International Journal of Scientific Engineering and Technology
Volume No. 12, Special Issue No. 1

ISSN : 2277-1581
29 Dec. 2023

Optimization of EDM Parameters in Obtaining Maximum MRR Using Taguchi Method

Md Sameer Farooque[1],Yogesh Mishra[2], Ram Narayan Sahu[3]
[1]Research Scholar Master of Technology (APS)
Department of Mechanical Engineering, NIIST, Bhopal
[2]Professor and Head Department of Mechanical Engineering, NIIST, Bhopal
[3]Assistant Professor Department of Mechanical Engineering, NIIST, Bhopal

Abstract: It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. AISI P20 Plastic mould steel that is usually supplied in a hardened and tempered condition. Good machinability, better polish ability, it has a grooving rang of application in Plastic moulds, frames for plastic pressure dies, hydro forming tools These steel are categorized as difficult to machine materials, posses greater strength and toughness are usually known to create major challenges during conventional and non- conventional machining. The Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time and diameter of tool of AISI P20 tool steel material. Using U-shaped cu tool with internal flushing. A well-designed experimental scheme was used to reduce the total number of experiments. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by which factor is most affected by the Responses of Material Removal Rate (MRR) and Tool Wear Rate (TWR).
Keywords: MMR, Taguchi, MINITAB 17, TWR, EDM, U shaped copper tool0

1. Introduction

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 figure 1.

Both tool and work piece are submerged in a dielectric fluid/Kerosene/EDM oil/deionized wateris very common type of liquid dielectric although gaseous dielectrics are also used in certain cases.

This Figure.1 is shown the electric setup of the Electric discharge machining. The tool is mead cathode and work piece are anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark in interval of from 10 of micro seconds. And positive ions and electrons are accelerated, producing a discharge channel that becomes conductive

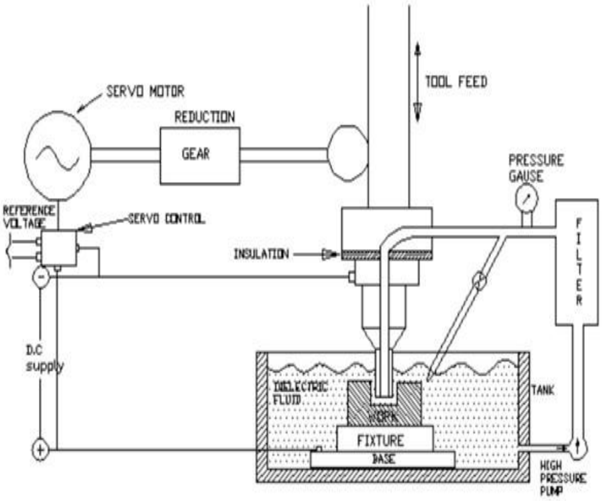

Figure1 Set up of Electric discharge machining

.

It is just at this point when the spark jumps causing collisions between ions and electrons and creating a channel of plasma. A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as a result of which a very high temperature is reached and at such high pressure and temperature that some metal is melted and eroded. 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.

Dhar and Purohit [1] evaluates the effect of current (c), pulse-on time (p) and air gap voltage (v) on MRR, TWR, ROC of EDM with Al–4Cu–6Si alloy–10 wt. % SiC_P composites. This experiment can be using the PS LEADER ZNC EDM machine and a cylindrical brass electrode of 30 mm diameter. And three factors, three levels full factorial design was using and analyzing the results. A second order, non-linear mathematical model has been developed for establishing the relationship among machining parameters. The significant of the models were checked using technique ANOVA and finding the MRR, TWR and ROC increase significant in a non-linear fashion with increase in current. Karthikeyan et .al [2] has presented the mathematical molding of EDM with aluminum-silicon carbide particulate composites. Mathematical equation is $Y=f(V, I, T)$. And the effect of MRR, TWR, SR with Process parameters taken in to consideration were the current (I), the pulse duration (T) and the percent volume fraction of SiC (25 µ size). A three level full factorial design was choosing.

ISSN : 2277-1581
29 Dec. 2023

Finally the significant of the models were checked using the ANOVA. The MRR was found to decrease with an increase in the percent volume of SiC, whereas the TWR and the surface roughness increase with an increase in the volume of Sic. Taweel [3]. The central composite second-order rotatable design had been utilized to plan the experiments, and RSM was employed for developing experimental models. Composite electrode is found to be more sensitive to peak current and Pulse on time than conventional electrode. The multi response optimization result for maximum MRR and minimum TWR.

