Parametric Optimization of Process Parameters For EDM of Stainless Steel 304

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ABSTRACT

The non-conventional machining specially EDM is one of the best technique for improvement of mechanical properties such as material removal rate (MRR), surface roughness, Tool wear rare, by different combination of electrodes. However, while machining, machining parameters also being very effective. In our study, we carried out an experiment to atomize the outcome of machining characteristics viz. discharge current (Ip), pulse on time (Ton), voltage (v) over the responses of MRR and SR. For carrying this Tungsten carbide tool was used and work piece chosen was AISI 304 stainless steel. AISI304 stainless steel is used for various purpose in many day to day life as well as engineering applications. An orthogonal array had been used for running the experiment. Among all the process parameters we analyze that pulse on time is most significant next to discharge current is over response of MRR and voltage is effective parameter for performing surface roughness. For the experimental analysis STATISTICA 9.0 software is used.

Keywords: Electrodes, Material removal rate, Surface roughness, Tungsten carbide.

Introduction

Electrical Discharge Machining is a most basic nontraditional machining process, where material is removed by thermal energy of spark occurring by means of repeated sequences of electrical ejections between the small gap of an electrode and a work piece. EDM is commonly used for machining of electrically conductive hard metals and alloys in automotive, aerospace and die making industries. EDM process is removing undesirable material in the form of debris and produce shape of the tool surface as of a metal portion by means of a recurring electrical ejection stuck between tool i.e. cathode and the work piece i.e. anode material in the existence of dielectric liquid. In this machining process work piece is called the anode because it is connected with positive terminal and electrode is connected with negative terminal i.e. called cathode. Dielectric fluid may be kerosene, transformer oil, distilled water, etc.

EXPERIMENT

The main aim of our experiment is to improve the mechanical properties with the help of machining parameters and all these parameters will decide the mechanical properties such as material removal rate, surface roughness and tool wear rate. For the design of experiments an L9 orthogonal array was mainly selected from the Taguchis method of design. Like as selection of work piece and tool.

EXPERIMENTAL SET UP

An experiment was performed on the electric discharge machining EDM die sinking type modeled as Electronica-electicaplus 50znc.The polarization of work pice was positive whilethe electrode was negative. The die electric fluid was used as EDM oil with a specfyc gravity of 0.763. The EDM machine contains with the following measures:

1) For circulation of dielectric there is reservoir at base, pump and valves for passage.
2) Power supply unit and CNC functions.
3) Tool holding device.
4) Leak-proof tank along with tool fixing chuck.
5) Servo control unit for vertical movement of the tool.
6) 2D table which is movable by leaver

 

Fig. 1.1: Die Sinker EDM machine setup with tool and work piece (Model: ELECTRONICA -ELECTRAPLUS PS 50ZNC)Selection of work piece

In this particular experiment AISI 304 stainless steel of size 80×50×5 mm^3 plate is chosen for conducting the experiment. The characterstics of Grade 304 is the commonly used stainless steel; this is the maximum grade category of stainless steel which is used for the most of the application. And provides a huge variety of products. It can be very easily molded to any other shape its mechanical properties are good which is used in many engineering applications for example its welding and forging properties are very good. The austenitic configuration provides these grades brilliant toughness, straight down to lower temperature.

This grade of steel has better oxidization prevention and resistance to corrosion activities .the material fusion properties are much better which make it a better kitchen as well as home appliance such as fastener, sinks, benches spring, railings, heat exchangers.

Table 3.1: Composition for AISI 304 stainless steel

Grade		C	Si	P	S	Mn	Cr	Ni	N
304	Minimum	-	-	-	-	-	18.0	8.0	-
	Maximum	0.07	0.72	0.042	0.033	2.5	20.0	10.5	0.10

Table 3.2: Mechanical properties of AISI 304 stainless steel

Grade	Tensile Strength (Mpa) min.	ield Strength 0.2% proof (Mpa) min.	Elongation % (in 50 mm) min.	Hardness	
				kwell Max.	nell Max.
304	510	200	405	90	205

Fig. 1.2: AISI 304 stainless steel work piece before machining

Selection of tool material

In this experiment Tungsten carbide electrode of 10×100 mm^2 used. The products of tungusten carbide are mainly their machinability, toughness and heat resistance. solid tungusten is mainly used for cutting dissimilar alloys, cast iron, stainless steel alloy, nickel steel alloy, non ferrous alloys

The solid tungsten carbide rods are offered as a ground and unground with metric or inch standards. These rods possess the features of good wear resistance and corrosion resistance. The other uses of these rods are as HSS cutting tool, carbide end mills, aerospace cutting tool, carbide drills, milling cutter, electronic cutter, gun barrel, metal cutting saw and several other

applications.

