IMPACT OF VARIUOS PARAMETERS ON SURFACE ROUGHNESS IN ELECTRONIC DISCHARGE MACHINING

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Abstract : The experiment was designed using DESIGN EXPERT software, response surface methodology with Central composite design and analyzed using ANOVA analysis. It is found that as voltage increases Ra decreases, I_P increases Ra increases slightly, T_{ON} increases Ra increases and T_{OFF} has little influence on surface roughness of the material when it is machined by electric discharge machining process and minimum surface roughness (R) was 3.795µm at voltage of 41.25V, current value of 10.75A, pulse on-time of 54.50µs & pulse off-time of 34µs. we found that current & pulse on-time are the most significant parameter to affect Ra within the range of 6-25A & 30-45V capacity of electric discharge machine
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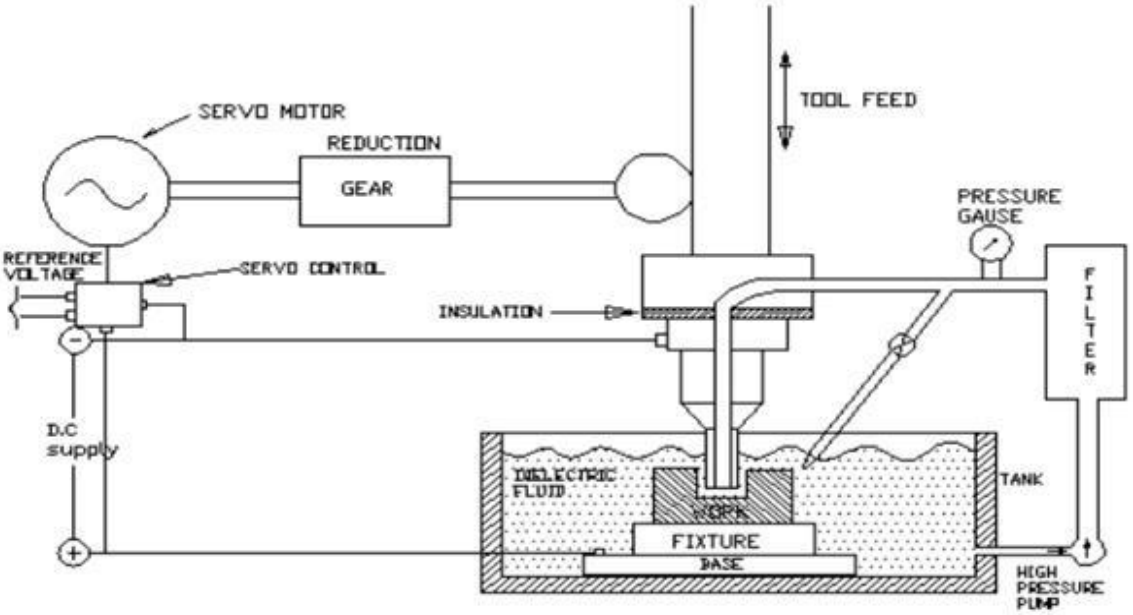
I. INTRODUCTION

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.

Principle of EDM –

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig 1.1. Both tool and work piece are submerged in a dielectric fluid .Kerosene/EDM oil/deionised water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases



Set of electric discharge machining

METHODOLOGY

We used DESIGN EXPERT software to design the experiment which designs the experimental runs according to the range of the factors and provides different design like Full Factorial, Taguchi-design, response surface methodology (RSM), etc. to achieve your objective i.e. to maximize or minimize the response.Central composite rotable design (CCRD) is used to design the experiment as the point is equally spaced around the circle in the rotable design and it gives perfect idea of the system. According to CCRD design, if the number of factors is K then 2^K is the corner points, 2K axial points and centre point to allow the turning parameters of second order polynomial. We had 30 experiments or runs in the design matrix with 6 repeatable values to check the errors.

pulse on – time & off – time-

Pulse on time is defined as the time during which the machining is peformed,

WORK-PIECE, ELECTRODE & DIE-ELECTRIC FLUID PROPERTIES

Table:3.1.In this experiment, work-piece used was AISID3 die steel having following chemical

C%	Si%	Mn%	Cr%	Cu%	W%	V%	Fe%
1.88	0.5	0.38	11.5	0.16	1	1	rest

: work-piece after machining by EDM

In this experiment cylindrical shaped Cu tool of 12mm diameter was used that has following chemical composition-

: chemical composition of electrode or tool

While die-electric fluid was kerosene having following property shown below by the table

: property of kerosene used

Surface tension (N/m)	Density (kg/m^3)	Dynamic viscosity
0.028	820	2400

Getting best model & R- Squared value, we applied backward elimination. Reduced ANOVA for material removal rate (response) shown above is the final analysis which indicates that voltage (V), current (I_P), pulse on-time (T_{ON}), pulse off-time are significant as probability > F (p-value) for all factors is less than 0.05 and lack of fit is non-significant which is good for our model.And R-Squared values are also good as their difference is less than 0.2.

