Experimental Study of Surface Parameters of EN31 on Powder Mixed EDM using Taguchi Methodology

Vipin Kumar[1] Mr. Rajpal[2] Manjeet Singh[3]
[1,3]GGS Kharar, Mohali [2]Ramgahria Institute of Engineering and Technology (PTU), Phagwara

Abstract— PEDM has become an effective method of machining extremely tough and brittle electrically conductive materials. It is widely used in the process of making moulds and dies and sections of complex geometry and intricate shapes. The work piece material selected in this experiment is EN 31 taking into account its wide usage in industrial applications. In today's world 304 stainless steel contributes to almost half of the world's production and consumption for industrial purposes. The input variable parameters are type of powder, current, pulse on time and powder concentration. Taguchi method is applied to create an L18 orthogonal array of input variables using the Design of Experiments (DOE). The effect of the variable parameters mentioned above upon machining characteristics such as Material Removal Rate (MRR) and Surface Roughness (SR) is studied and investigated. The tool material is copper. All the calculations are made with the help of MINITAB 16 software. Dielectric used for experimentation is kerosene. Two powders silicon carbide and boron carbide of 70 mesh is used. Most influence factor for MRR observed is powder concentration with 49.12 % contribution. For SR peak current with contribution of 43.4 % plays a n important role.

Key words: EDM machine, Boron Carbide, Silicon carbide , MRR , Surface Roughness, Taguchi methodology

I. INTRODUCTION

The new concept of manufacturing uses non-conventional energy sources like sound, light, mechanical, chemical, electrical, electrons and ions. With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed. New developments in the field of material science have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Non-traditional machining has grown out of the need to machine these exotic materials. The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. The problems of high complexity in shape, size and higher demand for product accuracy and surface finish can be solved through non-traditional methods. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process. The Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts. EDM has been replacing drilling, milling, grinding and other traditional machiningoperations and is now a well established machining option in many manufacturing industries throughout the world. And is 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. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas.

II. TAGUCHI METHOD AND DESIGNS OF EXPERIMENT

Taguchi method of design provides a simple, efficient and systematic approach for optimization of experimental designs for performance quality and cost. In this, firstly the input factors are selected which are used in experiments and these factors values are entered in Taguchi design .The experimental values are obtained by design of experiment technique.

In Taguchi method the results are analyzed to achieve to one or three following objectives

- To establish the best or optimum condition for product or a process
- To estimate the contribution of individual factors
- To estimate the response under optimum condition.

The optimum condition is identified by studying the main effects of each of the factors. The process involves minor arithmetic manipulation of numerical results and usually can be done by using simple calculator. The main effects indicate the general trend of influence of factors.

Signal-to-noise ratio or the SN number is calculated for each variable to determine the effect on the output. In the equations below, y_i is the mean value and s_i is the variance. y_i is the value of the performance characteristic for a given experiment.

$$SN_i = 10\log\frac{\bar{y_i}^2}{{s_i}^2} \quad \ldots (1)$$

where

$$\bar{y}_i = \frac{1}{N_i}\sum_{u=1}^{N_i} y_{i,u}$$

$$s_i^2 = \frac{1}{N_i - 1}\sum_{u=1}^{N_i}(y_{i,u} - \bar{y}_i)$$

i= Experiment number

u= Trial number

N_i= Number of trials for experiment i

For the case of minimizing the performance characteristic, the following definition of the SN ratio should be calculated:

$$SN_i = -10\log\left(\sum_{u=1}^{N_i}\frac{y_u^2}{N_i}\right) \quad ….(2)$$

For the case of maximizing the performance characteristic, the following definition of the SN ratio should be calculated:

$$SN_i = -10\log\left[\frac{1}{N_i}\sum_{u=1}^{N_i}\frac{1}{y_u^2}\right] \quad ….(3)$$

The table 1 indicates the factors and levels for selecting the orthogonal array. For experiment degree of freedom(DOF) is to be calculated. The DOF for orthogonal array should be greater than or at least equal to those for design parameters. In this experiment, L18 orthogonal is used having four columns and nine rows. This array has eight degree of freedom and it can be handle three level design parameter. The surface roughness, were analyzed by using this methodology

Factors	Factors designation	Level 1	Level 2	Level 3
Type of powder	A	Boron carbide	Silicon carbide	
Pulse on time (µs)	B	50	100	150
Peak current (ampere)	C	4	8	13
Conc. Of powder (g/I)	D	0	2	5

