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Optimization of Wire Cut EDM of Aluminium Alloy 6063 by using Taguchi Technique

Kandukuri Srinivas[1], K. Anabayan[1], P. H. J. Venkatesh[2]

[1]Department of Mechanical Engineering,
JB Institute of Engineering and Technology, Hyderabad, Telangana, India
[2]Department of Mechanical Engineering,
Vignans Institute of Information Technology(A), Visakhapatnam, Andhra Pradesh, India

ABSTRACT

The cold work applications like aluminium extrusion, it allows complex shapes to be formed with very smooth surfaces and it is popular for visible architectural applications such as window frames, door frames, roofs, and sign frames should have high toughness, wear resistance, compressive strength, high corrosion resistance, high surface finish and complex profiles. AA 6063 is an aluminium alloy, with magnesium and silicon as the alloying elements. This material can satisfy the above requirements, because of its hardness and strength AA 6063 cannot be machined easily through traditional machining processes. Advanced machining processes are used only when there is no suitable traditional machining process to meet necessary requirements efficiently and economically. Among them wire cut EDM is employed because of its tight tolerances and high surface finish. Based on intense literature survey, it was noticed that very few works were reported on WEDM of AA 6063. As a part of our thesis, WEDM of AA 6063 is considered for the study. In this work Pulse on time, pulse off time, peak current, wire speed, wire tension and flushing pressure of dielectric medium are considered as parameters and their effect on performance measures, metal removal rate (MRR) and surface roughness will be studied through experimental investigation. Using Taguchi approach, considered parameters will be optimized for maximum MRR and minimum for Surface roughness separately. Taguchi method will be applied to generate mean S/N ratios to identify the optimum process parameters.

KEYWORDS: *Compressive Strength, Complex Profile, EDM, MRR, Surface Roughness, Taguchi Approach*

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INTRODUCTION

As a part of our theory WEDM of Aluminium alloy 6063 (Silicon-0.2 to 0.6%, Iron-0.35%, copper-0.10 Manganese-0.1%, Magnesium-0.45 to 0.9%, Zinc-0.10%,Titanium-0.1%,Chromium-0.1max remaining is balanced by Aluminium) is considered for the study. In this research Peak Current, Pulse On time and Pulse Off time are considered as input process parameters. The effect of these parameters on performance measure i.e., metal removal rate (MRR) and Surface Roughness (Ra) is studied through experimental investigation. Taguchi Method is applied to identify the optimum process parameters at which MRR is maximum and Ra is minimum.

Applications of AA6063

AA6063 is an medium strength alloy and having high hardness.

Typical applications for AA6063:
A. Architectural applications
B. Extrusions
C. Window frames
D. Doors
E. Shop fittings
F. Irrigation tubing

WIRE ELECTRIC DISCHARGE MACHINING:

Electrical discharge machining (EDM) is a nontraditional, thermoelectric process which erodes material from the work piece by a series of discrete sparks between a work and tool electrode immersed in a liquid dielectric medium. These electrical discharges melt and vaporize minute amounts of the work material, which are then ejected and flushed away by the dielectric. The sparks occurring at frequency continuously remove the work piece material by melting & evaporation. The dielectric acts as a deionizing medium between two electrodes and its flow evacuates the solidified material debris from the gap assuring optimal conditions for spark generation. The material removal protocols for both EDM and WEDM are identical but the functional characteristics are different. Mainly, WEDM requires a thin wire for continuously feeding through the work piece by a microprocessor based control system which supports the various complex parts such as, shapes are machined with better accuracy. Due to such advantages the various kinds of micro shaped holes, micro gears, complex micro parts and dies etc. can be machined with a better performance by WEDM process than other machining process. According to the requirements of the product for industrial use the development of the WEDM machine has been done with the same principle as that of EDM. Wire electrical discharge machining (WEDM) also known as wire-cut EDM. In this process a thin single brass or copper coated electrode is fed through the work piece which is immersed in the dielectric fluid, mainly deionized water is used as a dielectric fluid. The wire-cut types of machines were used in the 60th century for the resolution of making tools and dies by hardened steel.

