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Optimization of Wire Cut Electro Discharge Machining Process Parameters for Aluminium 6082 by using Taguchi Technique

Mahesh Muley[1], Dr. A. M. Nikalje[2]
[1]*PG student, Department of Mechanical Engineering, Government College of engineering, Aurangabad*
[2]*Associate Professor, Department of Mechanical Engineering, Government College of engineering, Aurangabad*

Abstract: ***The manufacturing industry is changing very drastically in all the aspect regarding the manufacturing technology as well as the quality concern as per as the quality is considered. Quality is becoming a significant trend in todays growing automobile industry. In the field of metal cutting operations, the surface roughness is becoming more dominant parameter as per as the quality of the component is considered. Electrical discharge machining is becoming a most powerful non conventional machining which is being widely used in the field of machining. Most specifically our work was conducted on the electrical discharge wire cut machining for achieving the desired surface roughness (Ra) and adequate material removal rate (MRR). The input parameter for our research work were selected as Peak current, pulse on time & pulse off time while the output parameter was selected as MRR and the surface roughness. Aluminum 6082 Grade material is used as a specimen and the research methodology implemented for the research work is taguchi and Anova.***
Keywords: Wire cut EDM, Taguchi, MRR surface roughness, Anova.

I. INTRODUCTION

In the recent trend in the manufacturing sector of machining, there is a wide innovation was developed in the recent decades regarding the development of the machining processes. The most focus is mentioned on the non conventional machining process which utilizes the new mechanism or principle of working with the increased effectiveness as well as increased efficiency. Wire Electrical discharge machining (WEDM) is one of the most famous non-traditional machining process which is capable to give a surface finish in the range of microns. Before starting the main research work, we will take a brief introduction of WEDM. In general, electrical discharge machining is also called as spark machining or spark eroding.as the name indicates the mechanism of working, there is metal removal action with the help of spark generated by passing a stream of electric current through the wire which is used as a tool.

In Electrical discharge machining process, the wire is known as tool electrode while the work piece is called as work piece electrode.there is a little gap between the tool and the workpiece. This gap is filled by a fluid called as a dielectric fluid which is being circulated among tool and the work piece till the completion of the machining process.When the intensity of the current passing through the electrode is increased after a certain threshold value, the intensity of the electric field increases which causes the phenomenon of dielectric breakdown.Due to the dielectric breakdown, the electric arc is generated which is responsible to etching of the workpiece which creates the material removal action.As the dielectric fluid is continuously circulated through the gap between the tool and the workpiece, the removed material is taken away by the dielectric fluid. And this cycle is continuous till the desired result is achieved.

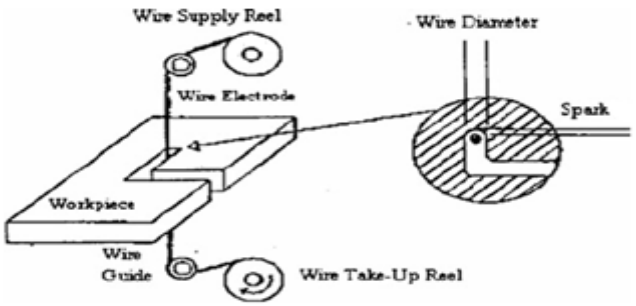


Fig.1. Schematic representation of Wirecut EDM machining [1]

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The wire cut electrodischarge machine was invented in early 1960 to deal with the machining of the hardened steel as it is hard to machine the steel by the machining processes that were available at that time. but in today's scenario, there are so many advanced machines are invented which can work as effective as the wire cut electro discharge machining. Nowadays the wire cut EDM are empowered with the numerical control technology to get accuarate readings in order of few microns to millimicrons.

