A Study and Investigation on MRR in Wire Electrical Discharge Machining using Molybdenum Wire

Vijay D. Patel[1] Dr.D.M.Patel[2] Prof. U.J.Patel[3] Biraj Patel[4] Nilesh Butani[5]
[1]Research Scholar [2]Principal [3]Assistant Professor [4,5]M.tech Student
[3]Mechanical Engineering Department
[1,3,4,5]U.V.Patel College Of Engineering, Ganpat university [2]Sarswati College of Engineering and Technology

Abstract— Wire electrical discharge machining process is a highly complex, time varying & stochastic process. The process output is affected by large no of input variables. Therefore a suitable selection of input variables for the wire electrical discharge machining (WEDM) process relies heavily on the operators technology & experience because of their numerous & diverse range. WEDM is extensively used in machining of conductive materials when precision is of prime importance. Rough cutting operation in wire EDM is treated as challenging one because improvement of more than one performance measures viz. Metal removal rate(MRR), surface finish & cutting width (kerf), Dimensional derivation, Cutting Speed, Machining Time are sought to obtain precision work. In this work an approach to determine parameters setting is proposed. Using taguchi‟s parameter design , significant machining parameters affecting using Copper, Brass, Tugstan carbide and aluminum wire electrode, the performance measures are identified as pulse peak current , pulse on time, pulse off time, Flushing Pressure, Wire Speed, Wire tension and duty factor . The effect of each control factor on the performance measure is studied individually using the plots of signal to noise ratio, Grey relation Analysis and ANN and ANOVA Technique, The study demonstrates that the WEDM process parameters can be adjusted so as to achieve better metal removal rate, surface finish, electrode wear rate.

Key words: Calculation Of Grey Relational, Analysis & Discussion Parameter, Confirmation Test

I. INTRODUCTION

The phenomenon of erosion of metals by electric spark was first noticed by Joseph Priestily in 1878 but this was not used for machining of metals until 1930s. Controlled machining of metals by electric sparks was first done by Lazarenko in Russia in 1944 [2].

One of the most widely used Non-Conventional Machining process in industry is Electrical Discharge Machining (EDM). Electric Discharge Machining is a non-traditional concept which is based on the principle of removing material by means of repeated electrical discharges between the tool termed as electrode and the work piece in the presence of a dielectric fluid [3]. Electrical Discharge Machining (EDM) uses thermal energy to achieve a high-precision metal removal process from a fine, accurately controlled electrical discharge. The electrode is moved towards the work piece until the gap is small enough so that the impressed voltage is great enough to ionize the dielectric [1]. Short duration discharges are generated in a liquid dielectric gap, which separates tool and work piece. The material is removed with the erosive effect of the electrical discharges from tool and work piece. EDM does not make direct contact between the electrode and the work piece thus it can eliminate mechanical stresses, chatter and vibration problems during machining [3, 4].

WEDM is considered as a unique adoption of the conventional EDM process which comprises of a main worktable, wire drive mechanism, a CNC controller, working fluid tank and attachments. The work piece is placed on the fixture table and fixed securely by clamps and bolts. The table moves along X and Y-axis and it is driven by the DC servo motors. Wire electrode usually made of thin copper, brass, molybdenum or tungsten of diameter 0.05-0.30 mm, which transforms electrical energy to thermal energy, is used for cutting materials. The wire is stored and wound on a wire drum which can rotate at1500rpm. The wire is continuously fed from wire drum which moves though the work piece and is supported under tension between a pair of wire guides located at the opposite sides of the work piece. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. Also the work piece and the wire electrode (tool) are separated by a thin film of dielectric fluid that is continuously fed to the machining zone to flush away the eroded particles. The movement of table is controlled numerically to achieve the desired three-dimensional shape and accuracy of the work piece [6].