Table 1: Factors and their levels of interest

Experiment no:	**Type of powder**	**Pulse on time (µs)**	**Peak current (ampere)**	**Conc. Of powder (g/I)**	**MRR Trial 1 mm^3/min**	**MRR Trial 2 mm^3/min.**	**MRR Mean**	**S/N Ratio**
1	SiC	50	4	0	1.97	2.05	2.01	6.063
2	SiC	50	8	2	3.73	3.79	3.76	11.50
3	SiC	50	13	5	7.65	7.74	7.69	17.71
4	SiC	100	4	0	1.67	1.75	1.71	4.659
5	SiC	100	8	2	4.13	4.23	4.18	12.42
6	SiC	100	13	5	9.2	9.4	9.3	19.36
7	SiC	150	4	2	1.98	2.04	2.01	6.063
8	SiC	150	8	5	6.12	6.14	6.13	15.74
9	SiC	150	13	0	7.30	7.34	7.32	17.29
10	B_4C	50	4	5	2.59	2.67	2.63	8.399
11	B_4C	50	8	0	2.39	2.47	2.43	7.712
12	B_4C	50	13	2	5.12	5.24	5.18	14.28
13	B_4C	100	4	2	2.02	2.12	2.07	6.319
14	B_4C	100	8	5	3.60	3.64	3.62	11.17
15	B_4C	100	13	0	3.94	4.00	3.97	11.97
16	B_4C	150	4	5	3.01	3.09	3.05	9.686
17	B_4C	150	8	0	3.1	3.7	3.4	10.62
18	B_4C	150	13	2	9.12	9.22	9.17	19.24

Table 2: Results for MRR

Experimentno:	**Type of powder**	**Pulse on time (µs)**	**Peak current (ampere)**	**Conc. Of powder (g/I)**	**SR Trial 1 µm**	**SR Trial 2 µm .**	**SR µm**	**S/N Ratio**
1	SiC	50	4	0	.26	.30	.28	11.05
2	SiC	50	8	2	.46	.52	.49	6.196
3	SiC	50	13	5	.67	.75	.71	2.974
4	SiC	100	4	0	.25	.33	.29	10.75
5	SiC	100	8	2	.51	.59	.55	5.192
6	SiC	100	13	5	1.21	1.25	1.23	-1.798
7	SiC	150	4	2	.45	.53	.49	6.196
8	SiC	150	8	5	.77	.85	.81	1.830
9	SiC	150	13	0	1.10	1.18	1.14	-1.138
10	B_4C	50	4	5	.32	.42	.37	8.636
11	B_4C	50	8	0	1.10	1.20	1.05	-0.423
12	B_4C	50	13	2	1.03	1.13	1.08	-0.668
13	B_4C	100	4	2	.77	.85	.81	1.723
14	B_4C	100	8	5	1.11	1.17	1.14	-1.138
15	B_4C	100	13	0	1.35	1.47	1.41	-2.984
16	B_4C	150	4	5	.95	1.03	.99	0.087
17	B_4C	150	8	0	1.15	1.19	1.17	-1.363
18	B_4C	150	13	2	.99	1.03	1.01	-0.086

Table 3: Results for surface roughness

III. CONCLUSIONS

The present study was carried out to study the effect of input parameters on the MRR and surface roughness. The following conclusions have been drawn from the study:

- MRR is mainly affected by type of powder, peak current and powder concentration.
- Surface roughness is mainly affected by type of powder, pulse on time and peak current.

IV. SCOPE FOR FUTURE WORK

With increasing competitiveness as observed in recent times, manufacturing system in the industry are being driven more and more aggressively. So there is always need for perpetual improvements. Thus for getting more accurate results we can take into account few more parameters as given below:

(1) Abrasive powders used in current experiments are silicon carbide and boron carbide . Since there are so many conducting abrasive powders in market like tungsten carbide , tantalum carbide , boron nitrite etc and not much work has been done on these abrasive particles . So there is large scope for further work on these abrasive particles .

(2) Other machining parameters like current, pulse on , pulse off time can also be changed for obtaining optimum MRR and surface finish.
(3) The residual stress analysis can also be extended in the future work.
(4) Further work can also be done by varying the concentration of these abrasive powder particles in dielectric and optimum results can be obtained .
(5) Work can also be done by changing the size of these abrasive particles for obtaining the optimum MRR and surface finish.

REFERENCES

[1] Ajeet Bergaley., Narendra Sharma., "Optimization of Electrical and Non Electrical Factors in EDM for Machining Die Steel Using Copper Electrode by Adopting Taguchi Technique"*International Journal of Innovative Technology and Exploring Engineering*, 2278-3075, Volume-3, Issue-3, August 2013.