II. LITERATURE REVIEW

1) In the scholar article entitled as "Investigation of WEDM process parameters of AleSiCeB4C composites using response surface methodology published by S. Suresh Kumar , F. Erdemir , Temel Varol , S. Thirumalai Kumaran ,M. Uthayakumar , Aykut Canakci, in their research work, they incorporated the use of response surface methodology to conduct the investigation on the aluminium – silicon carbide metal matrix cutting and to understood the effects of the machining parameters on the output parameters such as kerf width and the cutting speed. They concluded their research work with a concluding remark of getting the optimized combination set of parameters for the given metal matrix. [2]

2) The research article published under the title as "Assessment of Optimal Parameters of Wire EDM on Ni-Coated Al2O3p/ AA7075 MMCs Using PCA Coupled GRA by D. Vijay Praveen, D. Ranga Raju· M. V. Jagannadha Raju in the journal Arabian Journal for Science and Engineering, in their research work, they used stir casting method for the samples. Also they employed taguchi L18 multi level orthogonal array. The response obtained is investigated on the basis of ANOVA technique. They concluded their research with a concluding remark of maximization of the metal removal rate and minimization of the surface roughness. The main concluding remark of their research work was found that the grey relation grade has the highest impact on the machining as per the input parameters are concerned.[3]

3) In the research article "Experimental investigation and multi-objective optimization of wire electrical discharge machining (WEDM) of 5083 aluminum alloy" published by G. Selvakumar, G. Sornalatha, S. Sarkar, S. Mitra in the journal sciencedirect Trans. Nonferrous Met. Soc. China 24(2014) 373_379. In their research work, the main objective for their research work was finding a set of optimal parameters for the machining of the 5083 Aluminum alloy.the surface roughness was taken as the output paramaters or simply response. For the experimentation work, they used the taguchi method of design of experiment. The concluding remark of the research work was found that the cutting speed was found to be independent of the tension of the cutting wire.the process is also optimized by the pareto chart approach.[4]

4) In the scholar article entitled as "Parametric optimization of wire electrical discharge machining on aluminium based composites through grey relational analysis" published by S. Suresh Kumar, M. Uthayakumara, S. Thirumalai Kumarana, P. Parameswaran, E. Mohandas, G. Kempulraj, B.S. Ramesh Babu, S.A. Natarajan. In their research work, they used the specimen material as boron carbide and optimization of the parameters was the base objective to conduct the experimentation.in their research work,the conclusion of the research work was found that the kerf width is found proportional to the peak current. [5]

5) In the research article published under the title "Experimental investigation of MRR, RA of 304 stainless steel using WEDM" published by the author S Kalyanakumar, L Prabhu, M Saravanan1 A Imthiyas in the journal IOP Conf. Series: Materials Science and Engineering 993 (2020), in their research work, they used Austeinitic stainless steel 304 for the investigation purpose . they implemented the face centred response surface methodology for the research work. The conclusion remark of their research work was finding the optimal process parameters for the given set of conditions. [6]

6) The research article published under the title "Optimization of process parameters during wire electrical discharge machining of Ti Gr 2 for improving corner accuracy" by Saravanan M, Vinoth Kumar A M and Nirmal Kannan V and Stephan Thangaiah I S in the journal 5th International Conference of Materials Processing and Characterization (ICMPC 2016). In their research work they concluded their work with a notable remark that gap voltage , wire tension and the wire diameter plays an important role in the determination of response parameters in the machining process. [7]

7) The research article published by Lee soon-Kwan stated that Currently, the aircraft industry, aircraft parts as well as airframes have been produced by cutting rather than forging and casting because of the residual stress and stress concentration. In this study, the aircraft is being used in many parts of aluminum alloy 2024 in WEDM. The selected experimental parameters are peak current, no-load voltage, off time, and feed rate.[8]

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III.EXPERIMENTAL SETUP

In our experimentation work, we have created an array given by the software minitab for conducting the experimentation work.before starting the main experimentation work, we have mentioned the chemical and mechanical properties properties of the work material.

Table 1. Chemical properties of Aluminium.

Metals	Chemical composition
Mn	0.40 – 1.00
Fe	0.0 – 0.50
Mg	0.60 – 1.20
Si	0.70 – 1.30
Cu	0.0 – 0.10
Zn	0.0 – 0.20
Ti	0.0 - 0.10
Cr	0.0 - 0.25
Al	Bal

Table 2. Mechanical properties of Aluminium

Sr. No.	Property	Value
1	Melting Point	Approx. 555 C
2	Modulus of Elasticity	70 GPa
3	Electrical Resistivity	0.038x10-6 ohm.m
4	Density	2.7 g/cm3
5	Thermal Conductivity	180 W/M. k

The Experimental Machine Selection Table 3 states the specification of the WEDM used in this study. All the experiments were conducted at Kishan Engg. MIDC Waluj, Aurangabad, M.S, India.

