OPTIMIZATION OF MACHINING PARAMETERS IN WIRE EDM ON DIN (1.12344) Steel and HCHCr

Mr.D.Santhosh kumar[1], Dr.M.Komaraiah[2]

[1]Research Scholar, [2]Research Guide
Department of Mechanical Engineering
Mewar University, Rajasthan,India.

***Abstract*: Electrical Discharge Machining is a machining method primarily used for hard metals or those that are impossible to be machined with traditional techniques. The experimental investigation of material removal rate and surface roughness and hardness of oil hardened non-shrinking steel and high carbon high chromium with brass electrodes using EDM machine was carried out in this paper. This investigation presents the analysis and evaluation of heat affected zones and surface finish of the work piece using different tool electrodes and varying the machine parameters. The commercial grade kerosene oil has been used as dielectric fluid. The effect of various important EDM parameters such as discharge current (Ip) 2 to12A, pulse duration (Ton and Toff) and sparking voltage (V) of 80±5% have been used to yield the response in terms of Material Removal Rate (MRR) and hardness, surface roughness.**

Further a detailed analysis of the heat affected regions was also been carried out by sing scanning electron microscopy. Apart from the important role that Micromachining and ultra-precision machining has provided to the development of improved or innovative miniaturized products, these techniques have also attracted the interest of the researchers to obtain the highest accuracy and a thorough analysis of the principles governing the material removing mechanisms.

***Keywords*: Electronic Discharge Machining (EDM), Material Removal Rate (MRR), Hardness, Surface roughness.**

INTRODUCTION

The wire cut EDM uses a very thin wire 0.25 mm in diameter as an electrode and machines a work piece with electrical discharge like a band saw 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 proper composed of a work piece contour movement control unit (CNC 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 (de-ionized water) with constant specific resistance.

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.

WIRE EDM PRINCIPLE

Wire cut electrical discharge machining, is abbreviated as WEDM, sometimes referred to as linear cutting. Its basic physical principle is like after accumulating of free positive ions and electrons in a field, soon having formed into a conductive path which will be ionized. At this stage, electric current is likely to generate between the two plates which accounts for countless particle collisions that is responsible for the production of plasma zone. It then heats up to 8,000 or 12,000 degrees swiftly, melts down some parts of surface of the two conductors at the same time.

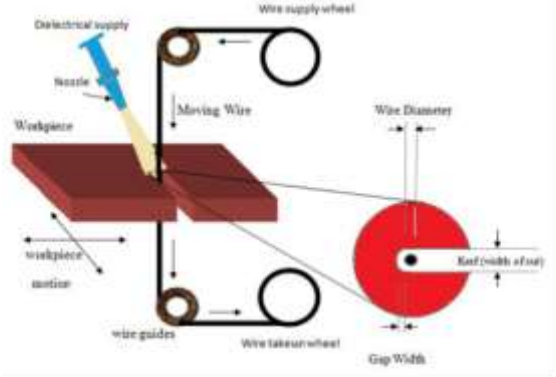


Figure 1: Exhibits the schematic diagram of the basic principle of WEDM process.

In order to produce taper machining, the wire electrode has to be tilted. This is achieved by displacing the upper wire guide (along U-V axis) with respect to the lower wire guide. The desired taper angle is achieved by simultaneous control of the movement of X-Y table and U-V table along their respective predetermined paths stored in the controller. The path information of X-Y table and U-V table is given to the controller in terms of linear and circular elements via CNC program.

PROPERTIES OF MATERIALS

1) Tool steel (AISI H13 steel)

The main feature of this grade is the combination of chromium, molybdenum and vanadium, Cr-Mo-V, which provides a high wear resistance to thermal shock. It is well known as for its great strength, and heat resistance. It is heavily used for die casting in the cold heading field. The presence of high vanadium in DIN 1.2344 can handle the abrasion at both low and high temperatures. It always provides a uniform and high level of machinability.