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ANALYSIS FOR RESPONSE (Ra)

After measuring Ra, result was analyzed using analysis of variance (ANOVA) which tells us about the significance of the model. For this, ANOVA table which is formed by the DESIGN EXPERT software for our response (Surface roughness) is analyzed where analysis of significant and non-significant term is carried out.

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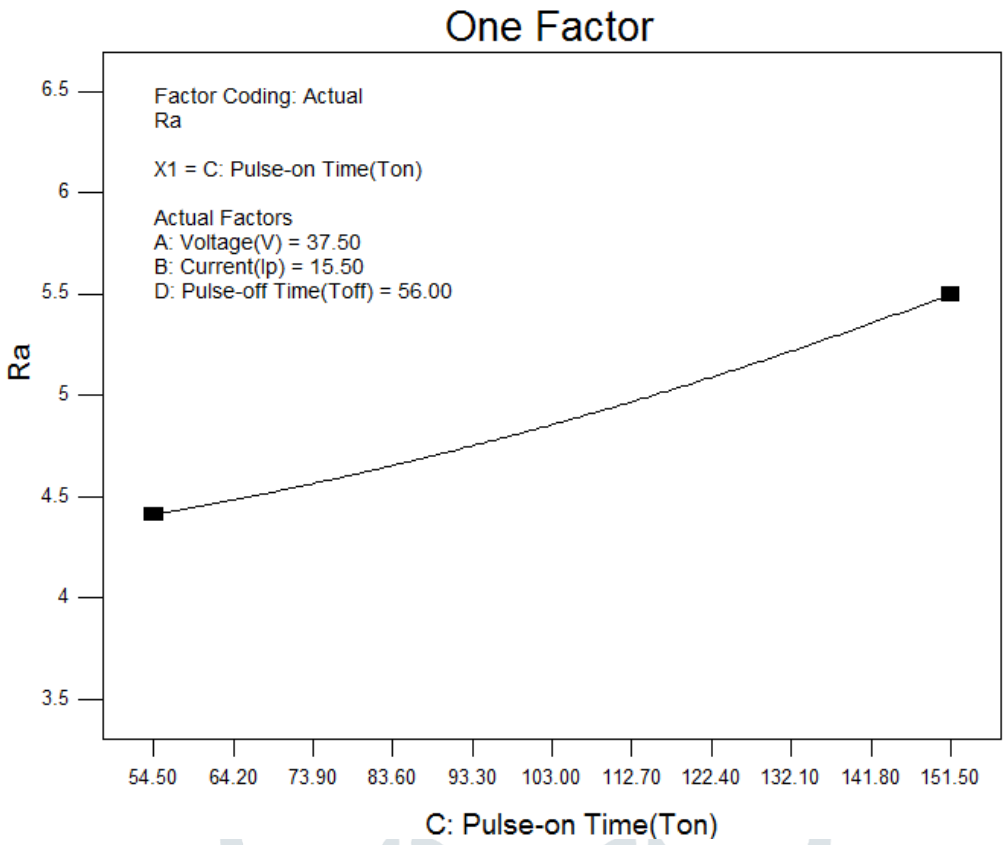
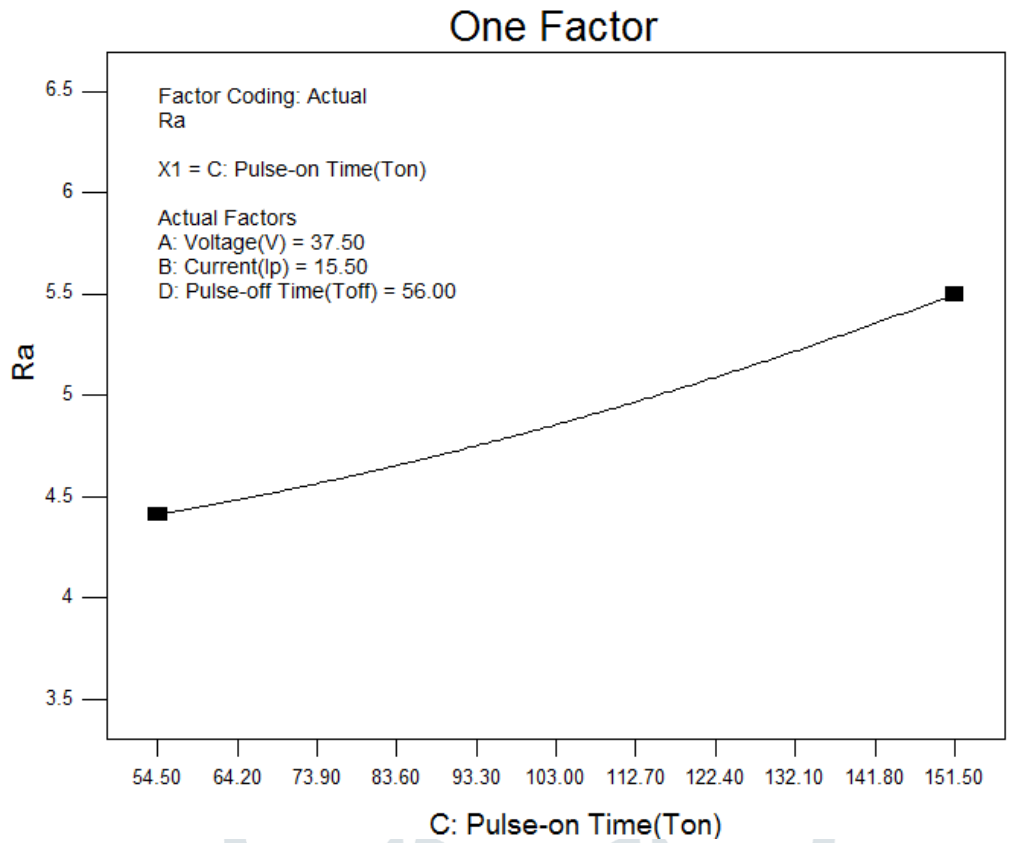


