EXPERIMENTAL ANALYSIS AND OPTIMIZATION OF PARAMETERS IN WEDM ON HCHCR STEEL

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Abstract :

Surface finish plays a critical role in increasing productivity in the machining industry and thus has important economic value. With the increasing demands of high surface finish and machining of complex shape geometries conventional machining process are now being replaced by non-traditional machining processes.

In this regard surface roughness and kerf width are of crucial importance in the field of machining processes. The experiment summarizes the Taguchi optimization technique, in order to optimize the cutting parameters in Wire EDM for High Carbon High Chromium (HCHCR) Steel. The objective of optimization is to attain the minimum surface quality simultaneously and separately.

In this present research work HIGH CARBON HIGH CHROMIUM STEEL (HCHCR) steel will be used as a work piece, Molybdenum wire of 0.25mm diameter will used as a tool. The input IPOL fluid will be used as a dielectric fluid.

This research applies Taguchi's design of experiment methodology and ANOVA (in MINITAB17) for optimization of process parameters. Experiments have been carried out based on L9 orthogonal array design with three process parameters namely pulse on time, pulse off time and amp current for machining time and MRR.

Key**words- EDM, Material removal Rate, HCHCR, Optimization, ANOVA**

I. INTRODUCTION

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. Wire EDM machines are able to cut the materials regardless of its hardness. The machines also specialize in cutting complex contours on fragile geometries that would be difficult to produce using conventional cutting methods .Such complex geometries can be found in intricate punches, dies, and various spindles. In the manufacturing of these products High carbon high chromium steel is used due to their good dimensional accuracy, good wear resistance, higher machinability, very high compressive strength, good corrosion resistance, and effective cost.

WEDM is a non-traditional thermoelectric process, which erode materials from the workpiece by series of discrete sparks between tool and workpiece. Deionized water is used as a dielectric medium. This dielectric medium provides insulation and ionization to the system. Enormous amount of energy is produced after the generation of spark this causes heating of the tool and workpiece.This heat is carried away by dielectric medium. Flushing of the dielectric in the spark gap prevents the contamination of debris and premature discharge.

Surface roughness is the most significant performance measure in quality of a product. Along with surface roughness material, removal rate is also an important characteristic in various manufacturing operation

II. LITERATURE SURVEY

Shailesh Dewangan[1] et.al were analyzed Surface integrity remains one of the major areas of concern in electric discharge machining (EDM).During the current study, grey-fuzzy logic-based hybrid optimization technique is utilized to determine the optimal settings of EDM process parameters with an aim to improve surface integrity aspects after EDM of AISI P20 tool steel. The experiment is designed using response surface methodology (RSM)considering discharge current (Ip), pulse-on time (Ton), tool-work time (Tw) and tool-lift time (Tup) as process parameters. Various surface integrity characteristics such as white layer thickness (WLT), surface crack density (SCD) and surface roughness (SR) are considered during the current research work. Grey relational analysis (GRA) combined with fuzzy-logic is used to determine grey fuzzy reasoning grade (GFRG). The optimal solution based on this analysis is found to be Ip ¼ 1 A, Ton ¼ 10 ms, Tw ¼ 0.2 s, and Tup ¼ 0.0 s. Analysis of variance (ANOVA) results clearly indicate that Ton is the most contributing parameter followed by Ip, for multiple performance characteristics of surface integrity.

Milan Kumar Das[2] were investigated combination of process parameters for optimum surface roughness and material removal rate (MRR) in electro discharge machining (EDM) of EN31 tool steel using artificial bee colony (ABC) algorithm. For experimentation, machining parameters viz., pulse on time, pulse off time, discharge current and voltage are varied based on central composite design (CCD). Second order response equations for MRR and surface roughness are found out using response surface methodology (RSM). For optimization, both single and multi-objective responses (MRR and surface roughness: Ra) are considered. From ABC analysis, the optimum combinations of process parameters are obtained and corresponding values of maximum MRR and minimum Ra are found out. Confirmation tests are carried out to validate the analyses and it is seen that the predicated values show good agreement with the experimental results. This study also investigates the influence of the machining parameters on machining performances. It is seen that with an increase in current and pulse on time, MRR and surface roughness increase in the experimental regime. Finally, surface morphology of machined surfaces is studied using scanning electron microscope (SEM) images.

