ISSN 2321-807X
Volume 12 Number23
Journal of Advances in chemistry

Effect of Cu/Zn on Material Removal Rate on Grey Cast Iron

T.Yuvaraj, Dr.P.Suresh

Assistant Professor, Department of Mechanical Engineering, Muthayammal Engineering College, Rasipuram
yuvappk@gmail.com
Professor, Department of Mechanical Engineering, Karpagam College of Engineering (Autonomous), Coimbatore
Suresh.me2004@gmail.com

ABSTRACT

Electrical Discharge machining (EDM) is capable of machining geometrically complex or hard material component and a widely used process in manufacturing industries for a high-precision machining of all types of conductive materials. Material of any hardness can be machined because the hardness is not a foremost parameter in EDM. In this paper, the effect of EDM parameters such as Pulse on Time, Pulse off Time, voltage and current on material removal rate (MRR) in Cast iron is investigated. Cast iron is an important material used in various applications because of its high hardness. Brass, whose main constituents are copper and zinc, is used as a tool material and the influence of copper and Zinc on cast iron workpiece is studied. Experiment is carried out and the results were analyzed using analysis of Variance and response graphs. Signal to Noise is used to identify the contribution of each cutting parameter towards the material removal rate.

Indexing terms/Keywords

Keywords: Electrical Discharge Machining, Grey Casi Iron, Copper, Zinc, MRR, Taguchi Method etc

Academic Discipline And Sub-Disciplines

Mechanical Engineering and Manufacturing Technology

SUBJECT CLASSIFICATION

Optimization of Input and output Parameters on Electrical Discharge Mechine.

TYPE (METHOD/APPROACH)

Taguchi Method of optimization Technique is used to find optimum output parameter

INTRODUCTION

Electrical Discharge Machining (EDM) is an unconventional manufacturing process based on removal of material from a part by means of a series of repeated electrical sparks created by electric pulse generators at short intervals between an electrode tool and the part to be machined immersed in dielectric fluid. . The material removal in EDM mainly occurs due to formation of shock waves as the plasma channel collapse owing to discontinuation of applied potential difference. Material is removed from the work piece through localized melting and vaporization of material. This method is especially effective in machining complex cavities and small work pieces moreover for high-precision machining of extremely hard steels and exotic metals. Since there is no mechanical contact between the tool and the work piece, thin and fragile components can be machined without the risk of damage. EDM has various applications in automobile, aeronautic, mold and die manufacturing industries especially for manufacturing die for injection molding, forging, extraction, etc. The objective of research in area of advanced machining has been to enhance the efficiency and reliability of machine tools while designing them. In this paper, grey cast iron is used as the work material, a study will be perform on the influence of the factors of pulse on time, pulse off time, gap size, and power supply voltage and investigations were carried out on the material removal rate using brass electrode.

