IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Optimization of Wire EDM with Brass wire as electrode on HCHCr steel by using Single Objective Taguchi Approach

I. Harish[1], Dr.P.Srinivasa Rao[2]

[1]Research Scholar, Department of Mechanical,
Centurion University,Parlakhemundi, ORISSA
Assistant Professor, Department of Mechanical,
DNR College of Engineering and Technology, Bhimavaram
[2]Professor in Mechanical Department, Centurion University,
JITM Campus, Parlakhemundi, ORISSA

ABSTRACT

This paper presents the performance of wire electric discharge machining (WEDM) on the basis of Material Removal Rate (MRR) and Surface Roughness (Ra). The important machining parameters of EDM which affecting on the performance parameters are discharge, current, pulse on time, pulse off time, arc gap, flushing pressure, servo voltage and wire tension. Taguchi design of experiments is used to conduct experiments by varying the parameters pulse on time, pulse off time and wire tension. The experimentations are carried out on WEDM in which HCHCr steel used as work piece, brass wire of 0.25mm diameterasan electrode, distilled water as dielectric fluid. By using single objective Taguchi optimization technique, optimal value for MRR and Surface Roughness has been obtained by varying the machiningparameters pulse on time, pulse off time and wire tension.In addition analysis of variance (ANOVA) is used to identify the most influencing factor.

Keywords:*ANOVA , High carbon high chromium (HCHCr), MRR , Surface roughness (Ra),WEDM.*

I. INTRODUCTION

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. Nevertheless, such materials are difficult to be machined by traditional machining methods. Hence, non-traditional machining methods like electrical discharging machine (EDM) are replacing traditional machining operation.There are two main types of EDM: conventional and wire. Conventional EDM uses a tool to disperse the electric current. This tool (cathode) runs along the work piece (anode), and the electrical current reacts to melt or vaporize the metal. As a result of the dielectric fluid, what little debris produced washes away from the piece. WEDM with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process, alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, precise, corrosion and wear resistant surface.

WEDM is considered as a unique adoption of the conventional EDM process, which uses an electrode to initialize the sparking process. However, WEDM utilizes a continuously travelling wire electrode made of thin

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. The wire is kept in tension using a mechanical tensioning device reducing the tendency of producing inaccurate parts [1].Wire cut EDM (or WCEDM) discharges the electrified current by means of a thin wire, which acts as the cathode and is guided alongside the desired cutting path, or kerf. Dielectric fluid submerges the wire and work piece, filtering and directing the sparks. The thin wire allows precision cuts, with kerfs as wide as three inches and a positioning accuracy of +/- 0.0002”ShivakanthTilekar,et al. carried out an experimentation on surface roughness and kerf width, with a Brass wire electrode of 0.25dia [2]. This heightened precision allows for complex, three dimensional cuts, and produces highly accurate punches,dies,stripers and plates. 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.

Additionally, wire EDM is able to cut metals as thin as 0.004”. At a certain thickness, wire EDM will simply cause the metal to evaporate, thereby eliminating potential debris [3]. The wire of a WCEDM unit emits sparks on all sides, which means the cut must be thicker than the wire itself. In other words, because the wire is surrounded by a ring of current, the smallest and most precise cutting path possible is the added diameter of the ring and wire; technicians easily account for this added dimension. Manufacturers continue to produce thinner and thinner wires to allow for smaller kerfs and even finer precision.

The main objective of this paper is to find the performance of WEDM for output parameters like MRR and Ra by varying various process parameters, using Taguchi L9 orthogonal array for experimental design.Further ANOVA is applied to find the most influencing factor.

II. DESIGN OF EXPERIMENTS

For the present experimental work the process parameters, pulse on time, pulse off time and wire tension, each at three levels has been decided. It is desirable to have three minimum levels of process parameters to reflect the true behavior of output parameters of study. The process parameters are renamed as factors and they are given in the adjacent column. The levels of the individual process parameters/factors are given in Table 2.1.