B.Mohan and Satyanarayana [4] evolution the of effect of the EDM Current, electrode marital polarity, pulse duration and rotation of electrode on metal removal rate, TWR, and SR, and the EDM of Al-Sic with 20-25 vol. % SiC, Polarity of the electrode and volume present of SiC, the MRR increased with increased in discharge current and specific current it decreased with increasing in pulse duration. Increasing the speed of the rotation electrode resulted in a positive effect with MRR, TWR and better SR than stationary. The electric motor can be used to rotate the electrode(tool) AV belt was used to transmit the power from the motor to the electrode Optimization parameters for EDM drilling were also developed to summarize the effect of machining characteristic such as MRR, TWR and SR.

Yan-Cherng et.al [5]. Experimental design was used to reduce the total number of experiments. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by ANOVA and F -test. The relationship of MRR and SR with pulse duration graph in different peak current is as shown in Fig. 2.3. During the experiment MRR increases with peak current MRR initially increased to a peak at around 100 μs, and then fell. J. Simao et al [6] was developed the surface modification using by EDM, details are given of operations involving powder metallurgy (PM) tool electrodes and the use of powders suspended in the dielectric fluid, typically aluminum, nickel, titanium, etc. experimental results are presented on the surface alloying of AISI H13 hot work tool steel during a die sink operation using partially sintered WC / Co electrodes operating in a hydrocarbon oil dielectric. An L8 fractional factorial Taguchi experiment was used to identify the effect of key operating factors on output measures (electrode wear, workpiece surface hardness, etc.). With respect to micro hardness, the percentage contribution ratios (PCR) for peak current, electrode polarity and pulse on time. Even so, the very low error PCR value (for micro hardness ~6%) implies that all the major effects were taken into account.

P. Narender Singh et al. [7] discuss the evolution of effect of the EDM current (*C*), Pulse ON-time (*P*) and flushing pressure (*F*) on MRR, TWR, taper (*T*), ROC, and surface roughness (SR) on machining as-cast Al-MMC with 10% SiCp . And use of metal matrix composites. ELEKTRAPULS spark erosion machine was used for the purpose and jet flushing of the dielectric fluid, kerosene, was employed. Brass tool of diameter 2.7mm was chosen to drill the specimens. An L27 OA, for the three machining parameters at three levels each, was opted to conduct the experiments. ANOVA was performed and the optimal levels for maximizing the responses were established. Scanning electron microscope (SEM) analysis was done to study the surface characteristics. A. Soveja et al [8] have defined the experimental study of the surface laser texturing of TA6V alloy. The influence of the operating factors on the laser texturing process has been studied using two experimental approaches: Taguchi methodology and RSM. Empirical models have been developed. They allowed us to determine a correlation between process operating factors and performance indicators, such as surface roughness and MRR. Results analysis shows that the laser pulse energy and frequency are the most important operating factors. Mathematical models, that have been developed, can be used for the selection of operating factors' proper values in order to obtain the desired values of the objective functions.

Biing Hwa et al. [9] has discuss the investigates the feasibility and optimization of a rotary EDM with ball burnishing for inspecting the machinability of Al_2O_3/6061Al composite using the Taguchi method. Three ZrO_2 balls attached as additional components behind the electrode tool offer immediate burnishing following EDM. Three observed values machining rate, surface roughness and improvement of surface roughness are adopted to verify the optimization of the machining technique. Design of tool electrode is Cupper ring shaped BEDM. This B-EDM process approaches both a higher machining rate and a finer surface roughness. Furthermore, the B-EDM process can achieve an approximately constant machining rate.

2. Experimental Details

In this experiment using AISI P20 tool steel material this **P-20 tool** steel materialis a pre hardened high tensile tool steel which offers ready machine ability in the hardened and tempered condition, therefore does not require further heat treatment. Subsequent component modifications can easily be carried out.