M.Dastagiri[3] were experimentally analyzed pursue the influence of four design factors current (I), voltage (V), pulse on(Ton), and duty factor (η) which are the most connected parameters to be controlled by the EDM process over machining specifications such as material removal rate (MRR) and tool wear rate(TWR) and characteristics of surface integrity such as average surface roughness (Ra) and the hardness (HR) and also to quantify them. In this paper the experiments have been conducted by using full factorial design 23 with three central point in the DOE techniques and developed a mathematical model to predict material removal rate, average surface roughness and hardness using input parameters such as current, voltage, pulse on, and duty factor. The predicted results are very close to experimental values. Hence this mathematical model could be used to predict the responses such as material removal rate, and average surface roughness effectively within the input parameters studied.

Vikas[4] were presented an idea about the effect of the various input process parameters like Pulse ON time, Pulse OFF time, Discharge Current and Voltage over the Surface Roughness for an EN41 material. Here, 5 different output parameters concerned with surface roughness like Ra, Rq, Rsk, Rku and Rsm are taken and optimized accordingly, using the Grey-Taguchi method. The Grey-Taguchi method used in the article considers an L27 orthogonal array, which uses a different combination of the 4-input parameters to obtain an optimized value of the surface roughness for EN41 material. The 5 different output values of the surface roughness are calibrated into a single value (i.e. Grade) by calculating their normalized, Δ and ξ values .On the basis of their Grade, the S/N ratio is obtained and accordingly the ANOVA table is generated. It was found that the Current had larger impact over the Surface Roughness value, followed by the Voltage. The experimental results thus, obtained were compared with the theoretical results and they were found very close to one another

M. Durairaj[5] et.al were analyzed Surface roughness and kerf width are of crucial importance in the field of machining processes. This paper summarizes the Grey relational theory and Taguchi optimization technique, in order to optimize the cutting parameters in Wire EDM for SS304. The objective of optimization is to attain the minimum kerf width and the best surface quality simultaneously and separately. In this present study stainless steel 304 is used as a work piece, brass wire of 0.25mm diameter used as a tool and distilled water is used as a dielectric fluid .For experimentation Taguchi's L;16, orthogonal array has been used. The input parameters selected for optimization are gap voltage, wire feed, pulse on time, and pulse off time. Dielectric fluid pressure, wire speed, wire tension, resistance and cutting length are taken as fixed parameters. For each experiment surface roughness and kerf width was determined by using contact type surf coder and video measuring system respectively. By using multi objective optimization technique grey relational theory, the optimal value is obtained for surface roughness and kerf width and by using Taguchi optimization technique, optimized value is obtained separately. Additionally, the analysis of variance (ANOVA) is to useful to identify the most important factor.

III. EXPERIMENTAL DETAILS

A. Work piece preparation

The HCHCR steel of 32 mm diameter 15 mm length is cut using Band saw in to circular pieces of 9 Numbers.

s.no	ELEMENT	COMPOSITION IN WEIGHT %I	
		MIN	MAX
1	Carbon, C	0.32	0.42
2	Manganese, Mn	0.00	0.50
3	Silicon, Si	0.80	1.20
4	Molybdenum, Mo	1.00	1.50
5	Chromium,Cr	4.50	5.50
6	Vanadium, V	0.30	0.50

Table.1.Chemical properties

PROPERTY	VALUE
Density	7.81 g/cm 3
Melting point	1427°C
Thermal expansion (@20-100ºC/68-212ºF)	11.9 x 10 -6 /ºC
Thermal conductivity (@100ºC/212ºF)	42.2 W/mK
Hardness, Rockwell C (air cooled from 982°C, 45 mins)	52.5

Table.2.Physical properties

B. Tool preparation

The tool material used for the experimentation is electrolytic copper tool (99.9%). The diameter of the tool electrode is 20mm and its total length is 25 mm.

EXPERIMENTAL SETUP

Electrodes were machined to a cylindrical shape of 20 mm diameter and 25mm length. Cylindrical piece of 32 mm diameter and thickness 15 mm of HCHCR has to be planned.