Fig. 1.3: Tungsten carbide electrode

Formula of MRR calculation

As we all know that MRR is the part of material removed from the work piece and it is being calculated as the weight of work piece before and after maching. And it depend up on the density of material and time taken for machining.

$$MRR = W_{bm} / W_{am}$$

Whereas:
W_{bm} = Weight of work piece before machining.
W_{am} = Weight of work piece after machining.
t = Machining period = 10 min.
ρ = Density of AISI 304 stainless steel work piece = 8000 kg/m^3

Measurement of Surface Roughness

Surface Roughness of the material may defined as the size of the texture or grains present inside the material. They are always expressed in terms of µm and denoted by Ra. The surface roughness and smoothness is depend on size weather it is large or small and are measured by a apparatus called profilometer.

Taguchi design

Whenever we are going to study the performence of the part or process and it is controlled by more than one factor then we go for Dr. Genichi Taguchi's approach or DOE . It is the most effective and accurate approach for better quality and process. IT is a common approach for the product optimization and analytical simulation because of unavailability of hardware.

Taguchi design experiments in STATISTICA 9.0

The software which is mainly used for the analysis is STATISTICA 9.0 it provide with many possible ways to execute experiment. For the easiness of experimental design there is an arrangement of certain orthogonal arrays, with the help of these arrays various numerous experiments can be carried out. A number of orthogonal arrays, such as L_4, L_8, L_9, L_{12}, L_{15}, L_{17}, L_{25} and so on, created for two or three level factors. STATISTICA 9.0 suggest respose tables and create main effects and ins/n ration plans intended for

1 S/N ratios [Signal-to-noise ratios] vs. control factors.

2 Means vs. control factors.

With the help of different types of level such as one, two , three, five, Seven mixed levels etc. In this experimental procedure we have choosen for the three level and overall of nine experimrntal trials were used and OA L9 is selected , certain more factors were also considerd for the for the easiness at future stage is also being selected. This makes our coparision of results to be simpler.

The levels of experiment parameters and discharge current (Ip), spark on time (Ton) and applied voltage (V) are shown in Table 1.1 and the design matrix is represented in Table 1.2

Table 1.1 Machining parameters and their level

Machining parameter	Symbol	Unit	Levels		
			Level 1	Level 2	Level 3
Discharge current	Ip	A	5	7	8
Pulse on time	Ton	µs	48	152	202
Voltage	V	V	47	57	63

Conduct of Experiments

Tungusten carbide was used as tool with a dimension of 10mm diameter and 100mm length in a die sinking PS50 ZNC EDM mchine. The dielectric fluid with specific gravity of 0.763 and freeing point of 94°C.The duty cycle was fixed at a constant value of 5.For three level of factor of overall 9 trials were used. A nozzle of flushing nature was used to remove eroded materials from the heating zone.

Design matrix and Observation table

Table 1.2: Observation table of Design matrix

Run	Ip	Ton	Voltage	Wt. of work piece (in gm)	
S. No.	(A)	(μs)	(V)	Wbm	Wam
1	5	50	44	150.60	150.32
2	5	150	54	150.42	150.041
3	5	200	64	150.41	149.652
4	7	50	54	149.820	149.451
5	7	150	64	149.320	148.896
6	7	200	44	148.910	148.348
7	9	50	64	148.410	147.683
8	9	150	44	147.902	147.215
9	9	200	54	147.162	146.524

Conclusion of experimentation

All the experimentation is being performed according to the Taguchi's design method. The machining setup and tungsten carbide electrode with side flushing were used and experimented. The processing parameters are the discharge current, pulse on time, voltage. The 9 orthogonal array continusely performed to give varied results and thus MRR and SR were calculated by weight of work piece and profilometer.