Table 1: Chemical Composition of AISI P-20 tool steel material

Elements	Weight limit %
C	0.28-0.40
Mn	0.60-1.00
Si	0.20-0.80
Cr	1.40-2.00
Mo	0.30-0.55
Cu	0.25
P	0.03
S	0.03
Fe	Balance

In this experiment using the copper tool electrode and the design of cupper tool is a U- shaped with internal flashing. Shapes of the tool same cavity produced in the workpiece. Using the U-shaped tool so U-shaped cavity produced on the workpiece.A Taguchi design or an orthogonal array the method is designing the experimental procedure using different types of design like, two, three, four, five, and mixed level. In the study, a three-factor mixed level setup is chosen with a total of eighteen numbers of experiments to be conducted and hence the OA L18 was chosen. This design would enable the two factor interactions to be evaluated. As a few more factors are to be added for further study with the same type of material, it was decided to utilize the L18 setup, which in turn would reduce the number of experiments at the later stage. In addition, the comparison of the results would be simpler. The levels of experiment parameters electrode diameter (D), spark on time (Ton), and discharge current (Ip) are shown in Table 2.

Table 2 Machining parameters and their level

Machining parameter	Symbol	Unit	Level		
			Level 1	Level 2	Level 3
Electrode diameter	(D)	mm	4	6	
Spark on time	(Ton)	µs	50	500	1000
Discharge current	(Ip)	A	1	3	5

3. Experimental methodology

In These experiments are related about influences of MRR is finding the result which factors discharge current, pulse duration, diameter of Cu tool, is most important with help of Taguchi method.

Influences on MRR

The analysis of variances for the factors is shown in Table 3 which is clearly indicates that the diameter of the tool is not important for influencing MRR and Ip and Ton are the most influencing factors for MRR and as well as the interaction Ip x Ton is significant (shown in bold). And other factors are not significant. The delta values are Dia. of tool, Ton and Ip are 1.1493, 15.0841 and 18.3901 respectively, depicted in Table 4. The case of MRR, it is "Larger is better", so from this table it is clearly definite that Ip is the most important factor then Ton and last is dia. of the tool.

Table 3 Analysis of Variance for S/N ratios for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Dia	1	5.94	5.94	5.944	3.38	0.140
Ip	2	1222.40	1222.4	611.19	347.29	**0.000**
Ton	2	683.05	683.05	341.52	194.06	**0.000**
Dia*Ip	2	2.17	2.17	1.087	0.62	0.584
Dia*Ton	2	30.98	30.98	15.491	8.80	0.034
Ip*Ton	4	163.28	163.28	40.820	23.19	**0.005**
Residual Error	4	7.04	7.04	1.760		
Total	17	2114.86				

Table 4 Response for S/N Rations Larger is better (MRR)

Level	Diameter	Ip	Ton
1	-2.1459	-13.1689	6.1093
2	-0.9966	3.2340	-1.8508
3		5.2212	-8.9721
Delta	1.1493	18.3901	15.0841
Rank	3	1	2

During the process of Electrical discharge machining, the influence of various machining parameter like Ip, Ton and Diameter of tool has significant effect on MRR, as shown in main effect plot for S/N ratio of MRR in figure 2. The discharge current (Ip) is directly proportional to MRR in the range of 1 to 3A. This is expected because an increase in pulse current produces strong spark, which produces the higher temperature, causing more material to melt and erode from the work piece. Besides, it is clearly evident that the other factor does not influence much as compared to Ip and similar conclusions were shown by Ghoreishi and Tabari [34]. But, with increase in discharge current from 3A to 5A MRR increases slightly. However, MRR decreases monotonically with the increase in pulse on time.

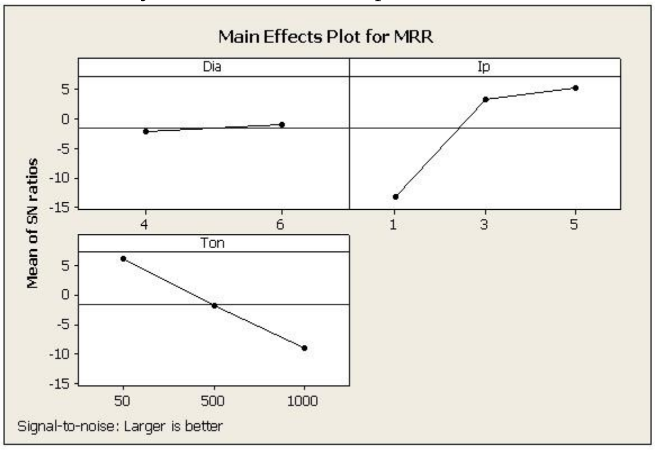

Figure 2 Main effect plot for S/N ratios (MRR)

5. Conclusions

In the present study on the effect of machining responses are MRR of the AISI P20 plastic mould steel component using the U-Shaped cu tool with internal flushing system tool have been investigated for EDM process. The experiments were conducted under various parameters setting of Discharge Current (Ip), Pulse On-Time (Ton), and diameter of the tool. L-18 OA based on Taguchi design was performed for Minitab software was used for analysis the result and theses responses were partially validated experimentally. Finding the result of MRR discharge current is most influencing factor and then pulse duration time and the last is diameter of the tool. MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically.