LITERATURE REVIEW

Sameh S. Habib et.al [1] study in this research investigates the parameter optimization of EDM on a copper rod 8mm diameter and graphite rod 8mm diameter ware selected as a tool electrodes. The optimization result showed that the pulse on-time has the most significant influence on MRR, surface roughness and gap size within the specific test range for copper and graphite electrodes. MRR, surface roughness and gap size are slightly affected with average machining voltage for both electrodes. **Samar Singh et.al** [2] study in this research paper a brass rod 2mm diameter was selected as a tool electrodes. From the analysis of variance (ANOVA) shows the percentage contribution of the control factor in the machining of Al-7075 in EDDM. The optimization result showed that the combination of maximum pulse on-time and minimum pulse off-time gives maximum MRR. **Pichai Janmanee et.al** [3] this paper is an investigation on the optimal process parameters to minimize the micro crack density, electrode wear ratio and maximize material removal. To reduce the number of experiments, the Taguchi design using an L_9 orthogonal array was used. Analysis of variance (ANOVA) and signal-to-noise (S/N) ratio were performed and calculated, respectively. The discharging current parameters mainly affected the MRR, EWR and Cr.S.Dn. micrographs from a scanning electron microscope (SEM) were used to study the density of microcracks on surfaces machined by EDM. **Rajmohan T et.al** [4] in this investigation, the effect of electrical discharge machining (EDM) parameters such as pulse on-time (T_{on}), pulse off-time (T_{off}), voltage (V) and current (I) on material removal rate (MRR) in 304 stainless steel was studied. From this study, it is found that different combinations of EDM process parameters are required to achieve higher MRR for 304 stainless steel. The current and pulse off-time are the most significant machining parameter for MRR in EDM of 304 SS. **R.Rajesh et.al** [5] in this paper presents a new approach to the machining problems based on the Genetic Algorithm. Metal removal rate and surface roughness are combined to have a single objective as gray relational grade by the application of gray relational analysis. Linear regression model have been developed to map the relationship between machining parameters and output responses. Finally the optimal conditions obtained by GA as. i.e. maximizing MRR and minimize the surface roughness simultaneously among the experimental data. **Chorng-JyhTzeng et.al**[6] this study is analyzed the MRR, EWR and workpiece surface finish on process parameters during the manufacturing of SKD61 by EDM. A hybrid method including a back-propagation neural network (BPNN), a genetic algorithm (GA) and response surface methodology (RSM) were proposed to determine optimal parameter settings of the EDM process. The results shows that the proposed algorithm of GA approach has better predication and confirmation result that the RSM method. **Raghuraman S et.al** [7] this paper aims to investigate the optimal set of parameters such as current, pulse on and off time in EDM process to identify the variations in three performance characteristics such as MRR, TWR and surface roughness value on the work material for machining Mild Steel IS2026 using copper electrode. The obtained result show that the Taguchi Gray relational analysis is being effective technique to optimize the machining parameters for EDM process. **P.B.Wagh et.al** [8] in this investigation, response surface methodology (RSM) is used to investigate the effect of four controllable input variables namely: discharge current, pulse duration, pulse off time and gape voltage on MRR. RSM is a precision methodology that needs only 31 experiments to assess the conditions. The industrialist can directly use the optimum values so that the MRR will be minimum. **SurajChoudhary et.al** [9] study in this research investigates the parameter optimization of EDM on a copper, brass and graphite ware selected as a tool electrodes. From the analysis of variance (ANOVA) shows the percentage contribution of the control factor in the machining of stainless steel 316 in EDM. The optimization result showed that the pulse on-time has the most significant influence on MRR and surface roughness within the specific test range for copper, brass and graphite electrodes. **Rama Rao.S et.al** [10] in this paper Metal matrix composites (MMCs) are now gaining their usage in aerospace, automotive and biomedical industries because of their inherent properties like high strength to weight ratio, low wear rate etc. The influence of the various process parameters, i.e. voltage, feed rate and electrolyte concentration on the predominant machining criteria, i.e. the metal removal rate (MRR) was studied. The settings of the process parameters were determined by using Taguchi's experimental design method. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA), and regression analyses are employed to find the optimal process parameter levels and to analyze the effect of these parameters on metal removal rate values.

EXPERIMENTAL SETUP

A EDM can only make cuts at right-angles to the work table, while a NC positioning system with a two-axis table can perform a wide variety of angled cuts. Independent four-axis machines can cut tapered angles and make cuts that result in different top and bottom profiles. This capability is needed in making extrusion dies and flow valves. The electrode never touches the work during cuts. Dielectric fluid is flushed through the spark gap and is supplied through a hole in the tool or from external jets. It may also be applied through holes in the work piece. For this purpose suction and pressure pots, which also serve as work piece holding devices are used. The dielectric fluid serves as a spark conductor, concentrating the energy to a very narrow region. In addition it serves as a coolant to quench the spark and cool the electrodes and also as flushing medium for disposal of the products of machining. In this Experiment we are using Dielectric fluid as Honex 401.Cast iron is a remelted and modified pig iron. C.I. like steel, is basically an alloy of iron and carbon. It is produced by melting pig iron along with scrap iron in a furnace called "cupola". Cast iron contains about 90 to 95% iron, 2 to 4% carbon and 1 to 3% silicon. The high % of carbon renders the cast iron brittle and unworkable, except by casting. Thus the name, CAST iron. Cast iron has excellent ductility, heat resistance and it damps out vibrations in machinery. Although C.I. is brittle and has lower strength properties than most steels, it is cheap and can be cast more readily than steel.The followings are the different electrode materials which are used commonly in the industry: Graphite, Electrolytic oxygen free copper, Tellurium copper – 99% Cu + 0.5% tellurium, Brass**.** The brass electrode 1.8mm diameter and 400mm length selected for achining. It is an alloy of copper and zinc, brass alloy have small amounts of other elements such as lead, tin or alumimium.