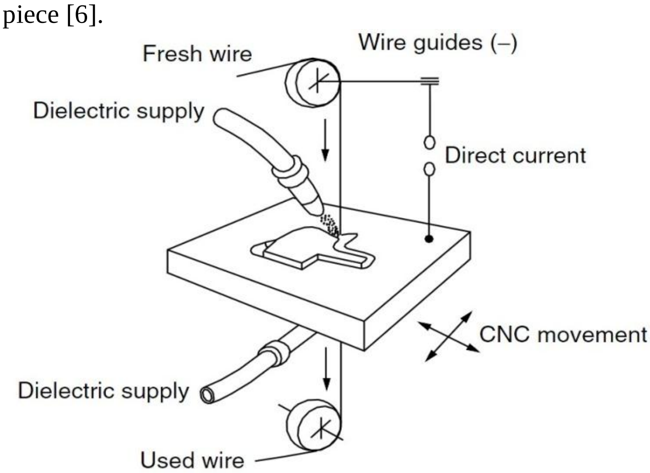

Fig. 1.2: WEDM schematic [1]

II. EXPERIMENT

The experimental setup and the experiment is designed with the primary goal of the dissertation work is to predict the MRR ,surface roughness ,and kerf width the work is carried out in sprintcut wire cut electro discharge machine of HCHCR material by varying machining parameters.The machine used for experiments is electronica sprintcut Wire cut EDM, Model- ELPULS-40 A DLX, incorporated with molybdenum wire technology.

A. *Material, test condition and measurement:*

The input and fixed parameters used in the present study are also listed in Table 1.and Table2 respectively. These were chosen through review of literature, experience, and some preliminary investigations. Different settings of Pulse On Time (µs), Pulse Off Time (µs), Flushing pressure (kgf/cm^2), Wire Tension (gms), Servo Voltage (volt), Wire Feed Rate (m/min) used in experiments.

Sr. No.	Machining process parameter	Level 1	Level 2	Level 3
1	Pulse On Time (µs)	110	115	120
2	Pulse Off Time (µs)	40	45	50
3	Flushing pressure (kgf/cm^2)	8	10	12
4	Wire Tension (gms)	550	750	950
5	Servo Voltage (volt)	15	20	25
6	Wire Feed Rate (m/min)	6	8	10

Table 1: Input Variables with Levels value

Sr. No.	Fixed Parameters	Set Value
1	Wire material	Molybdenum (0.25mm)
2	Peak current (IP)	230
3	Pulse peak voltage	2
4	Servo feed setting	250

Table 2: Fixed Variables

The material selected for this dissertation work is High Carbon High Chromium Die Steel (HCHCR). The workpiece of D2 too steel(2.19% C,11.11% Cr, 2.19%Mn, 0.021% Ph, 0.33%Si, 0.028% S, 0.04%V) was cut with 0.25 mm diameter stratified wire(Molybdenum) with vertical configuration was used and discarded once used. The most important measures in WEDM are MRR, Surface roughness and, Kerf width.

The material removal rate of the work piece is the volume of the material removal per minute MRR measured on weight base. Following equation is used to determine the material removal rate value.

B. *Based on Weight method*

MASS = Mass (before machining) – Mass (after machining)
MRR (mm3/min) = Mass Removed / Density × Time.
Steel Density = 7.86 × 10^3 kg/m^3

III. ANOVA FOR INDIVIDUAL MACHINING CHARACTERISTICS

A. *Result table for surface roughness*

Sr. No	T_{on} (µs)	T_{off} (µs)	F_p (Kgf/cm2)	W_t (gms)	S_V (volts)	W_f (m/min)	MRR (mm3/min)
1	110	40	8	550	15	6	6.5826
2	110	40	8	550	20	8	6.0960
3	110	40	8	550	25	10	5.7664
4	110	45	10	750	15	6	6.0711
5	110	45	10	750	20	8	5.7778
6	110	45	10	750	25	10	5.4864
7	110	50	12	950	15	6	5.6018
8	110	50	12	950	20	8	5.4668
9	110	50	12	950	25	10	4.9780
10	115	40	10	950	15	8	8.3965
11	115	40	10	950	20	10	7.7480
12	115	40	10	950	25	6	7.2169
13	115	45	12	550	15	8	7.0290
14	115	45	12	550	20	10	6.6949
15	115	45	12	550	25	6	6.3380
16	115	50	8	750	15	8	5.9778
17	115	50	8	750	20	10	5.7770
18	115	50	8	750	25	6	5.4474
19	120	40	12	750	15	10	8.5164
20	120	40	12	750	20	6	8.1123
21	120	40	12	750	25	8	7.9431
22	120	45	8	950	15	10	8.1194
23	120	45	8	950	20	6	7.8864
24	120	45	8	950	25	8	7.8596
25	120	50	10	550	15	10	7.6905
26	120	50	10	550	20	6	7.1651
27	120	50	10	550	25	8	6.9987