Principle of wire electrical discharge machining:
In WEDM metal is cut with a special metal wire electrode that is programmed to travel along a preprogrammed path. A WEDM generates spark discharges between a small wire electrode (usually less than 0.5 mm diameter) and a work piece with deionized water as the dielectric medium and erodes the work piece to produce complex two and three dimensional shapes according to a numerically controlled (NC) path. The wire cut EDM uses a very thin wire 0.02 to 0.3 mm in diameter as an electrode and machines a work piece with electrical discharge by moving either the work piece or wire. Erosion of the metal utilizing the phenomenon of spark discharge that is the very same as in conventional EDM. The prominent feature of a moving wire is that a complicated cutout can be easily machined without using a forming electrode.

Wire cut EDM machine basically consists of a machine properly composed of a work piece contour movement control unit (NC unit or copying unit), work piece mounting table and wire driven section for accurately moving the wire at constant tension, a machining power supply which applies electrical energy to the wire electrode and a unit which supplies a dielectric fluid (distilled water) with constant specific resistance.

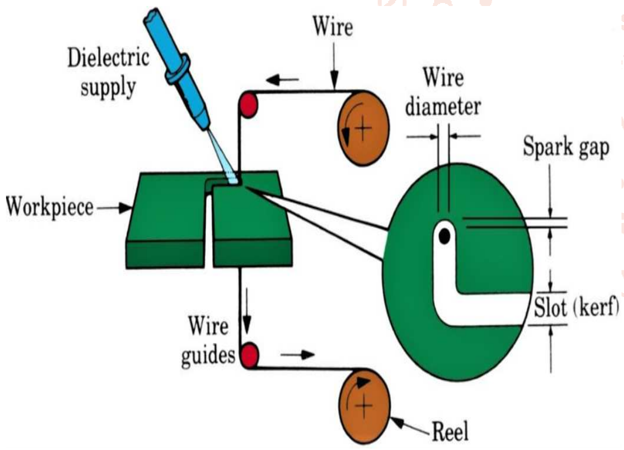

Figure 1: Cutting Mechanism of WEDM

The main goals of WEDM manufacturers and users are to achieve a better stability and higher productivity of the WEDM process, i.e., Higher machining rate with desired accuracy and minimum surface damage. However, due to a large number of variables even a highly skilled operator working with a WEDM is unable to achieve the optimal performance and avoid wire rupture and surface damage as the machining progresses. Although most of the WEDM machines available today have some kind of process control, still selecting and maintaining optimal settings is an extremely difficult job. The lack of mach inability data on conventional as well as advanced materials, precise gap monitoring devices, and an adaptive control strategy that accounts for the time-variant and stochastic nature of the process are the main obstacles toward achieving the ultimate goal of unmanned WEDM operation.

Material properties

Table 1.Material Properties of Brass

Properties	Value
Young's modulus(GPa)	106
Shear modulus(GPa)	37
Poisson's ratio	0.31
Density(g/cc)	8.49
Electrical resistivity($x10^{-8}$Ohm-m)	7.1
Specific heat (J/molK)	26.26
Melting point(°C)	890
Thermal conductivity(W/mK)	115

METHODOLOGY

Design of experiments:
Optimization of process parameters is the key step in the Taguchi method to achieve high quality without increasing cost. The optimal process parameters are selected not only to improve quality, but also to be least sensitive to the variation of environmental conditions. Basically, classical process parameter design is complex and not easy to use. Many experiments have to be carried out when the number of process parameters increases. To overcome this problem the Taguchi method uses a special design of orthogonal arrays to study the entire process parameter characteristics with a small number of experiments. A loss function is then defined to calculate the deviation between the experimental value and the desired value. Taguchi recommends use of the loss function to measure the performance characteristic deviating from the desired value. The value of the loss function is further transformed into a signal-to-noise (S/N) ratio. Usually, there are three categories of the performance characteristic in the analysis of the S/N ratio, that is, the lower-the-better, higher-the-better, and nominal-the-better. The S/N ratio for each level of process parameter is computed based on the S/N analysis. Regardless of the category of the performance characteristic, the larger S/N ratio corresponds to a better performance characteristic. Therefore, the optimal level of a process parameters is the level with the highest S/N ratio. This is true for the optimization of a single performance characteristic. However, optimization of multiple performance characteristics is different from that of a single performance characteristic. The higher S/N ratio for one performance characteristic may correspond to a lower S/N ratio for another. Therefore, the overall evaluation of the S/N ratio is required for the optimization of multiple performance characteristics.

