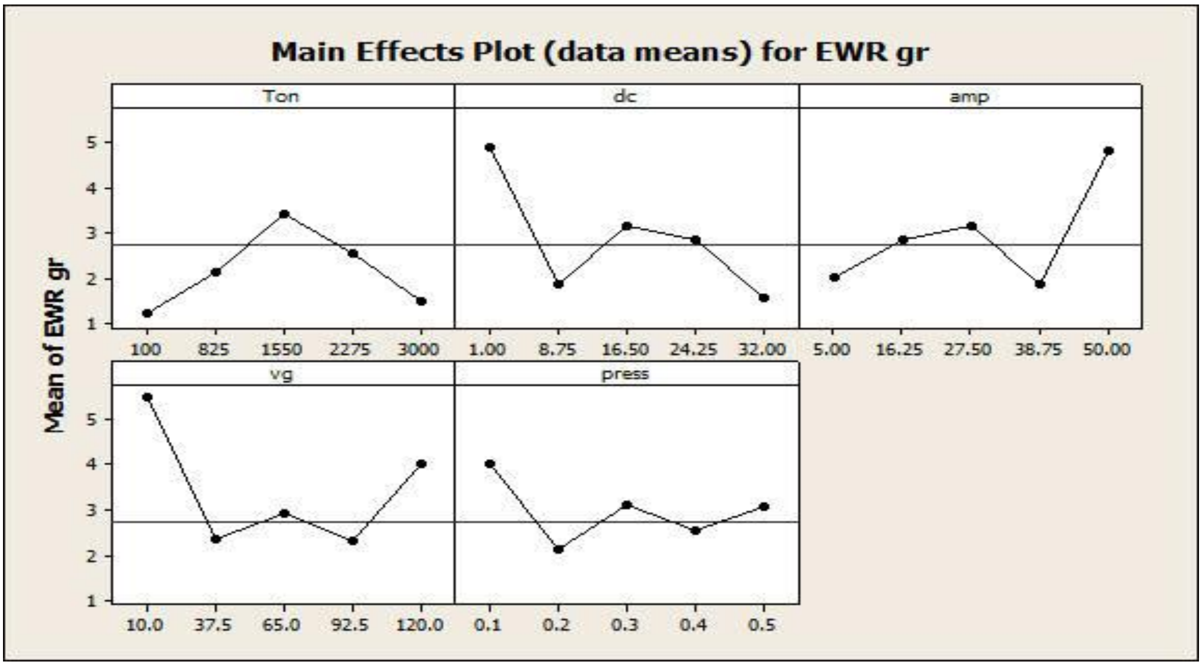

Fig 3.3 Main Effects Plot for EWR

Figure 3.3 represent the main effects of pulse on time, duty cycle, discharge current, voltage gap and pressure on electrode wear rate (EWR) using graphite as a tool electrode. First graph of this figure is show the variation of pulse on time on EWR, start with increase the electrode wear rate with pulse on time up to 1550 after than decrease from 1550 to 3000. Second graph is show the variation of duty cycle on EWR, in this case EWR decrease up to 8.75 then increase from 8.75 to 16.50 after then slightly decrease the electrode wear rate. In third graph electrode wear rate is increase up to 37.5 after then decrease from 27.50 to 38.50 and then finally increased. In fourth graph is show the variation of voltage gap on electrode wear rate first of all decrease the electrode wear rate up to 37.5 and after then increase and decrease and then finally increase the electrode wear rate. Last graph is show the variation of pressure on EWR. This graph follows the same path as to voltage gap.

4.Conclusions

In the present work parametric analysis of die- sinking EDM process has been done based on experimental results.

1. It is clear from the result there are no such single factor which significant in case of material removal rate with graphite tool. Interaction of pulse on time and duty cycle is most significant factor for MRR over the machining parameters.
2. Interaction of duty cycle and pressure and interaction voltage gap and pressure are most significant factor over remaining parameters for surface roughness with graphite tool.
3. Pulse on time is most significant factor over other machining parameters for electrode wear rate with graphite tool.

5.References

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