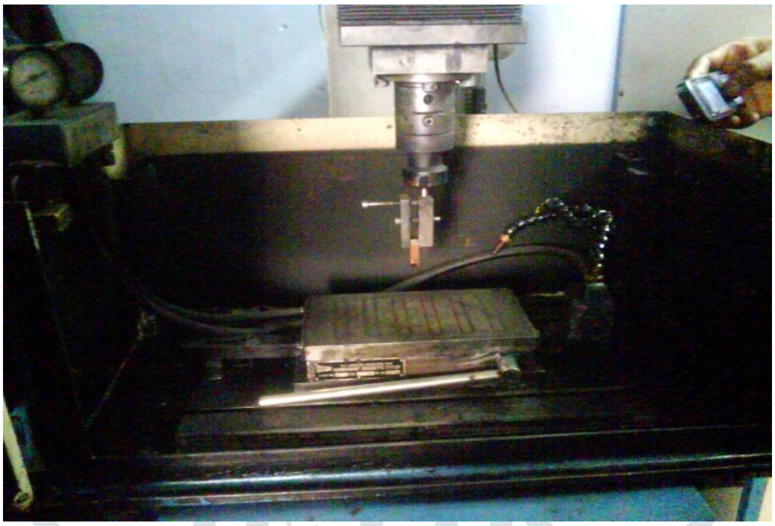


Fig.3.General Experimental Setup.

IV. DESIGN OF EXPERIMENTS:

In this process three factors at three levels are chosen which is given in table 3. The fractional factorial designed used is a standard L9 orthogonal array. This orthogonal array is chosen due to its capability to check the interactions among factors. Each row of the matrix represents one trail.

The basic principle in using any design of experiments (DOE) technique is to first identify the key variables in the process and then actively probe those variables to determine their effects on the process output. A typical DOE process consists of three different phases, screening, characterization, and optimization, although not all three phases are used in every study. Orthogonal designs are particularly useful because the estimate of the effect of a factor is unaffected by which other factors are under consideration. Factorial designs, which involve all possible combinations of levels of all the factors, can be investigated simultaneously. This technique also saves time and money because large number of factors can be investigated simultaneously.

S.NO	**Pulse on time(μs)**	**Pulse off time (μs)**	**Gap current (amps)**
1	2	8	3
2	3	9	4
3	4	10	5

Table.3.Levels of process parameters

V. EXPERIMENTS CONDUCTED:

S.NO	Design	T ON	T OFF	AMPS	Roughness (µm)	Material Removal Rate(gm/min)	Machine Timing(min)
1	$A_1B_1C_1$	2	8	3	2.411	0.0148	28.80
2	$A_1B_2C_2$	2	9	4	1.889	0.0124	33.00
3	$A_1B_3C_3$	2	10	5	2.002	0.0130	38.12
4	$A_2B_1C_2$	3	8	4	3.754	0.0166	30.40
5	$A_2B_2C_3$	3	9	5	3.766	0.0148	35.00
6	$A_2B_3C_1$	3	10	3	2.742	0.0121	34.50
7	$A_3B_1C_3$	4	8	5	3.930	0.0171	34.04
8	$A_3B_2C_1$	4	9	3	3.424	0.0168	32.68
9	$A_3B_3C_2$	4	10	4	3.770	0.0155	34.24

Table.4.L_9 Orthogonal Array

1. SURFACE ROUGHNESSES (ANALYSIS OF RESULT)

General Linear Model: RA versus TON, TOFF,AMPS

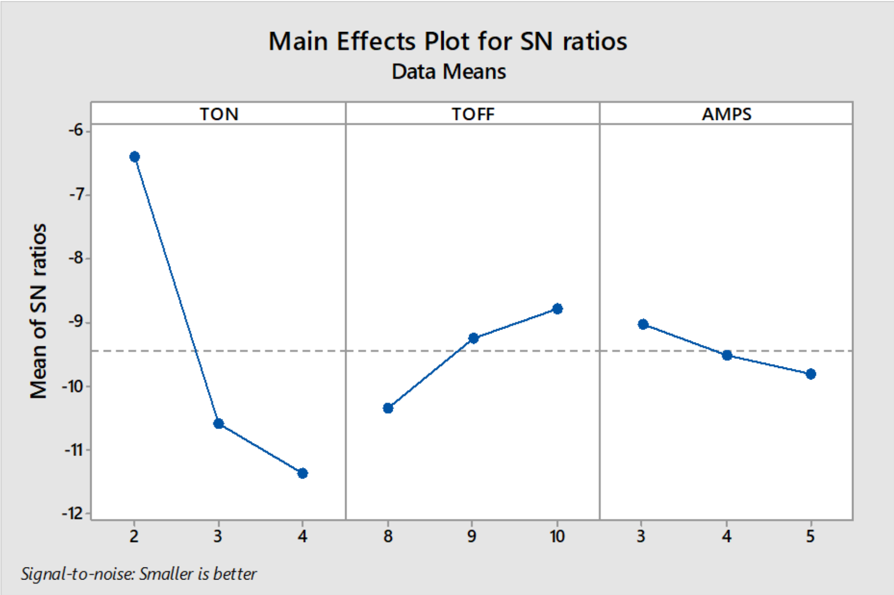
FACTOR	TYPE	LEVELS	VALUES
T ON	FIXED	3	2,3,4
T OFF	FIXED	3	8,9,10
AMPS	FIXED	3	3,4,5