Table 2.1: Process Parameters and their Levels

Factors	Parameters	L1	L2	L3
A	Pulse on Time	100	103	105
B	Pulse off Time	50	55	60
C	Wire Tension	5	10	15

As per Taguchi experimental design, for three process parameters, we have three possible interactions which have been included in the present study. As a two factor interaction consists of two process parameters and the degree of freedom of interaction will be equal to the product of DOF of the interacting factors. For each trail in the L-9 array, the levels of process parameters are indicated in the below Table 2.2

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 06, June 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Table 2.2 Taguchi's L-9 Standard Orthogonal Array

S.NO.	TON µs	TOFF µs	WT Kgf
1	100	50	5
2	100	55	10
3	100	60	15
4	103	50	15
5	103	55	5
6	103	60	10
7	105	50	10
8	105	55	15
9	105	60	5

III. EXPERIMENTAL WORK

The experiments were performed on EDM machine (ELEKTRA SPRINTCUT 734) of Electronica Machine Tools Ltd. installed at Central Institute of Tool Design (CITD), Balanagar Hyderabad. Various input parameters varied during the experimentation were pulse on time (Ton), pulse off time (Toff) and wire tension (WT). The effects of these input parameters are studied on cutting rate, surface roughness.

The WEDM machine tool has the following specifications:

MAKE : ELECTRONICA (INDIA)
MODEL : ULTRACUT S1
SOFTWARE : ELCAM
SPECIFICATION : X : 400 mm
: Y : 300 mm
: Z : 250 mm
JOB LOAD CAPACITY : 400 KG (MAX)
ACCURACY : 0.0001 mm
JOB MATERIAL : HARD (OR) SOFT CAN CUT
WIRE DIA : 0.25 mm (GENERALLY)
WIRE MATERIAL : BRASS
SPECIAL CASE : 0.1, 0.15, 0.25 mm
INPUT POWER : 3 phase, AC 415 V, 50 Hz
CONNECTED LOAD : 10 KVA

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 06, June 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Fig 3.1: Pictorial view of wedm machine tool

Fig 3.2 HCHCr steel plate mounted on wedm

The HCHCR steel plate of 150mm x 50mm x 10mm size is machined on the WEDM machine tool to obtain specimens of 10mm x 8mm x 10mm, machined specimens are shown in figure below . MRR was taken directly from the machine for each machining.

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 06, June 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Fig 3.3 wireedm machined specimens

3.1. Surface Roughness

In this work the surface roughness was measured by Surtronic 3+ (Figure 3.1.1). The surtronic 3+ is a shop–floor type surface-roughness measuring instrument, which traces the surface of various machine parts and calculates the surface roughness based on roughness standards, and displays the results in µm. The work piece is attached to the detector unit of the SJ-201P which traces the minute irregularities of the work piece surface. The vertical stylus displacement during the trace is processed and digitally displayed on the liquid crystal display of the SJ-201P. The surface test has a resolution varying from .01 µm to 0.4 µm depending on the measurement range.