Result and Discussion

In this section we are going to analyze the result and the effects of processing paraameters

Such as dischare current, pulse on time, voltage for Material removal rate and surface roughness of AISI 304 for solid tungsten carbide electrode and find which parameter is most important accourding to the taguchi design.

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Response Table

Table 1.3 Shows calculation and response along with MRR and SR

	Ip (A)	Ton (μs)	Voltage (V)	MRR (mm^3/min)	SR (μm)
1	5	50	44	2.8500	5.9633
2	5	155	54	4.0650	7.1533
3	5	200	64	3.4300	8.4250
4	7	50	54	4.8425	5.2547
5	7	155	64	6.0585	7.8520
6	7	200	44	6.6200	7.1253
7	9	50	64	5.6375	8.4350
8	9	155	44	9.2320	4.2420
9	9	200	54	8.5215	4.6327

From the above table we concluded only nine experiments with EDM and carried for a processing time of 10 min to each experiment. The impact on the work piece by machining process is shown in the below figure 1.3.

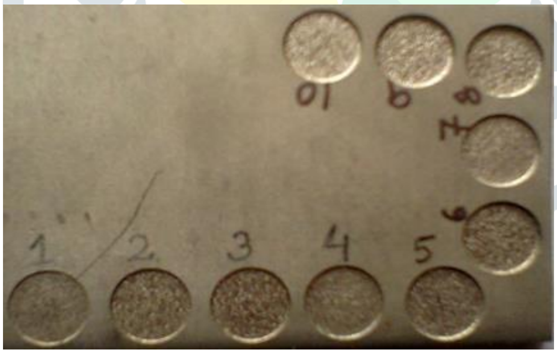


Fig. 1.3: AISI 304 stainless steel work piece after machining

Influences on MRR

The Taguchi's design method for "larger is better" is being analyzed for the response for result of response.The S/N ratios for MRR are calculated as given in Equation [1].

$$\text{LB: } \eta = -10 \log \sum [y_i/n] \quad [1]$$

Where η denotes the value of S/N ratios calculated from observed values, yi represents the experimentally observed value of the i^{th} experiment and n=1 is the repeated number of each experiment in L-9 Orthogonal Array is conducted.

With full factorial as a design of experiment, value of surface roughness for each sample will be obtained. Then, STATISTICA 9.0 software will be used for further analysis. The result is shown in figure 1.4

From the mean plots of figure 1.4 indicates that MRR at 9 A discharge current, 152 µs pulse on time and at voltage of 44 V voltage respectively gives the best results on input parameters.

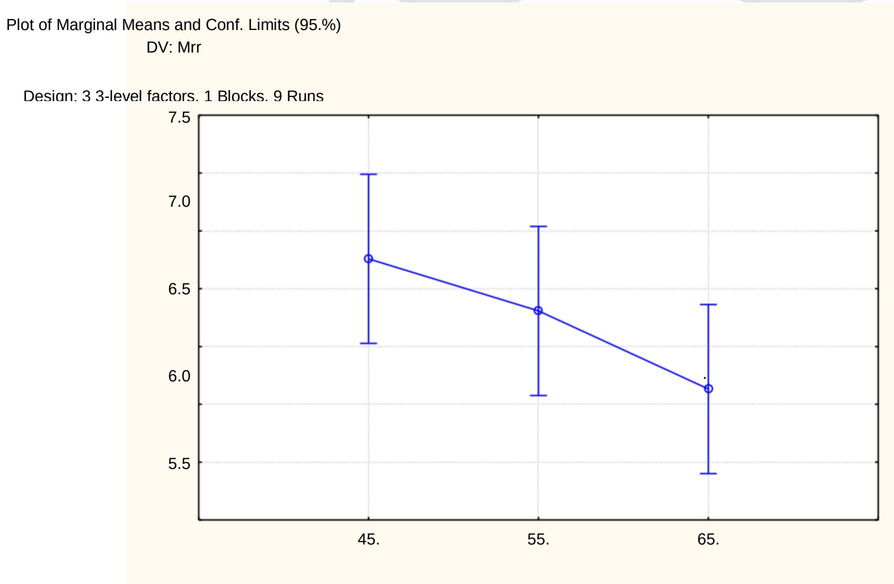


Fig 1.4: Mean plot of MRR(mm^3/min) versus voltage(v)