Table.5.Factor Information

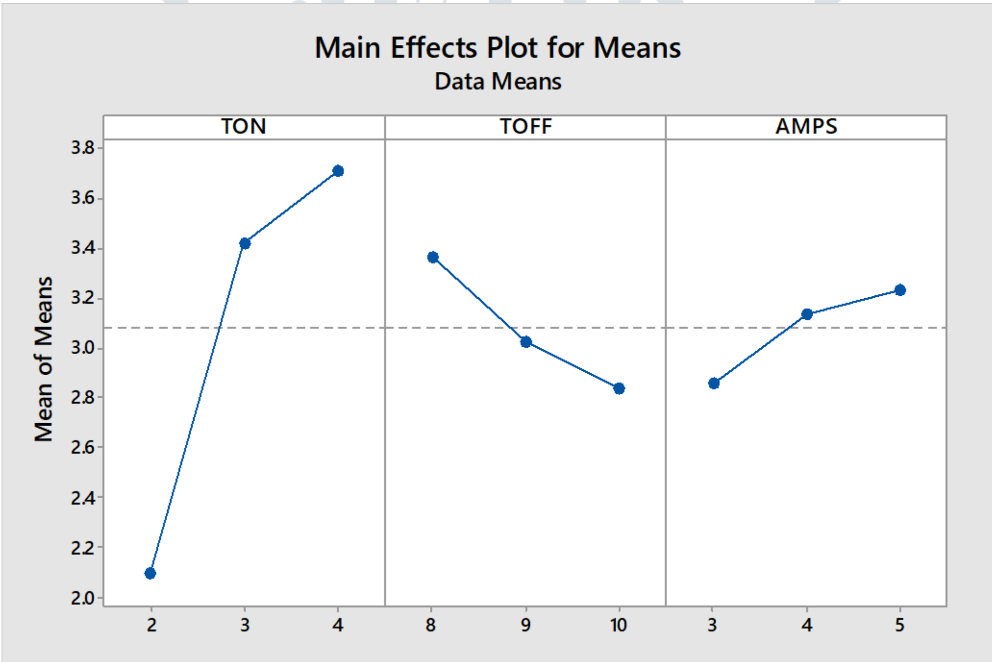
SOURCE	DF	SEQ SS	ADJ MS	F	P	% of contribution
T- ON	2	4.4085	2.2042	13.72	0.068	83
T- OFF	2	0.4279	0.2139	1.33	0.429	8
AMPS	2	0.2263	0.1132	0.70	0.587	4
ERROR	2	0.3214	0.1607			5
TOTAL	8	5.3841				100

Table.6. Analysis of Variance for RA

MAIN EFFECTS PLOT FOR SN RATIO



MAIN EFFECTS PLOT FOR MEANS



2.MACHINING TIME (ANALYSIS OF RESULT)

General Linear Model: MT versus T-ON, T-OFF, AMPS:

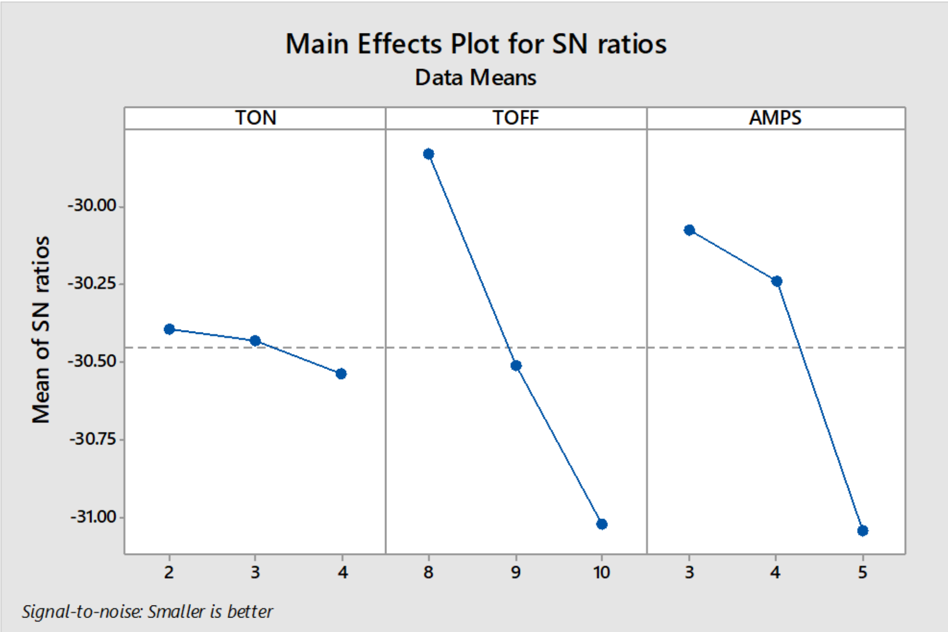
FACTOR	TYPE	LEVELS	VALUES
T ON	FIXED	3	2,3,4
T OFF	FIXED	3	8,9,10
AMPS	FIXED	3	3,4,5

Table.7.Factor Information

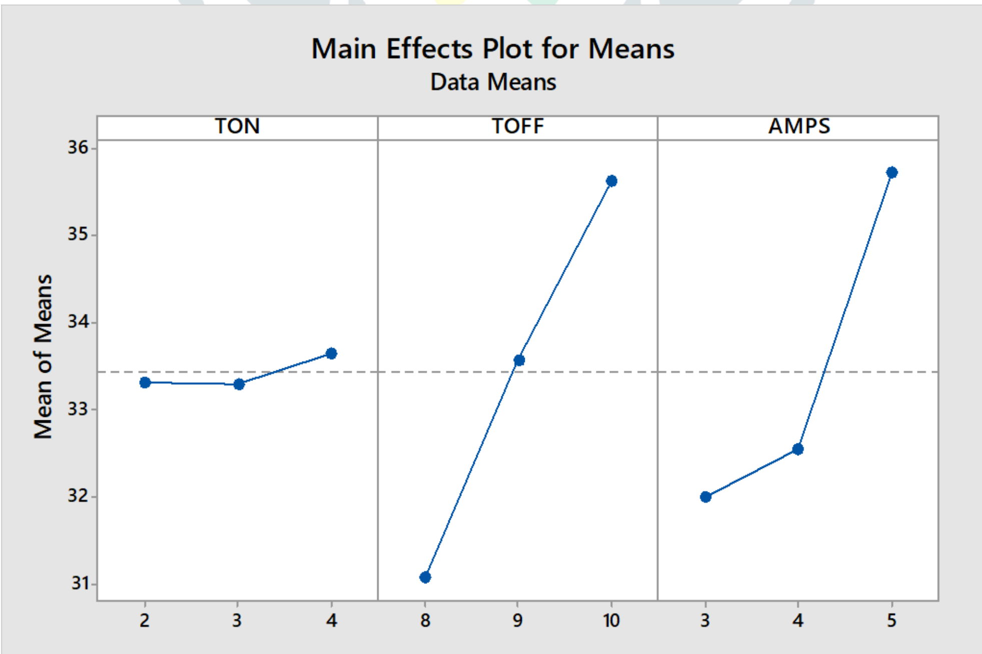
Source	DF	Seq SS	Adj MS	F	P	% OF CONTRIBUTION
T ON	2	0.2451	0.1225	0.10	0.910	1
T/OFF	2	31.0056	15.5028	12.48	0.074	53
AMPS	2	24.2643	12.1321	9.77	0.093	42
Error	2	2.4835	1.2417			4
Total	8	57.9984				100

Table.8.Analysis of Variance of MT

Main Effects Plot for SN Ratio



Main Effects Plot for Means



3. MATERIAL REMOVAL RATE (ANALYSIS OF RESULT):

General Linear Model: MT versus T-ON, T-OFF, AMPS:

FACTOR	TYPE	LEVELS	VALUES
T ON	FIXED	3	2,3,4
T OFF	FIXED	3	8,9,10
AMPS	FIXED	3	3,4,5

Table.9.Factor Information

B Weight	133.26	131.60	129.23	132.74	137.86	133.99	128.16	128.85	132.24
A Weight	132.60	130.28	127.89	131.43	136.49	131.69	126.82	127.90	130.87

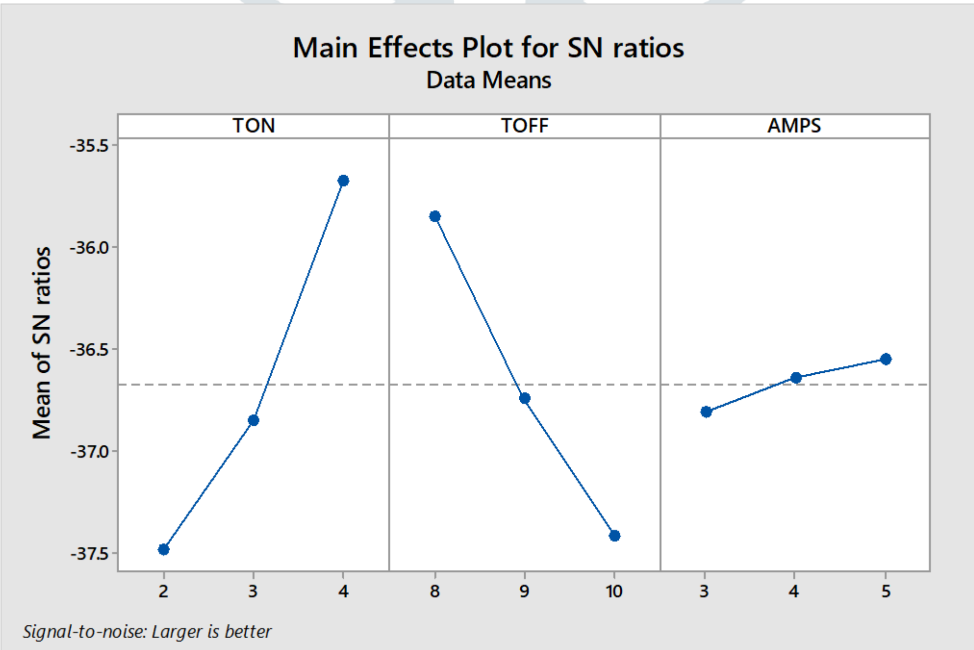
Table.10.MRR FORMULA: Before weight-After weight/Time taken X Density

Density of D2-7.7 gm/cc.

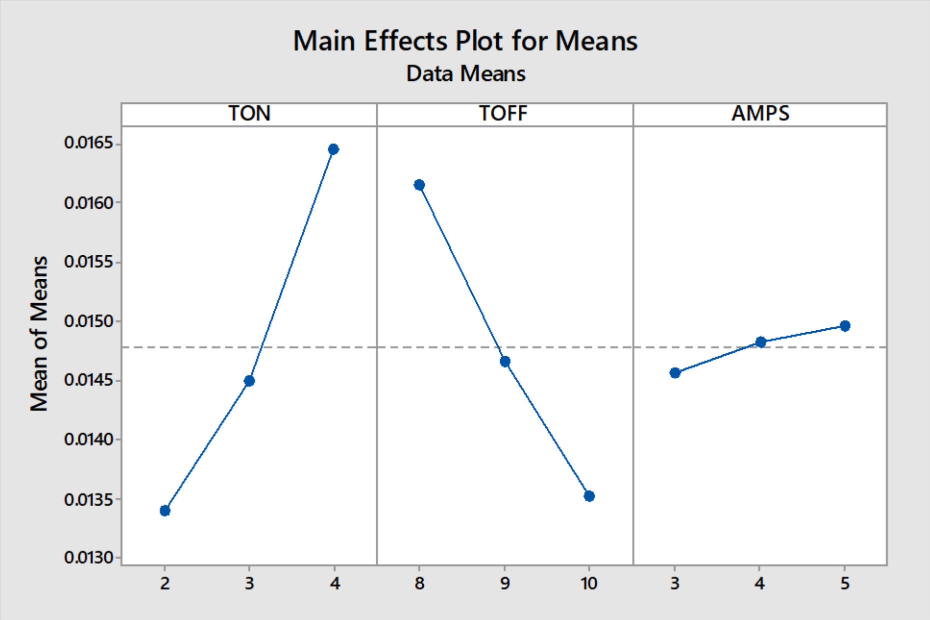
Source	DF	Seq SS	Adj MS	F	P	% OF CONTRIBUTION
T ON	2	0.000014	0.000007	3.52	0.221	82
T/OFF	2	0.000010	0.000005	2.55	0.282	8
AMPS	2	0.000000	0.000000	0.06	0.943	0
Error	2	0.000004	0.000002			10
Total	8	0.000029				100