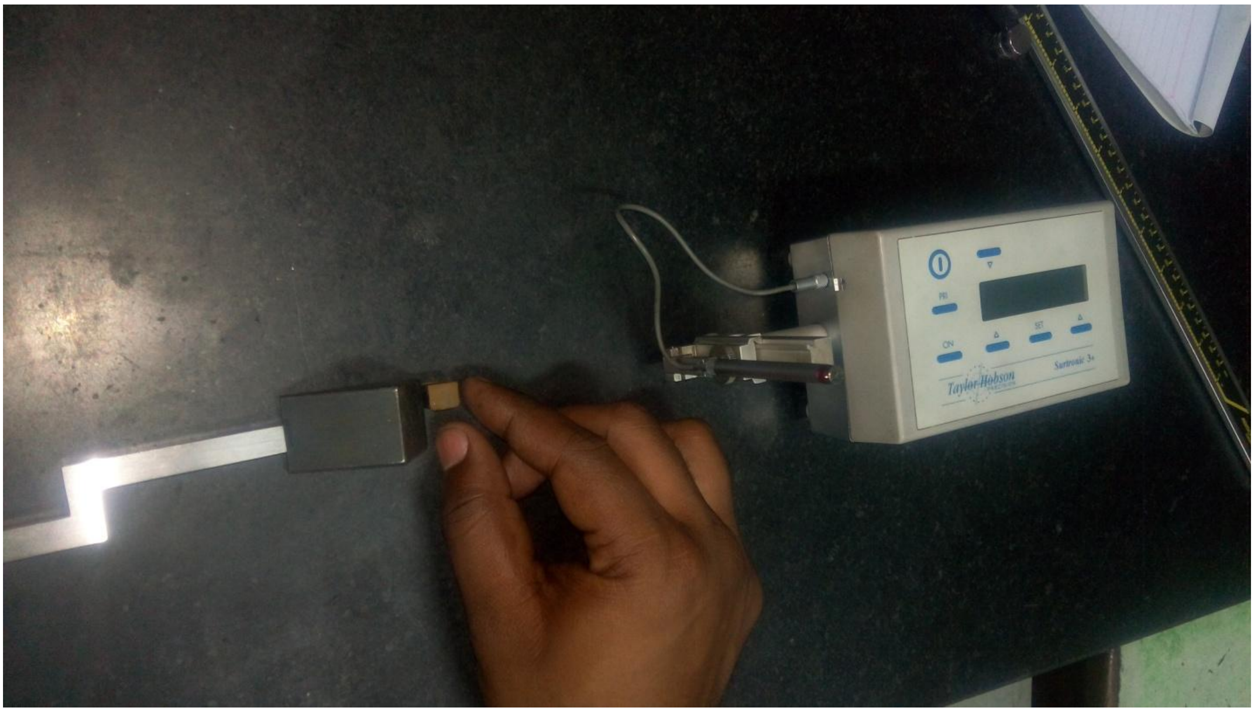

Fig 3.1.1 set up for surface roughness measurement

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 06, June 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

3.2. Results and Discussions

The WEDM experiments were conducted to study the effect of process parameters over the output response characteristics with the process parameters and interactions assigned to columns as given in Table 2.2. The experimental results for material removal rate and surface roughness are given in Table 3.1 . In this paper all the designs, plots and analysis have been carried out using Minitab statistical software.

Table 3.2.1: Experimental Results of Material Removal Rate and Surface Roughness

S.NO.	Ton µs	Toff µs	WT KgF	Time min	M.R.R mm^3/min	Ra µm
1	100	50	5	16	3.375	1.32
2	100	55	10	20	2.7	1.54
3	100	60	15	23	2.34	1.38
4	103	50	15	12	4.5	1.5
5	103	55	5	14	3.85	1.56
6	103	60	10	18	3	1.46
7	105	50	10	10	5.4	2.16
8	105	55	15	13	4.15	2.2
9	105	60	5	15	3.6	1.64

3.3. Effect on Material Removal Rate

In order to see the effect of process parameters on the material removal rate, the experiments were conducted using L-9 Orthogonal Array. The experimental data is given in Table 3.2.1. The average values of material removal rate for each parameter at levels 1, 2 and 3 for S/N ratioare plotted in Figure 3.3.1