From the Analysis of variance studied for the effect of factors on MRR is indicating in Table 1.4 which obviously shows that the discharge current is the most significant factor while machining of AISI 304 SS with tungsten carbide tool. After that pulse on time is an important parameter and voltage is not significant factor during machining. Figure 1.5 shows that the main effects of S/N ratios on MRR by the factor. For this case "higher is better" is chosen.

Table 1.5 ANOVA of S/N ratios for MRR

Influences on Surface Roughness

The method by which we are calculating S/N ration for SR is being given by the equation and is mentioned below. And the analysis is done by the taguchi design criteria. And we found that machining parameter for smaller is better criteria.

SB: $\eta = -10\log [y_i/n]$

According to Figure 1.5,1.6, 1.7 the values of SR at 7 A of discharge current, 50 µs of pulse on time and at voltage of 54 V respectively gives the best results for surface roughness (µm) is obtained.

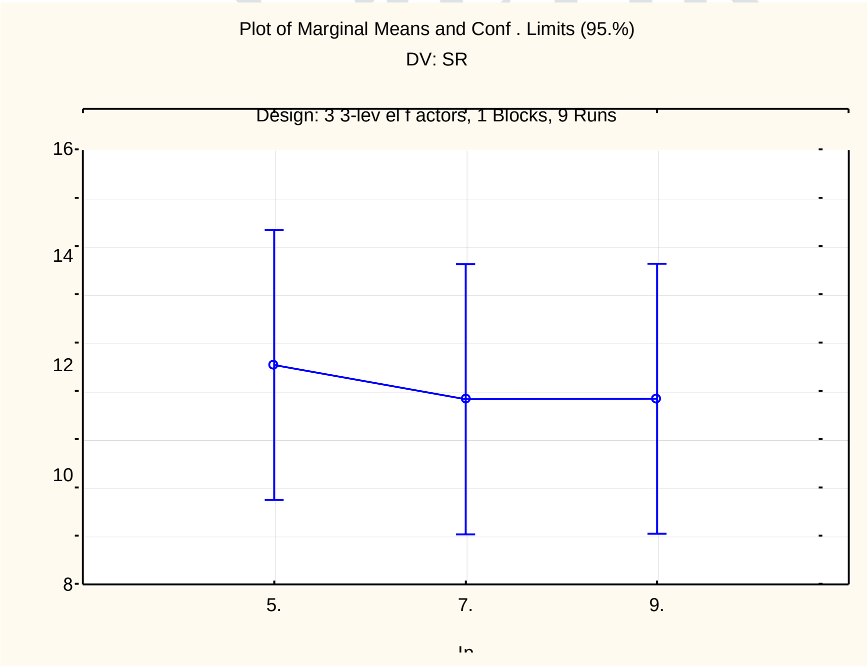


Figure 1.5: Mean plot of SR (µm) versus Ip (A)