Chemical Composition:

Carbon-0.39, Silicon-1.00,chromium-5.4, molybdenum -1.35 , vanadium-1.0

Mechanical Properties:

Tensile strength, ultimate (@20°C/68°F, varies with heat treatment)	1200 - 1590 MPa	174000 - 231000 psi
Tensile strength, yield (@20°C/68°F, varies with heat treatment)	1000 - 1380 MPa	145000 - 200000 psi
Reduction of area (@20°C/68°F)	50.00%	50.00%
Modulus of elasticity (@20°C/68°F)	215 GPa	31200 ksi
Poisson's ratio	0.27-0.30	0.27-0.30

I) High Carbon High Chromium (HCHCr)

These steels contain 1.5 to 2.35% of carbon and High 12% of chromium. Except type D3 steel, all the other group D steels include 1% Mo and are air hardened. Type D3 steel is oil-quenched; though small sections can be gas quenched after automatization using vacuum. This makes tools made with type D3 steel brittle during hardening. Type D2 steel is the most commonly used steel among the group D steels.

PHYSICAL PROPERTIES

Density	7.7 – 8.03 x 1000 kg/m3
Melting point	1426°C

WEDM is an essential operation in several manufacturing processes in some industries, which gives importance to variety, precision and accuracy. Several researchers have attempted to improve the performance characteristics namely the surface roughness, cutting speed, dimensional accuracy and material removal rate. But the full potential utilization of this process is not completely solved because of its complex and stochastic nature and more number of variables involved in this operation.

Spedding and Wang, (1997); Scott et. al. (1991): Developed mathematical models to predict material removal rate and surface finish while machining D-2 tool steel at different machining conditions. It was found that there is no single combination of levels of the different factors that can be optimal under all circumstances. Spedding and Wang (1997) attempted to model the cutting speed and surface roughness of EDM process through the response-surface methodology and artificial neural networks (ANNs).

Lin and Lin (2001): Reported a new approach for the optimization of the electrical discharge machining (EDM) process with multiple performance characteristics based on the orthogonal array with the grey relational analysis. Optimal machining parameters were determined by the grey relational grade obtained from the grey relational analysis as the performance index. The machining parameters, namely work piece polarity, pulse on time, duty factor, open discharge voltage, discharge current and dielectric fluid were optimized with considerations of multiple performance characteristics including material removal rate, surface roughness, and electrode wear ratio.

Parveen Kumar, Bharat Bhushan, Dr. R.K. Gupta (2013): These authors attempted an experimental study to optimize the process parameters during machining of H-13 steel by wire electrical discharge machining (WEDM) using Taguchi L9 orthogonal array method for following input process parameters of WEDM [Pulse-On time (TON), Pulse-Off time (TOFF) and Wire Speed rate (WS) and Wire Tension (WT)] were chosen as variables to study the process output in terms of Material Removal Rate (MRR), Wire wear ratio(WWR), Surface Flatness(SF) using Zn coated copper wire as electrode. They resulted that as the level of Ton increases mean MRR increases respectively. As the level of wire speed increases can obtain a good surface finish for this H-13 steel.

M.T. Antar, S.L. Soo, D.K. Aspinwall, D. Jones and R. Perez (2011): Made a brief review of recent minimum damage EDM pulse generator developments, experimental data is presented for workpiece productivity & integrity when WEDM Udimet 720 nickel based super alloy and Ti-6Al- 2Sn-4Zr-6Mo titanium alloy, using Cu core coated wires (ZnCu50 and Zn rich brass). Up to a 70% increase in productivity was possible compared to when using uncoated brass wires with the same operating parameters. Surfaces measuring 0.6 Ra, with near neutral residual stresses and almost zero recast were produced following two trim passes. Cross sectional micrographs of specimens following rough machining (180mm2/min) showed the recast to be < 7 thick (up to 11 for uncoated wire), with comparable results for both alloys. Surface cracking, when evident, was restricted to within the recast layer.

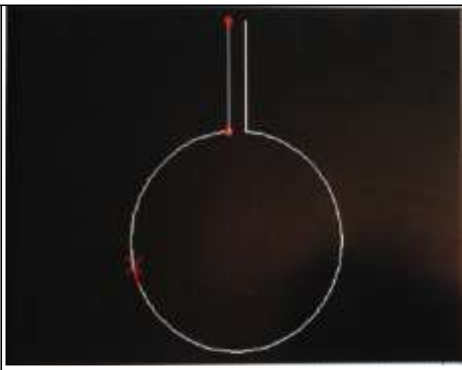
Vinod Kumar, Kamal Jangra, Vikas Kumar (2012): Discovered effect of WEDM parameters on machinability of NIMONIC-90(Ni based super alloy) Cutting speed is considered as machinability attribute in present work. Influence of WEDM parameters namely discharge current (Ip), pulse on time (Ton), pulse off time (Toff), servo voltage (SV) and wire feed rate (WF) has been investigated on cutting speed of Nimonic-90.It is concluded that cutting speed is increases slowly with increase in peak current. The cutting speed increases with increase in pulse off time and it sharply decrease with increase in pulse off time. Cutting speed increases with increases of wire feed, But further increase of wire feed rate has no influence on cutting speed.