Figure: one factor pulse on time v/s Ra

From the interaction plot, we found that when voltage increase surface roughness decreases but if compare the MRR for pulse on-time (T_{ON}) then, at higher value of pulse on-time, we got higher value of MRR at constant voltage



ANOVA for the average surface roughness (manual)

Table 4.1: ANOVA for Ra

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	14.9555	14	1.068249801	35.6338	< 0.0001	Significant
A-Voltage(V)	4.483989	1	4.483988602	149.573	< 0.0001	
B-Current(Ip)	0.23964	1	0.239640135	7.99372	0.01274	
C-Pulse-on Time(Ton)	7.100071	1	7.100070602	236.838	< 0.0001	
D-Pulse-off Time(Toff)	0.781998	1	0.781998202	26.0853	0.00013	
AB	0.05408	1	0.054079503	1.80394	0.19921	
AC	1.182548	1	1.182547503	39.4464	< 0.0001	
AD	0.221794	1	0.221793903	7.39842	0.01581	
BC	0.000398	1	0.000398002	0.01328	0.9098	
BD	0.010312	1	0.010312402	0.34399	0.56626	
CD	0.154096	1	0.154095503	5.14019	0.03859	
A^2	0.360787	1	0.360787214	12.0348	0.00343	
B^2	0.009835	1	0.009834514	0.32805	0.57529	
C^2	0.25709	1	0.257089743	8.57579	0.01038	
D^2	0.21031	1	0.210310114	7.01535	0.01824	
Residual	0.449678	15	0.029978554			
Lack of Fit	0.352601	10	0.035260148	1.81609	0.26472	not significant
Pure Error	0.097077	5	0.019415367			
Cor Total	15.40518	29				
Std. Dev.	0.173143		R-Squared			0.97081
Mean	5.10194		Adj R-Squared			0.94357

C.V. %	3.393673	Pred R-Squared	0.85909
PRESS	2.170775	Adeq Precision	22.311

From the above table, we found that lack-of-fit value is 0.26472which is non significant and good for the model. The value of Adjusted R-squared and Pre R-squared are around 0.9 and their difference is less than 0.2 which is good. The Adeq Precision ratio should be greater than 4 and it is correct in our case. But, we want best model and R^2 value. For getting this, we applied backward elimination and got final reduced ANOVA for response (Ra).

CONCLUSION

In this experimental study, we performed the experiment on AISID3 die steel (work-piece) using Cu electrode (tool) and kerosene as a dielectric fluid by electric discharge machining with the input parameters- voltage (V), Current (I_P), Pulse on-time (T_{ON}) & Pulse off-time (T_{OFF}) to calculate and statistical study surface roughness as our response. The following conclusions are found from this experimental study-

- We found that surface roughness decreases non-linearly when voltage increases so voltage should be not high.
- Similarly, surface roughness decreases when pulse off-time increases as pulse off time is like setting time between two sparks so it should be as low as possible.
- We observed that surface roughness increases slightly when current increases within the range of 6-25A.
- We found surface roughness increase when pulse on-time increases.
- Thus, surface roughness increases whether current or pulse on-time increases as in both the case, pulse discharge energy increases which results greater crack size (diameter and depth) and finally increased material removal rate but pulse on time is most significant parameter.
- From Thus, higher current, higher pulse on-time, low voltage & low pulse off-time result maximum the table below, we can easily say that pulse on time (T_{ON}) is the most significant factor for surface roughness while current (I_P) has very less effect on the response. Voltage (V) and pulse off-time pulse on time (T_{OFF}) has negative effect on the response as when their values increases material removal rate decreases.
- ANOVA table showing the significance and contribution of each factor is shown below where contribution % is calculated on the basis of F-value is shown below-

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