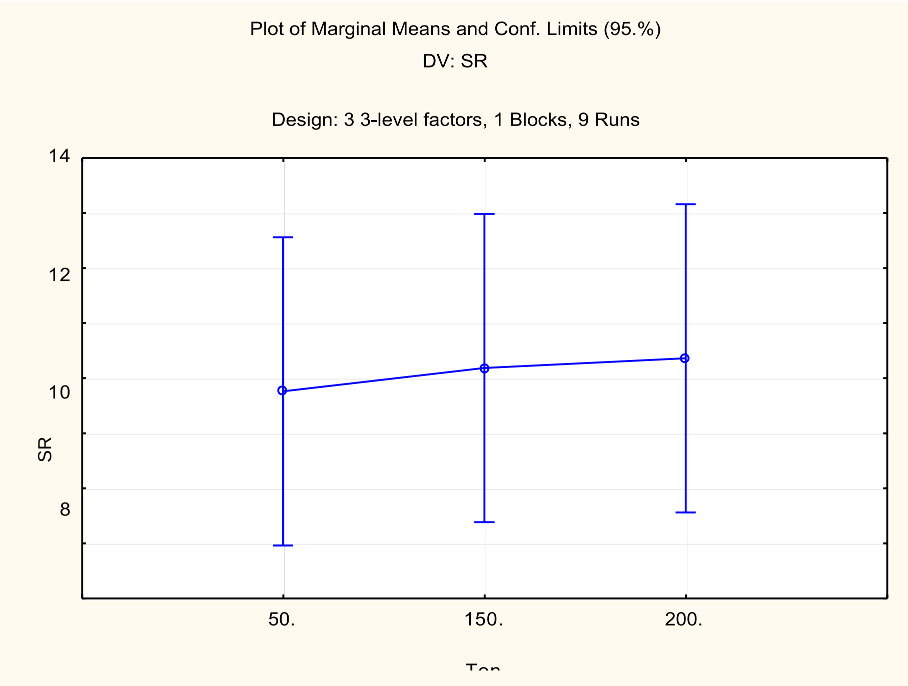


Fig: 1.6: Mean plot of SR (µm) versus Ton(µs)

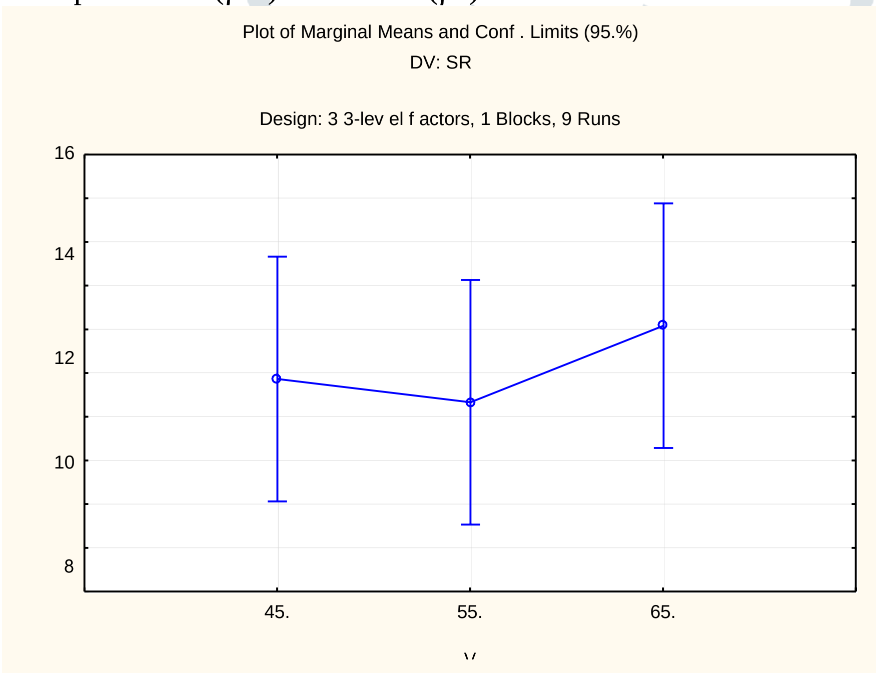


Fig: 1.7: Mean plot of SR (µm) versus Voltage (v)