EXPERIMENTATION

Machine Tool	Ultracuts1
Make	Electronic
Software	ELCAM
Specification	X :400MM Y :300MM Z :250MM
Job Load Capacity	400KG(MAX)
Accuracy	0.0001MM
Job material	Hard or soft can cut
Wire diameter	0.25MM(generally)
Wire material	Brass
Special case	0.1,0.15,0.25MM

TABLE 2: MACHINE SPECIFICATIONS

Fig: CNC displaying cutting plan



PARAMETERS SELECTION

The parameters and their levels are selected based on machine capability and literature survey. Some trail experiments are also performed to exclude some of the parameters.

The table shows the parameters and their levels used in experimentations.

TABLE parameters selection

S.No	Ton(µS)	Toff(µS)	Ip(AMP)	Sv(Volts)	Speed(MM/S)	Time(Min)	Mrr
1	100	63	12	20	0.2	90	0.78
2	102	60	12	30	0.25	73	0.83
3	104	58	11	40	0.3	68	0.85
4	106	56	11	50	0.4	52	0.92
5	108	54	10	60	0.5	262	0.71

MRR on H13 (1.2344)

S.No	Ton	Toff	Ip	Sv	Speed	Time(Min)	Mrr
1	100	63	12	20	0.25	80	9
2	102	60	11	40	0.3	94	10
3	104	58	11	40	0.3	116	6
4	106	56	11	50	0.4	240	7
5	108	54	10	60	0.08	320	8

MRR on HcHcr

S.No	Ton	Toff	Ip	Sv	Speed	Time(Min)	Sr
1	100	63	12	20	0.25	80	0.15
2	102	60	11	40	0.3	94	0.12
3	104	58	11	40	0.3	68	0.13
4	106	56	11	50	0.4	52	0.10
5	108	54	10	60	0.08	320	0.2

Surface roughness on H13 (1.2344)

S.NO	TON	TOFF	IP	SV	SPEED	TIME	SR
1	100	63	12	20	0.25	80	0.16
2	102	60	11	40	0.3	94	0.17
3	104	58	10	50	0.45	124	0.18
4	106	56	10	55	0.24	220	0.20
5	108	54	10	60	0.08	320	0.21

Surface roughness on HcHcr

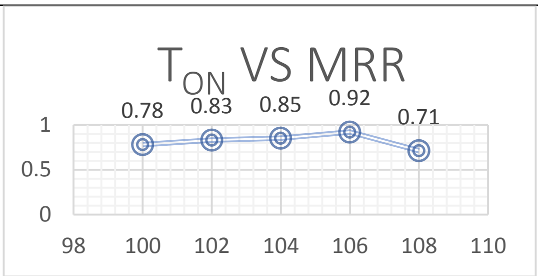
S.No	Ton	Toff	Ip	Sv	Speed	Time (Min)	Hardness
1	100	63	12	20	0.25	80	40
2	102	60	11	40	0.3	94	41
3	104	58	11	40	0.3	68	40
4	106	56	11	50	0.4	52	41
5	108	54	10	60	0.08	262	39

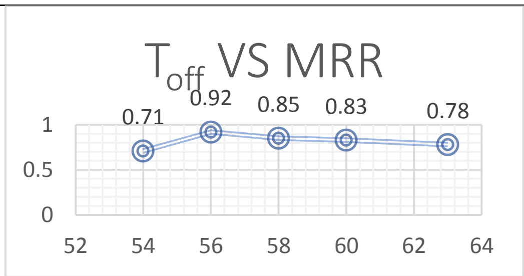
Hardness on H13 (1.2344)