Table 3. Technical specification of the machine

Make and Model	ECO-32S
Work Table Size	500 x 850 mm
Working Table	320 x 400 mm
Max. Work piece Weight	400 kg
Machine Dimensions	1800x1300x1900
Machine Weight	2000 kg

The sample workpiece material is Aluminum 6082 in form of a cubical block. The experiment is performed on the WEDM with Brass wire of 0.25 mm diameters as an electrode. A constant gap of 0.02 mm is maintained between the workpiece and electrode wire by a computer-controlled positioning system.

Fig.2 cut pieces of Al 6082



After conducting the experimentation, the readings were plotted against the array given by the Minitab software. the readings are tabulated as shown in table 4

A. Experimental Result

Table 4. readings for the response material removal rate and Surface roughness

Experiments	Ip (A)	T_{on} (µs)	T_{off} (µs)	MRR (mm3 /min)	Ra (µm)
1	4	28	6	6.64	3.65
2	4	32	7	7.86	3.94
3	4	36	8	8.27	4.12
4	5	28	7	8.98	4.34
5	5	32	8	9.27	4.68
6	5	36	6	9.46	4.719
7	6	28	8	10.06	4.830
8	6	32	6	10.12	4.840
9	6	36	7	11.50	4.890

B. Results of MRR

Fig 3. Main Effects Plot for S/N Ratio

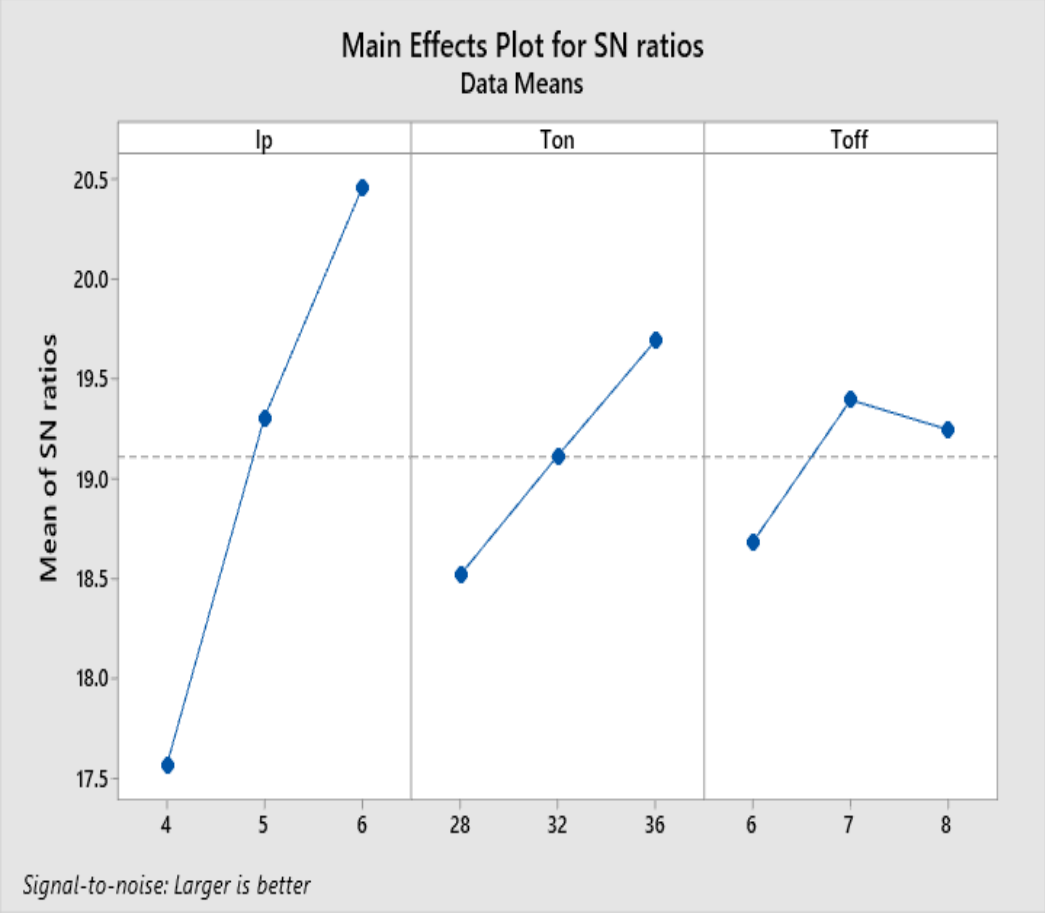