Experiments were conducted according to Taguchi method by using the machining set up and the designed U-shaped tubular electrodes with internal flushing. Finding the result of MRR discharge current is most influencing factor and then pulse duration time and the last is diameter of the tool. In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool. In the case of over cut the most important factor of discharge current then diameter of the tool and no effect on pulse on time

References

- *Dhar, s., Purohit, r., Saini, n., Sharma, a. and Kumar, G.H., 2007. Mathematical modeling of electric discharge machining of cast Al-4Cu-6Si alloy-10 wt.% sicp composites. Journal of Materials Processing Technology, 193(1-3), 24-29.*
- *Karthikeyan R, Lakshmi Narayanan, P.R. and Naagarazan, R.S., 1999. Mathematical modeling for electric discharge machining of aluminium-silicon carbide particulate composites. Journal of Materials Processing Technology, 87(1-3), 59-63.*
- *El-Taweel, T.A., 2009. Multi-response optimization of EDM with Al-Cu-Si-tic P/M composite electrode. International Journal of Advanced Manufacturing Technology, 44(1-2), 100-113.*
- *Mohan, B., Rajadurai, A. and Satyanarayana, K.G., 2002. Effect of sic and rotation of electrode on electric discharge machining of Al-sic composite. Journal of Materials Processing Technology, 124(3), 297-304.*
- *Lin, y.-., Cheng, C.-., Su, B.-. and Hwang, L.-., 2006. Machining characteristics and optimization of machining parameters of SKH 57 high-speed steel using electrical-discharge machining based on Taguchi method. Materials and Manufacturing Processes, 21(8), 922-929.*
- *.J. Simao, H.G. Lee, D.K. Aspinwall, R.C. Dewes, and E.M. Aspinwall 2003.Workpiece surface modification using electrical discharge machining,, 43 (2003) 121–128*
- *Singh, P.N., Raghukandan, K., Rathinasabapathi, M. And Pai, B.C., 2004. Electric discharge machining of Al-10%sicp as-cast metal matrix composites. Journal of Materials Processing Technology, 155-156(1-3), 1653-1657.*
- *Soveja, A., Cicala, E., Grevey, D. And Jouvard, J.M., 2008. Optimisation of TA6V alloy surface laser texturing using an experimental design approach. Optics and Lasers in Engineering, 46(9), 671-678.*
- *Yan, B.H., Wang, C.C., Chow, H.M. and Lin, Y.C., 2000. Feasibility study of rotary electrical discharge machining with ball burnishing for Al2O3/6061Al composite. International Journal of Machine Tools and Manufacture, 40(10), 1403-1421.*
- *Yan-Cherng Lin, Yuan-feng chen, Ching-tien Lin, AND Hsinn-jyh Tzeng Feasibility study of rotary electrical discharge machining with ball burnishing for Al2O3/6061Al composite 2008, vol.23: 391–399,.*
- *Lee, S.H. and Li, X.P., 2001. Study of the effect of machining parameters on the machining characteristics in electrical discharge machining of tungsten carbide. Journal of Materials Processing Technology, 115(3), 344-358.*
- *Puertas, I. And Luis, C.J., 2004. A study of optimization of machining parameters for electrical discharge machining of boron carbide. Materials and Manufacturing Processes, 19(6), 1041-1070.*
- *Wang, C.-. And Lin, Y.C., 2009. Feasibility study of electrical discharge machining for W/Cu composite. International Journal of Refractory Metals and Hard Materials, 27(5), 872-882.*
- *Tsai, H.C., Yan, B.H. and Huang, F.Y., 2003. EDM performance of Cr/Cu-based composite electrodes. International Journal of Machine Tools and Manufacture, 43(3), 245-252.*
- *Habib, S. S. (2009). Study of the parameters in electrical discharge machining through response surface methodology approach. Applied Mathematical Modelling, 33(12), 4397-4407.*