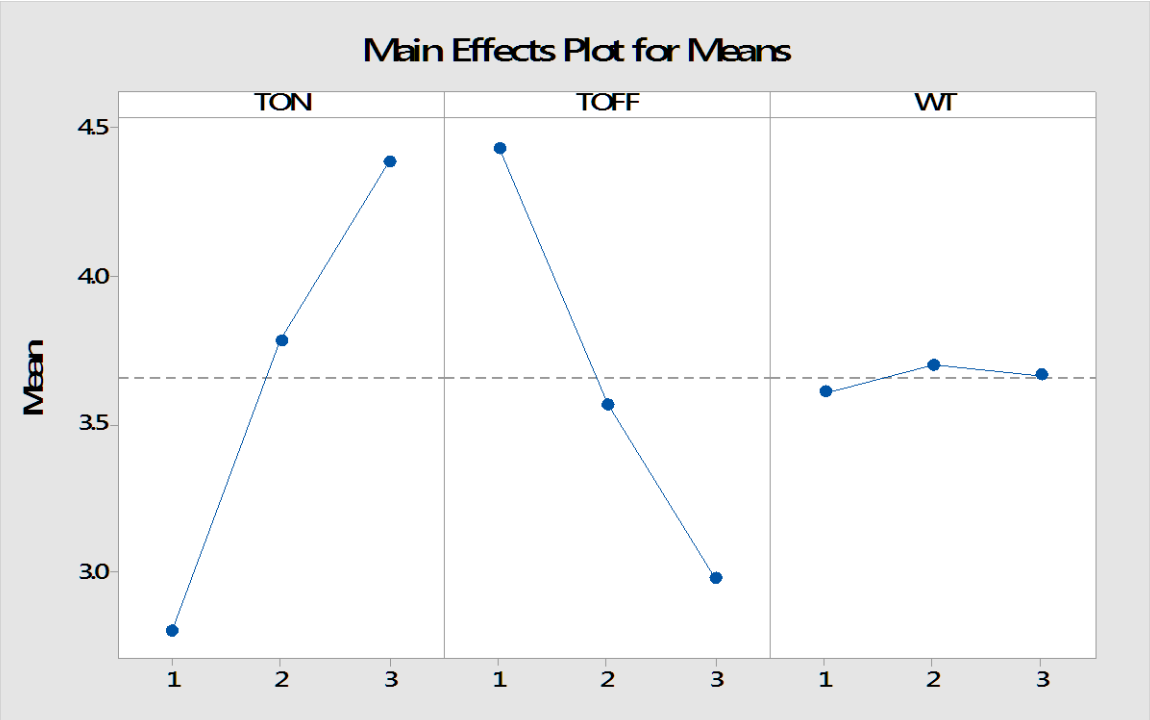

Fig 3.3.1.effect of process parameters on material removal rate (S/N Data)

Figure 3.3.1 shows that the material removal rate increases with the increase of pulse on time and decreases with increase in pulse off time. This is because the discharge energy increases with the pulse on time leading to a faster cutting rate. As the pulse off time decreases, the number of discharges within a given period becomes more which leads to a higher material removal rate. The effect of wire tension on material removal rate is not very significant. It is also evident that material removal rate is minimum at first level of pulse on time and maximum at first level of pulse off time.

3.4. Effect on Surface Roughness

In order to see the effects of process parameters on the surface roughness. The average values of surface roughness for each parameter at levels 1, 2 and 3 for S/N ratio are plotted in Fig 3.4.1