Table.11.Analysis of Variance

Main Effects Plot for SN Ratio



Main Effects Plot for Means



VI. RESULTS AND CONCULSIONS:

The aim of the research work was to investigate the machinability of HCHCR steel EDM process. In this study three process parameters are varied viz. Pulse on time, Pulse off time and ampere rating constant concentrations of powder in the dielectric to study the influence on the responses MRR, Machining timing and Ra. Based on the experimental results the following conclusions are drawn:

OPTIMAL CONTROL FACTOR:

1. Surface Roughness-A1 (Pulse on time -2µs) B2 (Pulse off time -9 µs) C3 (Amps-5)
2. Machining Timing- A3 (Pulse on time -4µs) B1 (Pulse off time -8 µs) C2 (Amps-4)
3. Material Removal Rate- A1 (Pulse on time -2µs) B2 (Pulse off time -9 µs) C3 (Amps-5)

Minimum Surface finish and machining timing and MRR were held at through lower level pulse on time and higher rating of amps and medium rating of pulse off time. Surface roughness responses were majorly influenced with amps according to this HCHCR Steel.

Percentage contribution of Process parameter

1. Surface Roughness- Amps- 83%
2. Machining Timing - Pulse off time 53%
3. Material Removal – Pulse on time 82%

VII. REFERENCES:

1. Shailesh Dewangan, Soumya Gangopadhyay*, Chandan Kumar Biswas Multi-response optimization of surface integrity characteristics of EDM process using grey-fuzzy logic-based hybrid approach. Engineering Science and Technology, an International Journal 18 (2015) 361e368
2. Milan Kumar Dasa, Kaushik Kumarb, Tapan Kr. Barmana*and Prasanta Sahooa Application of Artificial bee Colony Algorithm for Optimization of MRR and Surface Roughness in EDM of EN31 tool steel 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014)
3. Vikasa, Apurba Kumar Royb, Kaushik Kumarb* Effect and optimization of various Machine Process Parameters on the Surface Roughness in EDM for an EN41 Material using Grey-Taguchi 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014)
4. M. Durairaja, D. Sudharsunb,*, N. Swamynathanb Analysis of Process Parameters in Wire EDM with Stainless Steel using Single Objective Taguchi Method and Multi Objective Grey Relational Grade ,International Conference On DESIGN AND MANUFACTURING, IConDM 2013
5. D. Sudhakara, G.Prasanthi, Application of Taguchi method for determining optimum surface roughness in wire cut EDM of P/M cold worked tool steel (VANADIS-4E). Elsevier procedia Eng. 97, 1565-1576 (2014)CrossRef Google Scholar.

6. D. Sudhakara, G.Prasanthi, Optimization of dimensional deviation : wire cut EDM of vanadis-4e (powder metallurgical cold worked tool steel) by Taguchi method, 5th international and 26th all India manufacturing technology, design and research conference (AIMTDR-2014), IIT Guwahati, Assam, 12-14 Dec 2014 Google Scholar.
7. Dara.Sudhakara,G. Prasanthi, Parametric optimization of wire electrical discharge machining of powder metallurgical cold worked tool steel using Taguchi Method. Artical in Journal of the Institution of Engineers(India):2017
8. S.S. Mahapatra & Amar Patnaik, "Optimization of wire electrical discharge machining (WEDM) process parsmeters using Taguchi method", Artical in International Journal of Advanced Manfacturing Technology : January 2007 DOI: 10.1007/s00170-006-0672-6.
9. M Adinarayana, Optimization of cutting parameters for turning operations, scholor articles -2015
10. GK M.Adinarayana, G.Prasanthi, "Multi Objective Optimization During Turning Of EN24 Alloy Steel", International Journal of Engineering Research And Application 3 (5), 1193-1198, 2013.