Table 3: Experimental result for surface roughness

IV. CALCULATION OF GREY RELATIONAL COEFFICIENT & GREY RELATIONAL GRADE

The distinguishing coefficient can be substituted for the grey relational coefficient in Eq6.5 If all the process parameter has equal weighting, ζ is 1. Table 12 lists the grey relational coefficient and grade for each experiment of the L_{27} orthogonal array by applying Eqs.6.5, 6.7 and 6.8

$$\Delta\min = \min_{i\in I} \min_{k} \left| x_0(k) - x_i(k) \right| \quad \ldots\ldots (6.5)$$

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \zeta i(k) \quad \ldots\ldots\ldots\ldots\ldots (6.7)$$

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} W_k \zeta i(k) \quad \ldots\ldots\ldots. (6.8)$$

Where, Wk represents the normalized weighting value of factor k.

Exp No:	Grey Relation Co-efficients	Grey Relational Grade	Orders
	MRR		
1	0.4778	1.9180	4
2	0.4223	2.2605	2
3	0.3915	2.3902	1
4	0.4198	1.4929	18
5	0.3925	1.4749	19
6	0.3686	1.6191	11
7	0.3777	1.4005	20
8	0.3671	1.3575	22
9	0.3333	1.5246	16
10	0.9366	1.8496	5
11	0.6972	1.8162	6
12	0.5765	1.8013	7
13	0.5433	1.5288	15
14	0.4927	1.5617	14
15	0.4482	1.5684	13
16	0.4107	1.3083	23
17	0.3924	1.2687	25
18	0.3657	1.2019	27
19	1.0000	2.0333	3
20	0.8141	1.7963	8
21	0.7553	1.7747	9
22	0.8168	1.6601	10
23	0.7374	1.5755	12
24	0.7293	1.5012	17
25	0.6818	1.3797	21
26	0.5670	1.2849	24
27	0.5383	1.2532	26

Table 4: Calculation of Grey relational coefficient & Grey relational grade

According to performed experiment design, it is clearly observed from Table 12. that the 'wire cut EDM process parameters' setting of experiment no. 03 has the highest grey relation grade. Thus, the third experiment gives the best multi-performance characteristics among the 27 experiments.

Machining parameters	Average grey relational grade by factor level		
	Level 1	Level 2	Level 3
Pulse On Time, A	1.7153*	1.4098	1.3605
Pulse Off Time, B	1.5450*	1.2750	1.2400
Wire Feed Rate, C	1.5843*	1.1002	1.1845
Wire Tension, D	1.6828*	1.5522	1.6096
Servo Voltage, E	0.1870*	0.1725	0.1788
Flushing pressure, F	0.0208*	0.0192	0.0199

Table 5: Response table for grey relational grade

Table 13 shows average grey relational grade by factor level. From this table, one has concluded optimum parameter levels which are indicated by "*". In this table, higher grey relational grade from each level of factor indicates the optimum level. From this table it is concluded that the optimum parameter level for Pulse on time, Pulse off time, Flushing pressure, Wire tension, Servo voltage, Wire feed rate is (110 µs), (120 µs), (8 kgf/cm^2), (550gms), (15volts), and (6 m/min) respectively.

V. ANALYSIS & DISCUSSION PARAMETER

Optimal parameter combination the work-piece kerf width, material removal rate and surface roughness for different combinations of WEDM parameter of 27 experimental runs are listed in table no: 10.