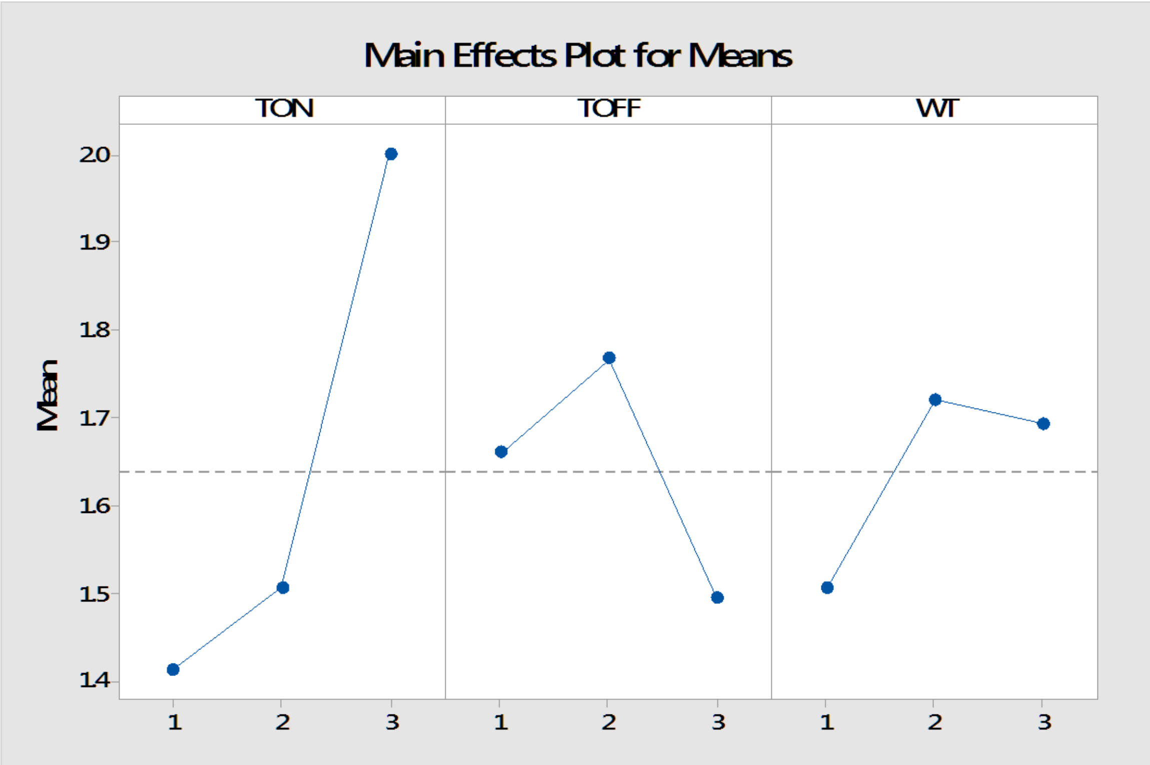

Fig 3.4.1 effect of process parameters on surface roughness

It is seen from the Figures 3.4.1,that the surface roughness decreases with the increase of pulse on time and increases with increase in pulse off time. The discharge energy increases with the pulse on time and larger discharge energy produces a larger crater, causing a larger surface roughness value on the work piece. As the pulse off time decreases, the number of discharges increases which causes poor surface accuracy. The effects of wire tension are not very significant.

IV. ANALYSIS OF VARIANCE (ANOVA)

ANOVA is a statistically based objective decision making tool for detecting any differences in the average performance of groups of items tested. The purpose of the analysis of variance is to investigate which machining parameter significantly affects the performance characteristic

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 06, June 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Table 4.1. Analysis of Variance (ANOVA) for MRR:

Source	DF	Adj SS	Adj MS	F-Value	P-Value
TON	2	3.80827	1.90414	18.69	0.051
TOFF	2	3.16894	1.58447	15.55	0.060
WT	2	0.01277	0.00639	0.06	0.941

Table 4.2. Analysis of Variance (ANOVA) for Ra:

Source	DF	Adj SS	Adj MS	F-Value	P-value
TON	2	0.59627	0.29813	19.11	0.050
TOFF	2	0.11387	0.05693	3.65	0.215
WT	2	0.08107	0.04053	2.60	0.278

The analysis of variance for MRR and Ra are shown in table 4.1 & 4.2 for pulse on time and pulse off time respectively. It is observed that the input variable Ton is the most effective parameter for both MRR and Ra. Statistical significant effect of Ton on surface roughness is up to 96.5% and up to 97.5% for MRR

In the counter plots for MRR and Ra in the figure 4.1& 4.2 shows that particular input parameters can be obtained for a specified range of output parameters.