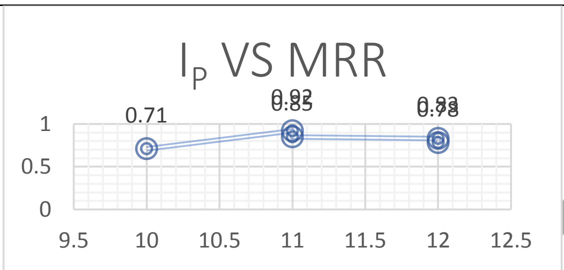
S.No	Ton	Toff	Ip	Sv	Speed	Time(Min)	Hardness
1	100	63	12	20	0.25	80	42
2	102	60	11	40	0.3	94	41
3	104	58	10	50	0.45	124	41
4	106	56	10	55	0.24	220	42
5	108	54	10	60	0.08	320	42

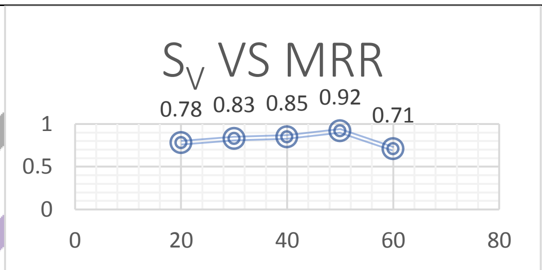
Hardness on HcHcr

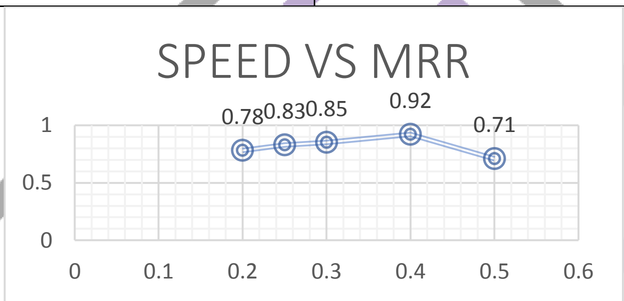
H13 (1.2344)