Table 6 ANOVA Result of MRR versus Ip, Ton, Toff

Source	DF	Adj SS	Adj MS	% Contribution
Current	2	13.2314	13.2314	81.85
Pulse on time	2	2.1004	2.1004	12.99
Pulse off time	2	0.3174	0.3174	1.96
Error	2	0.5163	1.033	3.19
Total	8			100

It shows that the current (81.85%), the pulse on time (12.99%) have major influence on the material removal rate. Contribution of current (81.85%) is highest among all three parameters hence it is most dominating parameter while pulse off time is least affecting parameter.

C. Results of Surface roughness

Fig 4. Main Effects Plot for S/N Ratio

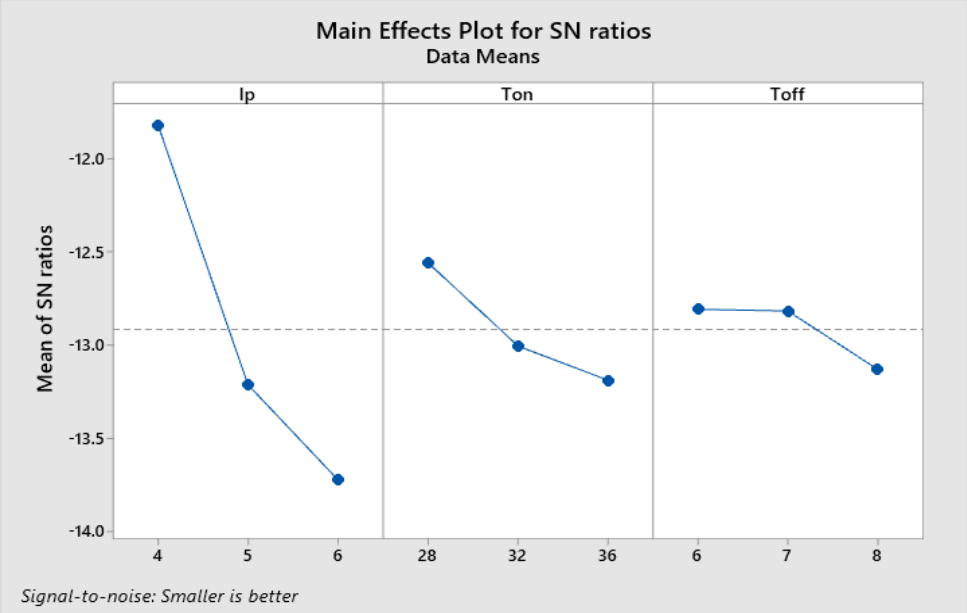


Table 6 ANOVA Result of Ra versus Ip, Ton, Toff

Source	DF	Adj SS	Adj MS	% Contribution
Current	2	1.35375	1.35375	82.73
Pulse on time	2	0.13771	0.13771	8.42
Pulse off time	2	0.02954	0.02954	1.81
Error	2	0.11527	0.02305	7.04
Total	8			100

It shows that the current (82.73%), the pulse on time (8.42%) have major influence on the material removal rate. Contribution of current (82.73%) is highest among all three parameters hence it is most dominating parameter while pulse off time is least affecting parameter.