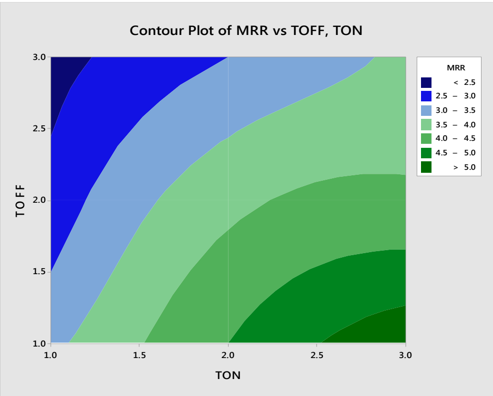

Fig 4.1.counter plot of MRR vs. Ton &Toff

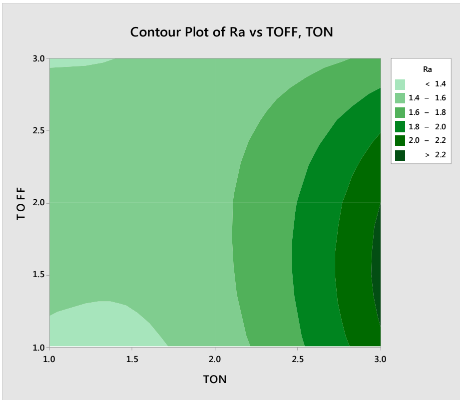

Fig4.2. counter plot of Ravs. Ton &Toff

V. CONCLUSION

In the earlier chapters, the effect of process variables on Material Removal Rate, Surface Roughness of the Wire Electric Discharge Machining (WEDM) process has been discussed. An optimal set of process variables that yields the optimum quality features produced by WEDM process has also been obtained for HCHCR Steel. The important conclusions from the present work are summarized below:

1. Based on Taguchi optimization method the optimum input parameter combination achieved for maximum MRR is Ton 105 µs , Toff50 µs and wire tension 5 KgF
2. Similarly the optimal input parameter combination for minimum Ra isTon 100µs Toff 55 µs and wire tension 5 KgF
3. The Analysis of variance resulted that input variable Ton is the most effective parameter for both MRR and Ra. Statistical significant effect of Ton on surface roughness is upto 96.5% and upto 97.5% for MRR
4. ANOVA resulted that wire tension has no significant effect on MRR and Ra

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

REFERENCES

[1] Optimisation machining processparameters in wire cut edm by manikandan.D, Gokulraja.S ,Joel.Jkarthick.S, Karthikeyan.A.S., IJIRSET, Vol 5, Special issue 8, May 2016

[2] Shivkanthtilekar, SankhaShuvra Das, P.K.Patowari, "Process parameter optimization of Wire EDM on aluminum and mild steel by using Taguchi Method", international conference on AMME 2014.

[3] DhruvH.Gajjar et al. "Optimization of MRR , SR, Kerf width in WEDM using molybdenum wire ", IJER volume 4 issue 2 FEB 2015.

[4] Ramakrishnan R. and Karunamoorthy.L. (2008), "Modeling and multi-response optimization of Inconel 718 on machining of CNC WEDM process", Journal of materials processing technology, 207, 343–349

[5] Roy, R.K. (2001), "Design of Experiments Using the Taguchi approach" Canada John Wiley & Sons.

[6] Rajurkar, K.P. and Wang, W.M. (1993), "Thermal modeling and on-line monitoring of wire-EDM", Journal of Materials Processing Technology, 38, 417-430.

[7] Bharat singh et al. "Experimental investigation on machining characteristics in WEDM of HCHCr(D2)" imperial journal of interdisciplinary research , vol-3 , Issue-1, 2017.

[8] Ibrahem Maher et al."Improve wire Edm performance at different machining parameters-ANFIS modeling" Science Direct IFAC-Papersonline 48-1 (2015) 105-110