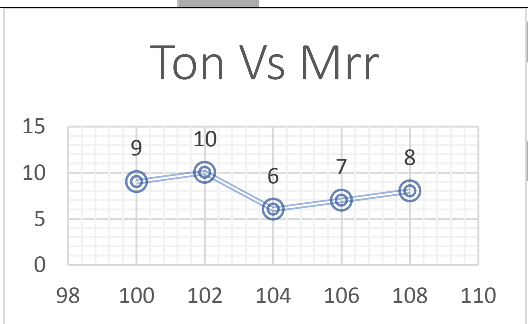


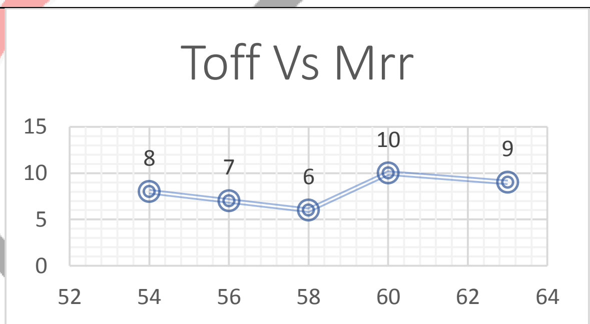


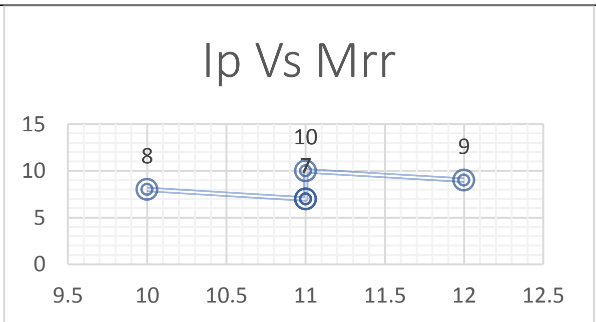


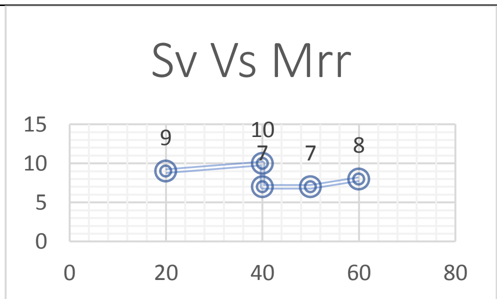


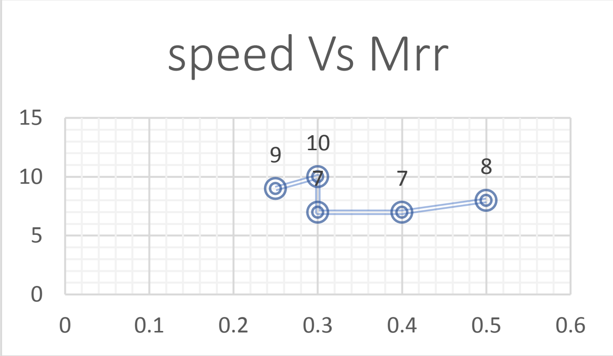
HCHCr



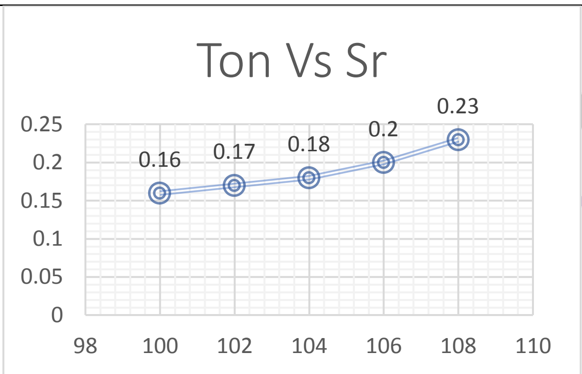


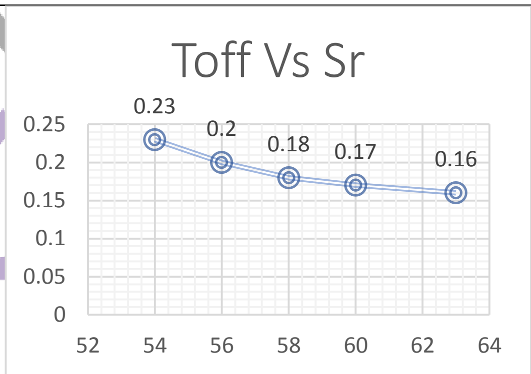


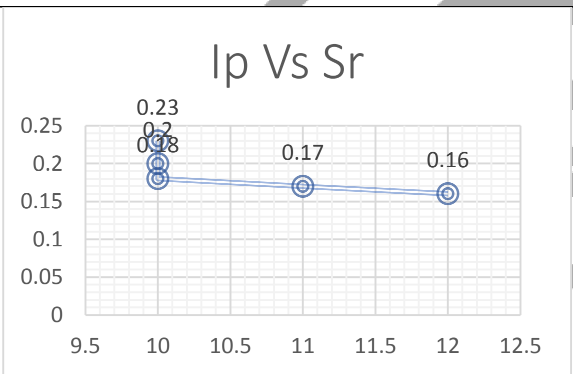


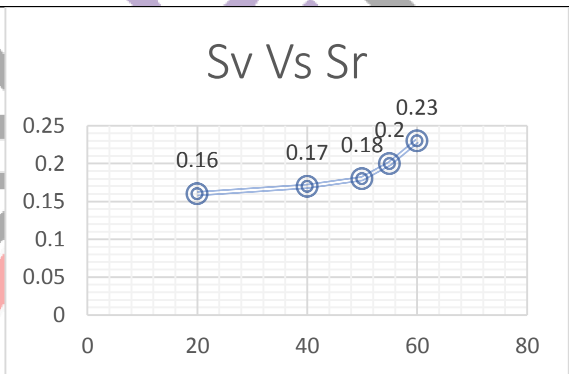


Surface roughness HcHcr

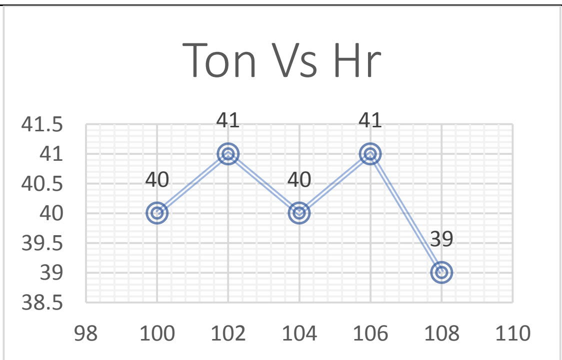


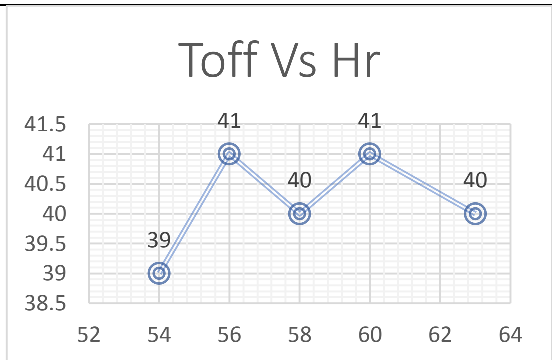


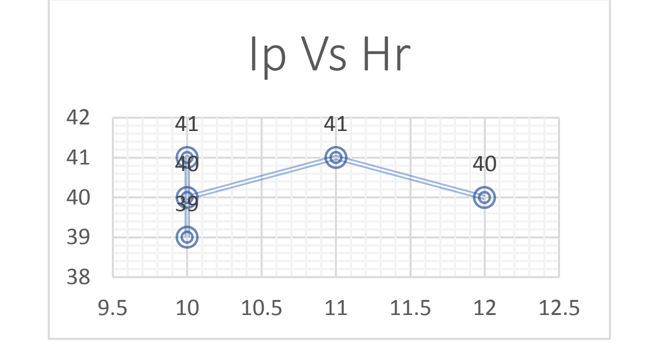


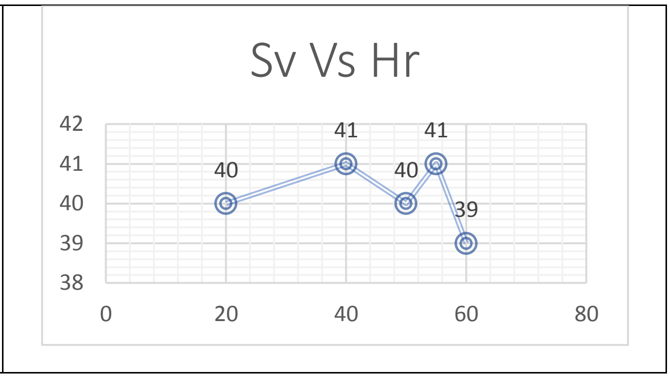


H13 (1.2344)Hardness

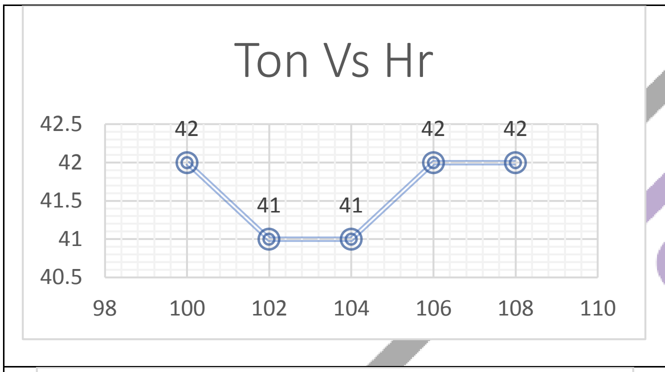


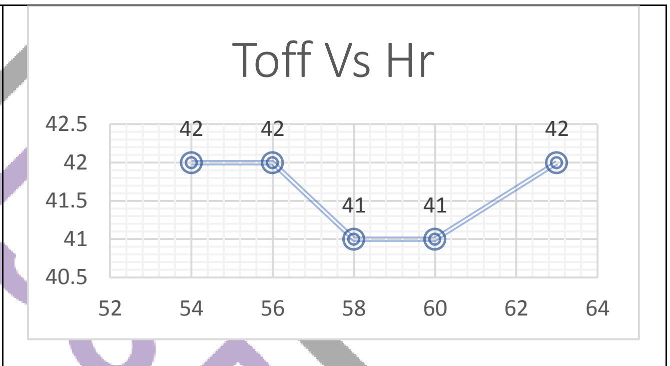


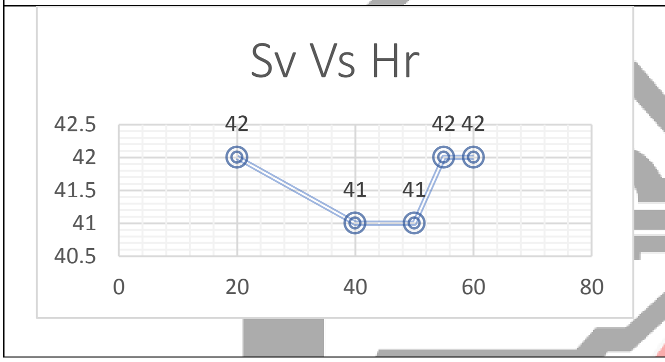


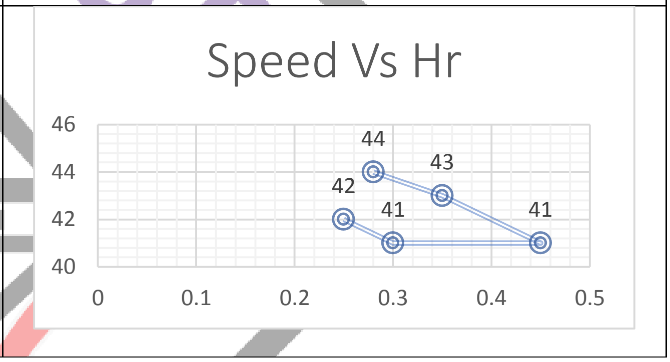


HcHcr Hardness









CONCLUSION

1. All the experiments were conducted by M/s Electronica, Ultra Cut s1, Wire EDM machine as per Taguchi OA plan and subsequently all the output values were measured by precision instruments.

2. All the collected output data are showing normal distribution within 95% CI.