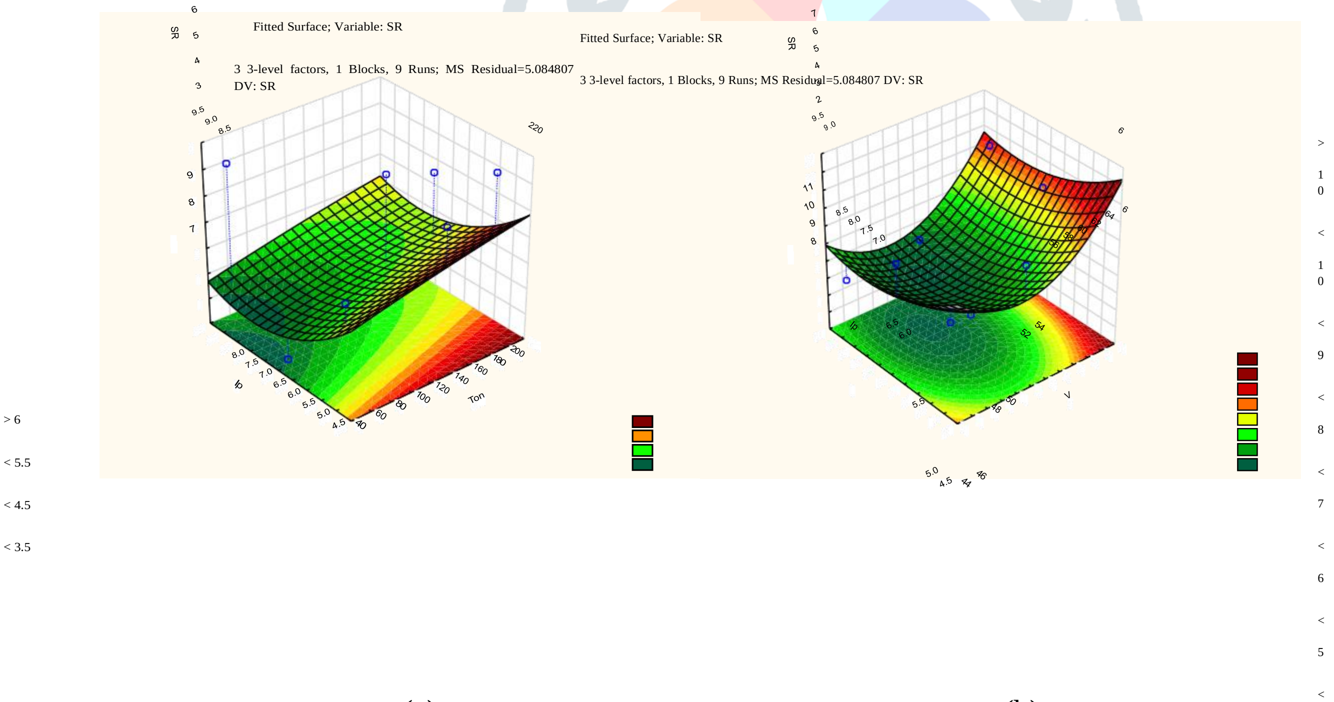
ANOVA analysis is being performed to check the statical validity of the experimental setup. The value of R^2 states the significance of model and the participation of the voltage on surface roughness of the material in EDM process. The factors mainly considerd as discharge current (Ip) and pulse on time (Ton) these both have less impact on surface quality of the work-piece. The study determine states the effectiveness of the voltage on the EDM process.

Table 1.4 ANOVA of S/N ratios for SR

Effect	Analysis of Variance (SR)				
	SS	Df	MS	F	% Contribution
1 Ip	14.5668	2	7.28341	0.407676	0.19139
2 Ton	11.5843	2	5.79219	0.324208	0.152204
3 V	49.9595	2	24.97975	1.398199	0.656406
Residual error	35.7313	2	17.86566		

Surface plots

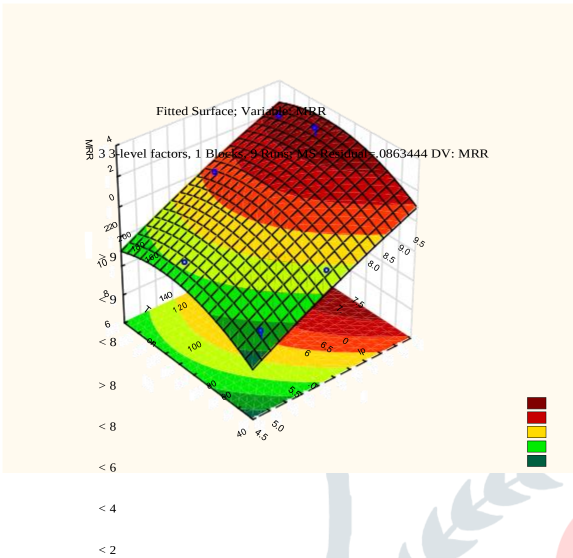
Figure 1.09(a) shows the three dimensional surface plot of surface roughness (SR) against discharge current (Ip), pulse of time (Ton)when the Ton increases SR increases and Figure 1.8(b) show SR decreases when ip increases . Similarly, when V increases, SR increases and when Ip increases SR has slightly increases these influences has been shown in the figure