[2] Kun Ling Wu., Biing Hwa Ya., Fuang Yuan Huang., Shin Chang Chen., "Improvement of surface finish on SKD steel using electro-discharge machining with aluminum and surfactant added dielectric" International *Journal of Machine Tools & Manufacture*, 45 (2005) 1195–1201.

[3] Norliana Mohd Abbas., Darius G. Solomon., Md. Fuad Bahari., "A review on current research trends in electrical discharge machining (EDM)" *International Journal of Machine Tools & Manufacture*, 47 (2007) 1214–1228.

[4] H.K. Kansal., Sehijpal Singh. P. Kumar., "Parametric optimization of powder mixed electrical discharge machining by response surface methodology" *Journal of Materials Processing Technology*, 169 (2005) 427–436.

[5] Y.-F. Tzeng., C.-Y. Lee., "Effects of Powder Characteristics on Electrodischarge Machining Efficiency" *Int J Adv Manuf Technol*, (2001) 17:586–592.

[6] H.K. Kansal., Sehijpal Singh. P. Kumar., "Effect of Silicon Powder Mixed EDM on Machining Rate of AISI D2 Die Steel" *Journal of Manufacturing Processes*,Vol. 9/No. 1,2007.

[7] Mohd. Junaid Mir., Khalid Sheikh., Balbir Singh., Navdeep Malhotra., "Modeling and analysis of machining parameters for surface roughness in powder mixed EDM using RSM approach"*International Journal of Engineering, Science and Technology*,Vol. 4, No. 3, 2012, pp. 45-52.

[8] Soni ss., Pandey A B., "Development of fuzzy model for powder mixed electro discharge machining using copper and graphite tool" *International Journal of Engineering Science and Technology (IJEST).*

[9] Anirban bhattacharya., Ajay batish., Kulwinder singh., "Fe simulation and experimental validationof powder mixed edm process for estimatingthe temperature distributionand volume removed in single crater" *International journal of modeling, simulation,and scientific computing*,vol. 3, no. 2 (2012) 1250006 (22 pages).

[10] Soumyakant padhee, Niharranjan nayak, S k panda., P r dhal., S S Mahapatra., "Multi-objective parametric optimization of powder mixedelectro-discharge machining using response surfacemethodology and non-dominated sorting genetic algorithm" *Indian academy of sciences*, vol. 37, part 2, april 2012, pp. 223–240.

[11] Hideki Takezawa., Tadashi Asano., Naotake Mohri., "Influence of Gap Phenomenon on Various Kinds of Powder-Suspended EDM" *Int. J. of Automation Technology*, Vol.7No.4, 2013.

[12] Manoj Modi., Gopal Agarwal., "Powder-Mixed Electro-Discharge Diamond Surface Grinding Process Modelling, Comparative Analysis and Multi-Output Optimisation Using Weighted Principal Components Analysis" *Journal of Mechanical Engineering*, 59(2013)12, 735-747.

[13] Kuldeep Ojha., R. K. Garg., K. K. Singh., "Experimental Investigation and Modeling of PMEDMProcess with Chromium Powder Suspended Dielectric" *International Journal of Applied Science and Engineering*, 2011. 9, 2: 65-81.

[14] Soumyakant Padhe., Niharranjan Nayak., S K Panda., P R Dhal., S S Mahapatra., "Multi-objective parametric optimization of powder mixedelectro-discharge machining using response surfacemethodology and non-dominated sorting genetic algorithm"*Indian Academy of Sciences* ,Vol. 37, Part 2, April 2012, pp. 223–240.

[15] C Cogun., B O zerkan., T Karacay., "An experimental investigation on the effect of powder mixed dielectric on machining performance in electric discharge machining" *Proc. IMechE* 2006, Vol. 220.

[16] Ashvarya Agrawal., Avanish Kumar Dubey., Pankaj Kumar Shrivastava., "Modeling and Optimization of Tool Wear Rate in Powder Mixed EDM of MMC" *International Conference on Mechanical and Robotics Engineering (ICMRE'2013)* ,Dec. 17-18, 2013.

[17] Anil Kumar., Sachin Maheshwari., Chitra Sharma., Naveen Beri., "Realizing Potential of Graphite Powder in EnhancingMachining Rate in AEDM of Nickel Based SuperAlloy 718" *Int. J. on Production and Industrial Engineering*, Vol. 01, No. 01, Dec 2010.

[18] Khalid Hussain Syed ., P. Kuppan., "Studies on Recast-layer in EDM usingAluminium Powder Mixed Distilled WaterDielectric Fluid"*International Journal of Engineering and Technology (IJET).*

[19] www.google.com

[20] www.sciencedirect.com