3. Material removal rate (MRR) and cutting rate (CR) have improved from 23.83% to 31.43% with H13 (1.2344) when compared with HCHCR of 0.25 mm diameter. The T OFF time is found to be has major influence among other parameters and the MRR is increases with lower T OFF time value.

4. The Surface roughness of higher lengths (10 X 20 mm) is found lower with Zn coated wire. EDM parameter TON time has major influence on surface roughness and the roughness value is increases with increase in TON time value.

5. The brass wire is highly advisable for machining of higher diameters.

6. In depth surface integrity analysis of machined surfaces is needed for further findings and more number of experiments also needed for better understanding of cutting behavior.

REFERENCES

[1] Trupti G. Raut and M.Y. Shinde, "A review on optimization of machining parameters in EDM", Int. Journal of Innovative Research in Science, Engg. and Tech., Vol. 4(3), (2015), pp. 893-896

[2] Kuldeep Ojha, R.K. Garg and K.K. Singh, "MRR improvement in sinking electrical discharge machining: A review", Journal of Minerals & Materials Characterization & Engineering, Vol. 9(8), (2010), pp. 709-739

[3] N. Anand et al, "Analysis of the influence of EDM parameters on surface quality, MRR, EWR and micro hardness of AISI O2 (1.2842)", International Journal of Scientific and Engineering Research, Vol. 5(3), (2014), pp. 850-857

[4] Asif Iqbal and Ahsan Ali Khan, "Modeling and analysis of MRR, EWR and surface roughness in EDM milling through response surface methodology", American Journal of Engineering and Applied Sciences, 2010, 3(4), 611-619

[5] Kapil Banker et al, "Parameter optimization of electro discharge machine of AISI 304 steel by using taguchi method", International Journal of Application or Innovation in Engineering & Management, Vol. 3(8), (2014), pp. 20-24

[6] Manjinder Singh et al, "Experimental investigation of machining parameters using rotary electrode for EDM of HCHCR D2 steel", Advances in Materials and Manufacturing Technology, Vol. 4(10), (2015), pp. 83-86.

[7] Surender Kumar, Satpal Kundu and Ravinder, "Optimization of process parameter and experimental investigation of MRR on H-13 die tool steel using EDM with application of taguchi technique", International Journal of Engg. and Mgt. Research, Vol. 4(1), (2014), pp. 162-167

[8] Kamaljit Singh, "An experimental investigation: machining of H13 (1.2344) steel by EDM", Journal of Engineering, Computers & Applied Sciences, Vol. 2(6), (2013), pp. 39-42 International Journal of Engineering Research in Africa Vol. 22 119 .