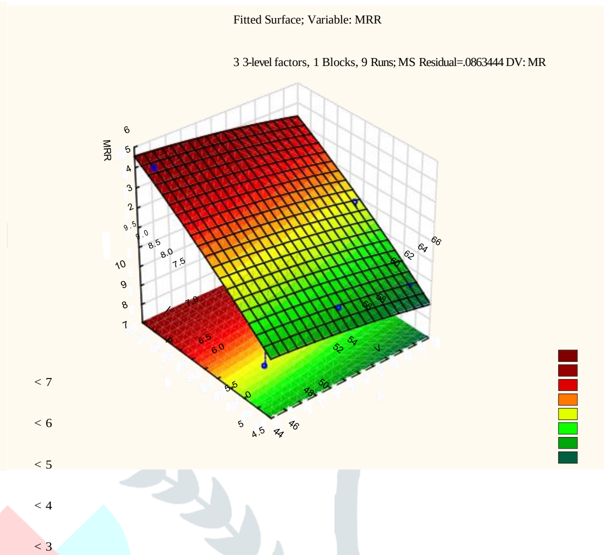
(a) (b)

Fig 1.9 (a)and (b)Three diensional surface plots of the main effects of Ip, Ton and V

Figure 1.10 (a) & (b) shows that three dimensional surface plot of MRR against pulse on time (Ton) & discharge current (Ip) and Ip & V respectively. However, Ip has greater impact on MRR as compared to Ton and V, in which MRR increases rapidly as the Ip increases.



(a)



(b)

Fig. 1.10 (a) & (b): Three dimensional surface plots of the main effects of Ip, Ton and V

CONCLUSION

After the experimental investigation on EDM the outpts of the parameters were considerd are material removal rate, surface roughness, on AISI304 stainless steel using a solid tungsten carbide tool with side flushing of the eroded material have been studied well there is wide industrial application the experiment depend upon sevral variable parameters such as pulse on time, discharge current, voltage etc have been selected All the experiment is being carried out by the Taguchis design analysis For this analysis STATISTICA 9.0 have been used. The following points can be conclude from the experiment:

1. From our experiment the influencing factor is the discharge current which effects MRR more rapidly

after that pulse on timeand then voltage. We analyze that with discharge current MRR varies linearly and increases or decreases with pulse on time and voltage.

2. While calculating the surface roughness voltage is the atmost parameter after that current is less effective on machined work piece

References

[1] http://www.docstoc.com/docs/135847346/ELECTRICAL-DISCHARGE-MACHINING

[2] Reddy Sidda B., Rao PS, Kumar JS and Reddy KVK, Parametric study of electric discharge machining of AISI 304 stainless steel, International journal of engineering science and technology, 2(8) (2010): pp. 3535-3550.

[3] Rahman M.M., Khan M.A.R., Kadirgama K., Noor M.M. and Bakar R.A., Experimental Investigation into Electrical Discharge Machining of Stainless Steel 304, Journal of Applied Sciences, 11(3) (2011): pp. 549-554.

[4] Dewangan S.K., Experimental Investigation of Machining parameters for EDM using U- shaped Electrode of AISI P20 tool steel, M-Tech Thesis (2010), http://ethesis.nitrkl.ac.in/2071/1/Thesis_EDM.pdf

[5] Tomadi S.H., Hassan M.A. and Hamedon Z., Analysis of the influence of EDM parameters on surface quality, material removal rate and electrode wear of tungsten carbide, Proceedings of the International Multi Conference of Engineers and Computer Scientists, Vol II (2009).

[6] Iqbal AKM A. and Khan A.A., Optimization of process parameters on EDM milling of stainless steel AISI 304, Advanced Materials Research, 264-265 (2011): pp. 979-984.