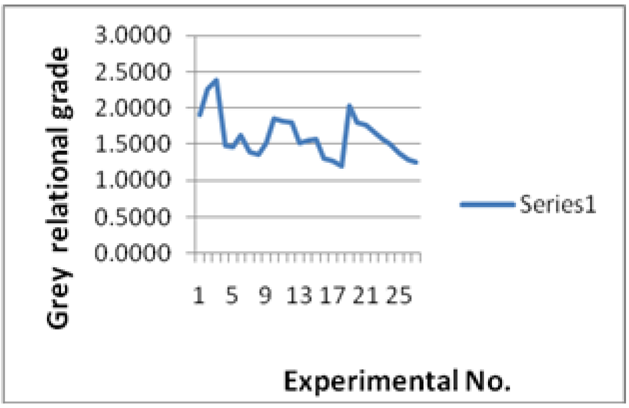

Fig. 1: Graph of Grey relational grades

According to performed experimental design, it is clearly observed from Table 4 and the Grey relational grade graph (Figure 1) which shows the change in the response when the factors go from one level to other that the WEDM parameters setting of experiment no. 3 has highest grey relation grade. Thus, the tenth experiment gives the best multi- performance characteristics of the WEDM process among the 27 experiments.

VI. CONFIRMATION TEST

The final step in the experiment is to do confirmation test. The purpose of the confirmation runs is to validate the conclusion drawn during the analysis phases. In addition, the confirmation tests need to be carried out in order to ensure that the theoretical predicted parameter combination for optimum results using the software is acceptable or not. The parameters used in the confirmation test are suggested by grey relational analysis. The confirmation test with optimal process parameters is performed for Wire cut EDM of HCHCR at levels A1 (110 µs Pulse on time), B1 (120 µs Pulse off time), C1 (8 kgf/cm^2 Flushing pressure), D1 (550gms Wire tension), E1(15volts Servo voltage) , F1(6 m/min Wire feed rate) and it gives material removal rate of , surface roughness of 3.7822 µm and kerf width of 0.4393 mm with the error in surface roughness is 9 % and error in kerf width is 7 %.

In this chapter, one has done grey relational analysis based optimization of WEDM process parameters for HCHCR. In this chapter, from the values of normalization and grey relational coefficient, grey relational grade is calculated. Higher grey relational grade gives better multi performance characteristics and from the table of average grey relational grade, optimum parameter levels are obtained. With the next chapter, one has discussed the obtained results.

REFERENCES

[1] S.Datta and S. S. Mahapatra, "Modeling, Simulation and Parametric Optimization of Wire

EDM Process Using Response Surface Methodology Coupled with Grey-Taguchi Technique", International Journal of Engineering, Science and Technology,162-183 (2010).

[2] Lokesh Goyat, Rajesh Dudi and Neeraj Sharma , "Investigation of Process Parameters Contribution and their Modeling in WEDM for D-2 Tool Steel Using ANOVA",Global Journal of Engineering,Design andTechnology,2(3),41-46(2013),

[3] Kuriachen Basil, Josephkunju Paul and Jeoju M.Issac, "Spark Gap Optimization of WEDM Process on Ti6Al4V", International Journal of Engineering Science and Innovative Technology (IJESIT) 2(1), 364-369(2013).

[4] C.D. Shah, J.R.Mevada and B.C.Khatri , "Optimization of Process Parameter of Wire Electrical Discharge Machine by Response Surface Methodology on Inconel-600", International Journal of Emerging Technology and Advanced Engineering, 3(4), 2250-2459(2013).

[5] Atul J Patel , Prof.Satyam P Patel, "Parametric Optimization of Wire Cut EDM Machine on Hard Steel Alloy with Multiple Quality Characteristics", 4(2), 74-77(2013).

[6] 6.S.B. Prajapati and N. S. Patel, Effect of Process Parameters on Performance Measures of Wire EDM for AISI A2 Tool Steel, International Journal of Computational Engineering Research,03,274-278 (2013).

[7] B. C. Routara, B.K. Nanda, D.R.Patra "Parametric Optimization Of Cnc Wire Cut Edm Using Grey Relational Analysis",International Conference on Mechanical Engineering, ICME09-RT-24(2009).

[8] Chiang, K.T., Chang, F.P, "Optimization of the WEDM process of particle- reinforced material with multiple performance characteristics using grey relational analysis", Journal of Materials Processing Technology, 180, 96-101.(2006).

[9] M.S.Hewidy, T.A. El-Taweel, M.F.El-Safty., "Modeling the machining parameters of wire electrical discharge machining of Inconel 601 using RSM", Journal of Materials Processing Technology, 169, 328–336. (2005)