Orthogonal Array Experiment
Selection of an appropriate orthogonal array for experiments depends on these items in order of priority:

The number of factors and interactions of interest.

The number of levels for the factors of interest.

The desired experimental accuracy or cost limitations. In the present study, a three factors Peak current, Pulse on time, Pulse off time are selected . The next step is to select an appropriate orthogonal array to fit the specific task. The degrees of freedom for the orthogonal array should be greater than or at least equal to those for the machining parameters. In this study, an L9 orthogonal array is used. This array has three columns and 9 rows and it can handle the three-level cutting parameters at most. Therefore, only 9 experiments are needed to study the entire cutting factor space using the L9 orthogonal array.

Computational procedure:

The experimental observations are further transformed into a signal-to-noise (S/N) ratio. There are several S/N ratios available depending on the type of characteristics. The characteristic that higher value represents better machining performance, such as MRR, is called 'higher is better, HB'. Inversely, the characteristic that lower value represents better machining performance, such as surface roughness, is called 'lower is better, LB. Therefore, "HB" for the MRR 'LB" for the SF and "LB" for the kerf were selected for obtaining optimum machining performance characteristics were selected for obtaining optimum machining performance characteristics.

The loss function (L) for objective of HB and is defined as follows:

$L_{HB} = (1/n\Sigma^{n}|_{=0}\ 1/y^{2}|)$

The S/N ratio can be calculated as a logarithmic transformation of the loss function as shown below

S/N ratio for MRR = $-10\log 1/n(\Sigma^{n}|_{=0}\ 1/y^{2}|)$

The loss function (L) for objective of LB and is defined as follows:

$L_{LB} = (1/n\Sigma^{n}|_{=0}\ y^{2}|)$

The S/N ratio can be calculated as a logarithmic transformation of the loss function as shown below

S/N ratio for SR = $-10\log 1/n(\Sigma^{n}|_{=0}\ y^{2}|)$

Optimization of process parameters of WEDM on AA6063 by using

Taguchi technique

Design of Experiments

The taguchi method is very helpful to reduce the number of experiments by its robust design. This can be done by design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. Taguchi developed a method for designing experiments to investigate influence of process parameters on output performance measures. Optimization of WEDM by using Taguchi technique consists of several steps. These are explained below.

Selection of process parameters

Table2: Machining parameters and their levels

S. no	Parameter	Level 1	Level 2	Level 3
1	Peak current in Amps	10	11	12
2	Pulse on time in µsec	100	104	108
3	Pulseoff time in µsec	55	59	63

Selection of orthogonal array:

Table 3:L9 Orthogonal Array

Test case	IP	Ton	Toff
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Experimentation:

Figure2: CNC WIRE CUT EDM machine

Figure3: work pieces after machining

RESULT AND DISCUSSION

Table 4: Experimental Results

Sl.no	Peak Current (I/p)	PULSE ON TIME (Ton)	PULSE OFF TIME (T off)	MRR (mm3/ min)	SR (µm)
1	10	100	55	3.6675	1.73
2	10	104	59	3.7521	1.84
3	10	108	63	4.6210	2.19
4	11	100	59	3.9610	1.71
5	11	104	63	5.9640	2.31
6	11	108	55	8.6850	2.85
7	12	100	63	4.1540	1.96
8	12	104	55	7.6350	2.73
9	12	108	59	9.6730	2.95

S/N RATIOS OF MRR

Table5: S/N ratios for MRR

Sl. no	S/N RATIO
1	11.2874
2	11.4855
3	13.2947
4	11.9561
5	15.5108
6	18.7754
7	12.3693
8	17.6562
9	19.71112

Table6: Average S/N ratios for MRR

LEVEL	I/P	T_{ON}	T_{OFF}
1	12.02	2.255	3.11
2	15.41	5.03	2.47
3	1.91	5.34	5.80

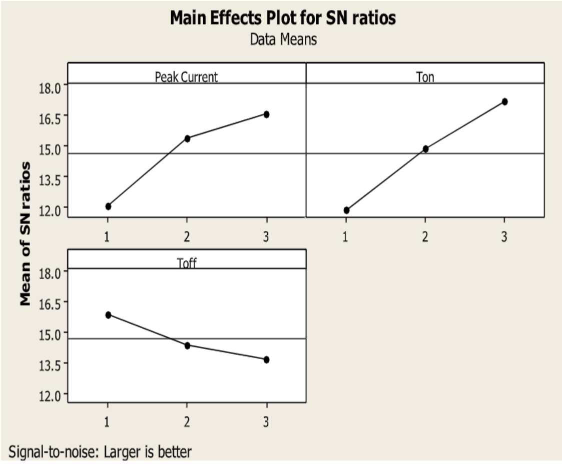

Figure 4: Average S/N ratios of MRR V/S Levels

Table7: Optimum process parameter values for MRR

parameters	Levels	Optimal values
Peak Current	3	12 Amp
Pulse on time	3	108 µsec
Pulse off time	1	55 µsec