[7] Abbas Md. N., Solomon D.G. and Bahari Md. F., A review on current research trends in electrical discharge machining (EDM), International Journal of Machine Tool and Manufacture, 47 (2007): pp. 1214-1228.

[8] Singh S., Maheshwari S. and Pandey P., Some

investigations into the electric discharge machining of hardened tool steel using different electrode materials, Journal of Materials Processing Technology, 149 (2004): pp. 272-277.

[9] Kumar S., Singh R., Singh T. P. and Sethi B.L., Surface modification by electrical discharge machining: A review, Journal of Materials Processing Technology, 209(8) (2009): pp. 3675-3687.

[10] Bhattacharyya B., Gangopadhyay S. and Sarkar B.R., Modelling and Analysis of EDMed job surface integrity, Journal of Materials Processing Technology, 189 (2007): 169-177.

[11] Dhar S., Purohit R., Saini N., Sharma A. and Kumar G.H., Mathematical modelling of electric discharge machining of cast Al-4Cu-6Si alloy-10 wt.% SiCp composites, Journal of Materials Processing Technology, 194 (2007): pp. 24-29.

[12] Puertas I., Luis C.J. and Alvarez L., Analysis of the influence of EDM parameters on surface quality, MRR and EW of WC-Co, Journal of Materials Processing Technology, 153-154 (2004): pp. 1026-1032.

[13] Simao J., Lee H.G., Aspinwall D.K., Dewes R.C., and Apinwall E.M., Workpiece surface modification using electrical discharge machining, 43 (2003): pp. 121-128.

[14] T. M. Chenthil Jegan, Dev Anand M. and Ravindran D., Determination of electro discharge machining parameters in AISI202 stainless steel using grey relational analysis. International Conference on Modeling, Optimization and Computing, Procedia Engineering, 38 (2012): pp. 4005-4012.

[15] Jai Hindus S., Prasanna Rajendra Kumar R., Oppiliyappan B. and Kuppan P., Experimental investigations on electrical discharge machining of SS 316L, International Journal on Mechanical Engineering and Robotics, 1(2) (2013): pp. 39-45.

[16] Rajmohan T., Prabhu R., Subba Rao G. and Palanikumar K., Optimization of machining parameters in electrical discharge machining (EDM) of 304 stainless steel, International Conference on Modeling, Optimization and Computing, Procedia Engineering, 38 (2012): pp. 1030-1036.

[17] Kiyak M. and Cakir O., Examination of machining parameters on surface roughness in EDM of tool steel, Journal of Materials Processing Technology, 191 (2007): pp. 141-144.

[18] Reza M. S., Hamdi M., Tomadi S. H., Ismail A. R.,

Optimization of control parameters for EWR in injection flushing type of EDM on stainless steel 403 workpiece, World Academy of Science, Engineering and Technology, 72 (2010).

[19] Kumar Ashok, Bedi Kuldeep Singh, Dhillo Karaj Singh and Singh Rashpal, Experimental investigation of machine parameters for EDM using U shaped electrode of EN- 19 tool steel, International Journal of Engineering Research and Applications, 1(4): pp. 1674- 1684.

[20] Rao P. Srinivasa, Reddy Sidda B., Kumar JS and Reddy KVK, Fuzzy modeling for electrical discharge machining of AISI 304 stainless steel, Journal of Applied Sciences Research, 6(11) (2010): pp. 1687-1700.

[21] S. Abdurrahman Celik, Surface roughness investigation in the electrical discharge machining of powder metal material, Journal of Applied Sciences, 7 (12) (2007): pp. 1608- 1613.

[22] Vasudevamurthy G. and Knight T. J., Effect of system parameters on size distribution of 304 stainless steel particles produced by electrical discharge mechanism, Materials Letters, 61(27) (2007): pp. 4872-4874.

[23] Jahan M. P., Rahman M. and Wong Y. S., A review on the conventional and micro- electrodischarge machining of tungsten carbide, International Journal of Machine Tool and Manufacture, 51 (2011): pp. 837-858

[24] Rajurkar K. P., Sundaram M. M. and Malshe A. P., Review of electrochemical and electrodischarge machining, Procedia CIRP, 6 (2013): pp. 13-26.