Nominal composition of Brass

Table 1. Composition of Brass

COMPOSITION	Cu	Sn	Zn	Ni	Fe	Al	Pb	Others
%	69	<0.05	30	<0.2	<0.05	<0.2	<0.005	<0.1

Material Removal Rate (MRR)

The material removal rate of the work piece is the volume of the material removed per minute. It can be calculated using the following relation.

$$MRR = 1000 \times \frac{WBM - WAM}{\rho \times t}$$

Where,MRR- material removal rate in mm^3/min,WBM-Weight of workpiece before machining in grams,WAM- Weight of workpiece after machining in grams,ρ-Density of workpiece in g/cc^3,t-Machining time in min.

RESULTS AND DISCUSSION

The 4 factors such as current, pulse on time, pulse off time and gap voltage were choosed as input factor and their 3 levels are minimum, average and maximum of machine levels.

Table 2.Experimental Factors and Levels

FACTORS	LEVEL 1 (min)	LEVEL 2 (avg)	LEVEL 3 (max)
Current (amps) A	15	30	60
Pulse on-time (µs) B	60	500	1200
Pulse off-time (µs) C	45	200	900
Gap voltage (V) D	30	60	120

Signal-to-noise ratio

Taguchi recommends analyzing the mean response for each run in the inner array, and he also suggests analyzing variation using an appropriately chosen signal-to-noise ratio (S/N).It is measure used in science and engineering that compares the level of descried signal of the back ground noise. It is define as the ratio of signal power and the back ground noise power

$$S/N = P_{signal} / P_{noise}$$

S/N ratio for MRR = - 10 $\log_{10}$ [sum $(1/y^2)$ / n] larger is better, So we find the best optimal parameters by using S/N ratio graph

Table 3. S/N Ratio for MRR

S.No	Time (min)	Workpiece Before weight (g)	Workpiece After Weight (g)	MRR (mm^3/min)	S/N ratio
1	17.19	69.534	69.448	0.7046	-2.6272
2	15.14	69.448	69.354	0.8745	-2.6272
3	13.49	69.354	69.289	0.6786	-2.6272
4	4.7	69.289	69.151	4.1355	9.9337
5	4.49	69.151	69.051	3.1369	9.9337
6	4.49	69.051	68.967	2.6310	9.9337
7	3.39	68.967	68.854	4.6948	13.1766
8	3.52	68.854	68.732	4.8817	13.1766
9	3.33	68.732	68.633	4.1873	13.1766
10	15.25	68.633	68.540	0.8589	-2.6736
11	16.44	68.540	68.465	0.6425	-2.6736
12	19.7	68.465	68.360	0.7507	-2.6736
13	3.03	68.360	68.244	5.3921	12.6233
14	3.24	68.244	68.137	4.6514	12.6233
15	3.05	68.137	68.062	3.4634	12.6233
16	3.29	68.062	67.945	5.0088	13.8432
17	4.12	67.945	67.821	4.2390	13.8432
18	3.46	67.821	67.675	5.9432	13.8432
19	15.29	67.675	67.592	0.7646	-2.1901
20	15.47	67.592	67.498	0.8558	-2.1901
21	15.11	67.498	67.420	0.7271	-2.1901
22	4.54	67.420	67.320	3.1023	9.8910
23	4.48	37.320	67.204	3.6469	9.8910
24	5.1	67.204	67.103	2.7893	9.8910
25	4.2	67.103	66.985	3.9571	11.6978
26	4.59	66.985	66.847	4.2346	11.6978
27	5	66.847	66.724	3.4648	11.6978