IV. CONCLUSION

After successful conduction of the experimentation work and the ANOVA, we come to conclusion that out of the parameters like peak current, pulse time on , pulse off time, Material removal rate and surface roughness, the material removal rate and the surface roughness are selected as the final response parameters or we can say that the MRR and surface roughness are the output parameters in our research work. We concluded that the peak current and pulse on time plays a significant role in the material removal rate and the surface roughness.

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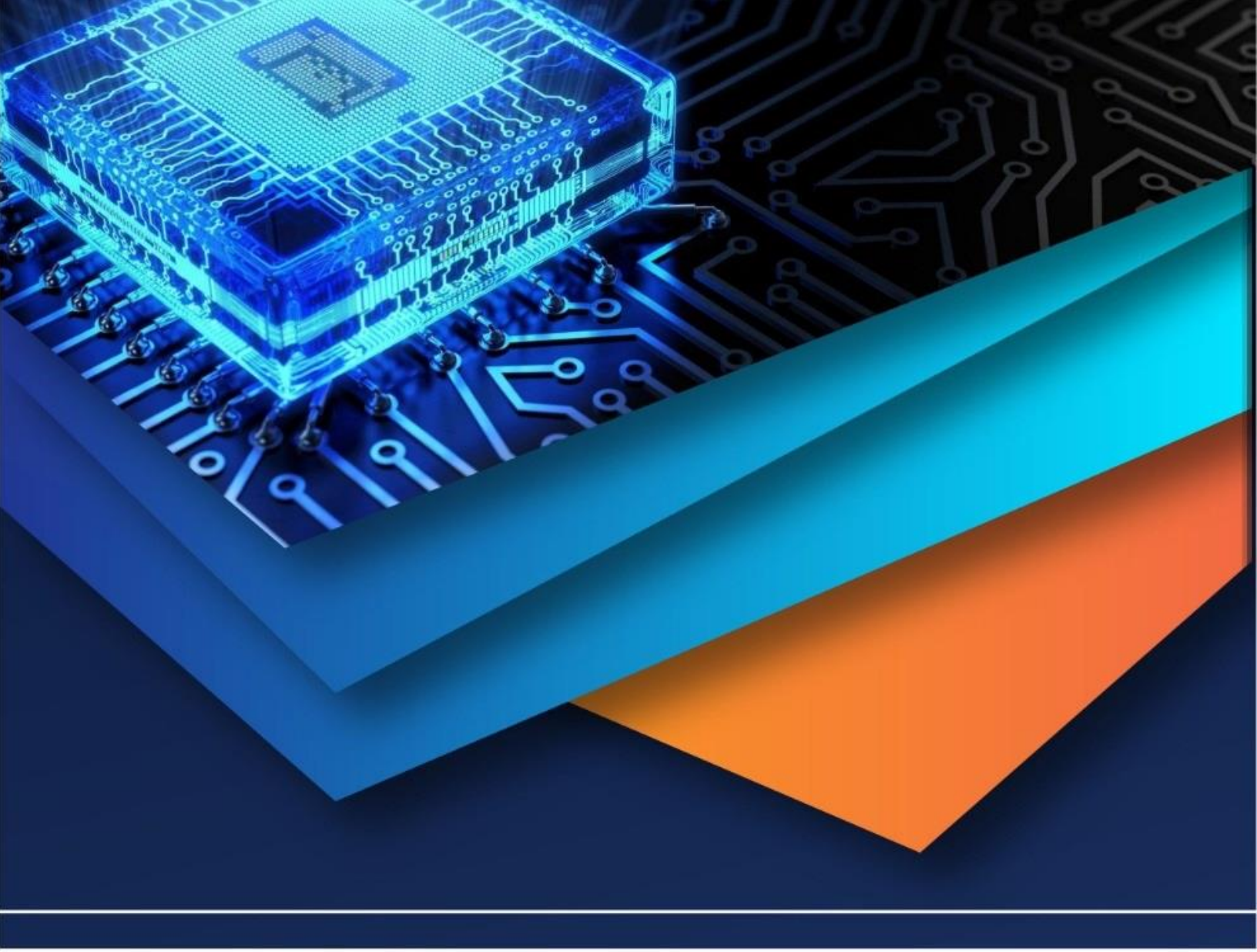
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