Table 8:S/N RATIOS OF SR

LEVEL	I/P	T_{ON}	T_{OFF}
1	-5.622	-5.089	-7.527
2	-7.047	-7.135	-6.451
3	-7.988	-8.434	-6.679

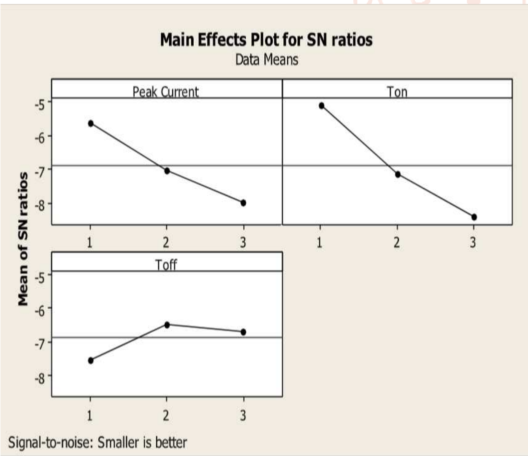

Figure5: Average S/N ratios of SR v/s Levels

Table9: Optimum process parameter values of SR

parameters	Levels	Optimal values
Peak Current	1	10 Amp
Pulse on time	1	100 µsec
Pulse off time	2	59 µsec

CONCLUSION

The results obtained explains that an attempt was made to determine the significant machining parameters for performance measures like MRR and SR separately of AA6063 by using WEDM process the factors like Peak current, Pulse on time and Pulse off time have been found to play a significant role for MRR and Surface roughness. Taguchi's method is used to obtain optimum process parameters combination for maximization of MRR and minimization of SR. The confirmation experiments were conducted to evaluate the result predicted from Taguchi Optimization and the future scope of the work on AA 6063 is used in many manufacturing companies and machining industries now-a-days to manufacture tools for different types of machining because it has medium strength for a material. Therefore, the present work may give some guidelines for the researchers working in the electric discharge machining of AA 6063.This work describes the machining characteristics of AA 6063, as the performance measures get affected with the change in input variables.

REFERENCES

[1] S. S. Mahapatra et al., Optimization of Correlated Quality Characteristics in WEDM Process using Taguchi Approach Coupled with Principal Component Analysis, J. Manuf. Sci. Prod. Volume 13 & 2013 (de gruyter).

[2] Saurabh Chhabra and Deepak Gupta, Optimization of electrical discharge machining of composite 900 WC-10 Co base on Taguchi approach"` European journal of scientific research Vol. 64 No. 3 (2011), pp 426-436.

[3] P. Bharathi and G. Srinivas Rao, Experimental investigation of WEDM variables on surface roughness of AISI H13, Manufacturing Science and Technology 2013; 1 [2]: 23-30.

[4] Dipti Ranjan Patra et al. Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 6, (Part -4) June 2015, pp.57-62.

[5] Vikram Singh and S. K. Pradhan,Optimization of WEDM Parameters Using Taguchi Technique and Response Surface Methodology in Machining of AISI D2 Steel, Procedia Engineering, Volume 97, 2014, Pages 1597-1608.

[6] Atul kumar and Dr D. K. Singh. Optimization of machining parameters in WEDM of AISI D3 Steel using Taguchi Technique, Procedia CIRP 2014; 14: 194-199.

[7] Kamal Jangra et al. Optimization of multi machining characteristics in WEDM of WC-5.3%Co composite using integrated approach of Taguchi, GRA and entropy method Frontiers of Mechanical Engineering Volume 7 & 2013 (springer link)

[8] Jaganathan P, naveen Kumar T, Dr. R. Sivasubramanian " Machining parameters optimization of WEDM process using Taguchi method" International journal of scientific and research publication Vol. 2.