Main Effects Plot for SN ratios

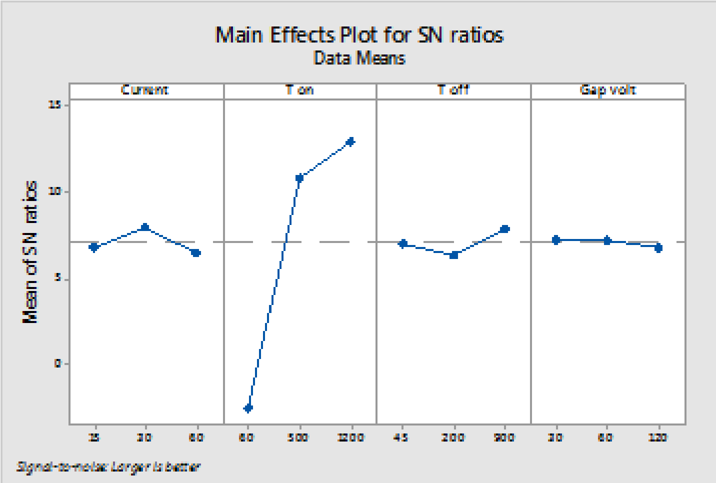

Fig 1: Graph MRR Vs Current, Pulse on-time, Pulse off-time and Gap voltage

Optimum condition for MRR

Current = 30 amps
Pulse on-time = 1200 µs
Pulse off-time = 900 µs
Gap voltage = 30 volts

Table. 4 Optimal Parameter setting of Input Factors

Physical Requirement	Optimal combination Current (I)	Optimal combination T on	Optimal combination T off	Optimal combination Gap voltage(V)
Max. MRR	30	1200	900	30

Table. 5 Verification Experimental Results

Verification exp. For	MRR (mm^3/min)
Max. MRR	**4.268**

CONCLUSIONS

This research investigates the parameter optimization of electrical discharge machining on Gray cast iron work piece with brass tool electrode using Taguchi approach. The main conclusions of this research are the following:

Machining performance of the EDM process can be improved effectively by using optimum factors as determined within this works.The mean S/N ratio for each level of the cutting parameters reveals that, when using brass electrode, the effect of cutting parameters can be ranked as following: pulse on-time, pulse off-time, current and gap voltage.The optimal process parameters that have been identified to yield that the best combination of process variables are brass electrode are Average level of current, highest level of pulse on-time, highest level of pulse off-time and lowest level of gap voltage.

REFERANCES

1. Sameh S. Habib, "**Parameter Optimization of Electrical Discharge Machining Process by using Taguchi Approach"**, Journal Of Engineering And Technology Research, April 2014, Vol 6(3),pp27-42, DOI: 10.5897/JETR2014.0356
2. Samar Singh, MukeshVerma , **"A Parametric Optimization of Electric Discharge Drill Machine Using Taguchi Approach"**, Journal of Engineering, Computers & Applied Sciences (JEC&AS)ISSN No: 23195606 Volume 1, No.3, December 2012
3. PichaiJanmanee, ApiwatMuttamara, **"Optimization of Electrical Discharge Machining of Composite 90WC-10C_o Base on Taguchi Approach"** European Journal of Science Research, ISSN 1450-216X Vol.64 No.3 (2011), pp. 426-436
4. Rajmohan T, Prabhu R, Subba Rao G, Palanikumar K, **"Optimization of Machining Parameters in Electrical Discharge Machining (EDM) of 304 Stainless Steel"** , ELSEVIER Science Direct, Procedia Engineering 38 (2012) 1030- 1036, ICMOC 2012, DOI; 10.1016/j. proeng.2012.06.129

5. R,Rajesh and M. DevAnand, **" The Optimization of the Electro-Discharge Machining Process Using Response Surface Methodology and Genetic Algorithms"**, ELSEVIER Science Direct, Procedia Engineering 38 (2012) 3941-3950, ICMOC-2012, DOI: 10.1016/j.proeng.2012.06.451
6. Chorng-JyhTzeng and Rui-Yang Chen, **"Optimization of Electric Discharge Machining Process Using the Response Surface Methodology and Genetic Algorithms Approach"**, International Journal of Precision Engineering and manufacturing Vol. 14, No. 5, pp. 709-717, DOI: 10.1007/s12541-013-0095-x, May 2013/709
7. Raghuraman S, Thiruppathi k, Panneeselvam T, Santhosh S, **" Optimization of EDM Parameters using Taguchi method and Grey Relational Analysis for Mild Steel IS 2026"**, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, ISSU 7, July 2013
8. P.B.Wagh, R.R.Deshmukh, S.D.Deshmukh, **" Process Parameters Optimization for Surface Roughness in EDM for AISI D2 Steel by Response Surface methodology"**, International journal of Mechanical Engineering and Technology, ISSN 0976-6340, Vol 4, ISSE 1, January-February 2013
9. SurajChoudhary, Krishna Kant and Parveen Saini, **"Analysis of MRR and SR with Different Electrode for SS 316 on Die-Sinking EDM using Taguchi Technique"**,Global Journal of Researches in Engineering Mechanical and Mechanics Engineering Volume 13 Issue 3 Version 1.0 Year 2013 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Inc. (USA) Online ISSN: 2249-4596 Print ISSN:0975-5861
10. Rama Rao. S, Padmanabhan. G, **"Application of Taguchi methods and ANOVA in optimization of process parameters for metal removal rate in electrochemical machining of Al/5%SiC composites"**, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622,Vol. 2, Issue 3, May-Jun 2012, pp. 192-197
11. Dinesh Kumar, Naveen Beri, Anil Kumar, **"STUDY OF OVERCUT DURING ELECTRIC DISCHARGE MACHINING OF HASTELLOY STEEL WITH DIFFERENT ELECTRODES USING THE TAGUCHI METHOD"**, International Journal of Advanced Engineering Technology, ISSN 0976-3945, IJAET/Vol.II/ Issue I/January-March, 2011/306-312
12. SrinivasAthreya, DrY.D.Venkatesh, **"Application Of Taguchi Method For Optimization Of Process Parameters In Improving The Surface Roughness Of Lathe Facing Operation"**,International Refereed Journal of Engineering and Science (IRJES), ISSN (Online) 2319-183X, (Print) 2319-1821 Volume 1, Issue 3 (November 2012), PP.13-19
13. Maninder Pal Singh, C S Kalra, Shahbaz Singh, **"An Experimental Investigation of Radial Overcut During Machining of Al/Al2O3 MMC by Rotary EDM"**, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 4, April 2013
14. Dinesh Kumar.Kasdekar, Vishal Parashar, Jasveersingh, M.K.Gour, **"Taguchi Method and ANOVA: An Approach for Selection of Process Parameters of EDM of EN-353 Steel"**, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 6, June 2014

Author's biography with Photo

T.Yuvaraj received B.E., degree in Mechanical Engineering from Mahendra Engineering college, Thiruchengode,Tamilnadu,India and M.E., degree in Engineering Design from Sona College of Technology, salem, Anna University, India, in 2005 and 2007, respectively. Currently he is pursuing towards his Ph.D. degree in Anna University, India. Presently, he is as Assistant Professor in the Department of Mechanical Engineering in Muthayammal Engineeirng College, Rasipuram,India.

Dr.P.Suresh M.E, Ph.D is currently working as Professor and Head, Department of Mechanical Engineering, Karpagam College of Engineering (Autonomous), Coimbatore, Tamilnadu, India. Previously, he was the Head of the Department at Muthayammal Engineering college, Rasipuram, Tamilnadu, India. He received his Ph.D in the field of Industrial Engineering from Anna University,Tamilnadu, India. His research interests are in the areas of scheduling for manufacturing systems, production planning, optimisation techniques, etc.. He received M.E degree from MIT, Chennai, Tamilnadu, India. He received his B.E degree in Mechanical Engineering from Adhiyamaan College Of Engineering, Hosur,Tamilnadu, India. He has published more than 50 technical papers in the international journals and conferences.