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EXPERIMENTAL INVESTIGATIONS ON CAVITY EDM AND WIRE EDM DURING MACHINING OF H-11 STEEL

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Abstract: Electric discharge machining has been utilized for machining hard to machine substances that are not being synthesis by customary mass-produced techniques. This thermal metal removal process machine the work piece by high temperature spark erosion of material. Two different techniques falling under this category like cavity EDM and WEDM remove the material from electric conducting materials. In present investigations the cavity EDM and WEDM have been used to machine the holes of 10mm diameter on H-11 steel at different operative variable like current, voltage, On-time, Off-time. In Taguchi L-9 experimental design has been used for experimentation and the output response in terms of MRR, Tool wear ratio; Wire wear ratio and surface roughness have been recorded at different process parameters levels as per experimental design. Parametric optimization of Input variables has been made by using Regression analysis and to depict the relation between the significant parameters. The regression analysis shows that current influences the tool wear and MRR in cavity EDM as compared to voltage, on-time has significantly affected the tool wear, surface roughness and MRR and off-time has significantly affected the tool wear only. On the other hand current has significantly affected the performance of WEDM in terms of wire wear ratio, MRR and surface roughness. The regression analysis confirms that the on-time has significant contribution on wire wear ratio as well as the off-time has significantly affected the surface roughness of the work material. The significance of voltage on the performance of cavity EDM and wire EDM has been reported less as compared to other parameters. The experimental result shows that the cavity EDM is consuming almost 5-7 times more current than WEDM but the MRR is 3-4 times less than WEDM. The machining time of cavity EDM is 3-4 more time than WEDM and there has been improved surface roughness of wire EDM machining as compared to cavity EDM.
Keywords: Cavity EDM, Wire EDM, Material removal rate, Surface roughness, Tool wear ratio, Wire wear ratio, On-Time, Off-Time, Regression analysis.

1. INTRODUCTION

1.1 Cavity Electric Discharge Machining

Cavity Electrical Discharge Machining (EDM) is an inside and out seen machining process for making geometrically perplexing or hard material parts that is not really hard to appliance by customary synthesis procedure. It has been for the most part used to create design, aviation, vehicle factory and careful segments. One of the essential clarifications behind utilizing is that it is likewise valuable for synthesis breakable substance, as there is fundamentally no connection between the apparatus and work piece.

There are distinctive period of electrical releases happens through EDM. At first, the anode pass near the work piece, when the prospective contrast expands between the two planes, the insulator separates and particles are produced. Solid electric liquid sought after by electrical releases well make where the partition between the two planes is slightest. A regularly expanding number of particles are created, which will decrease the ensuring stuff of the insulator through a limited passage at the end where most heavy electric field produced. Right now the voltage achieves its high point, while the current is still nil. A release passage starts to shape between the terminal and the work piece. The voltage keeps on diminishing during current keeps on expanding. This will enable the warmth to grow rapidly, causing a segment of the anode, cathode, and insulating substance to vaporize.

The warmth and weight, inner part of the medium have achieved the greatest and a couple of substances have been liquefied and evacuated. The fluid metal is bear set up by the constraint of the condensation. At the point when the voltage and current way to deal with nothing in the release path and base it to fall, in this way enabling the liquid substance to be removed from the work piece plane. The ongoing improvements in the area of EDM have advanced because of the difficulties being looked by the advanced assembling enterprises. The improvement of modern substance that is hard and difficult to machine such as tool steels, ceramics, super composite, hastalloy, nitralloy, nemonics and so forth can assembled effortlessly with the assistance of EDM. Distinctive device terminal utilized in EDM are copper, brass, tungsten, steel, copper tungsten, and copper chromium alloys and so on.

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1.2 Wire EDM

Wire electrical release machining process has been developed as a vital irregular thermo electrical synthesis method to machine the substances which are a conveyor of power. The component of substance evacuation is similar to the fundamental EDM operation. The trimmed apparatuses are galvanic sparkles, which have been layout and supervised with the assistance of a producer. Since the wire terminal isn't exactly contacting the work piece, the galvanic demand has delivered to a electromotive force that grants it to interchange the hole among terminal, work piece, and destroys of the modest piece of the work piece. The electrolytic conductor chills off the cutting zone as well as wipe off the garbage between wire terminal and work piece to constrain them from being snags for the accompanying sparkle. This procedure is used in the aviation, car, & apparatus fabricating enterprises. It is conceivable to acquire and determine the coveted side complete on a work piece throughout synthesis in wire EDM procedure in some complicated state of the work piece regardless of its solidity. As in Wire EDM, wire terminal can't be recycling, along these lines; it is hard to guide the wire ruination and farthest point the expense of wire. Inconel compounds are hard to slit substance by the ordinary synthesis procedure. It, notwithstanding, is fundamental to locate a profitable and capable machining procedure for Inconel combinations'. For synthesis galvanic substance, wire EDM is initiated as a lively, energetic and correct system. Variable point of interests and system gave in appliance producer's physically have not adequately accommodate data for synthesis fresh substance and distinctive figure needed by analysts or generation design. The advanced programming modifies the hole and different variables in the producer of appliance continuously to create sparks controlled painstakingly. A sparkle with less vitality grows reduced warmth; which results in little influenced areas. A considerable measure of investigation is being executed by various specialists for inspecting the effect of wire EDM on the substance evacuation rate, plane trustworthiness of nickel compound with respect to revise coating and HAZ.

2. LITERATURE REVIEW

J.F. Liu and Y.B. Guo (2016) studied the residuary strain exemplary in EDM by Consolidating Extensive Unmethodical Releases. In this examination irregular release has been produce to reproduce remaining pressure development in die-sinking EDM of the ASP 23 apparatus steel. They found that the internal horizontal leftover strain shape in the belowground are same, during the normal flat surface lingering pressure demonstrates an indistinguishable trademark in the sub plane.

Teepu Sultan et al. (2014) experimentally investigated Substance Eroding Rate, Terminal eroding rate, and Plane Shrillness Assessment in Die Sinking EDM with vacant appliance along with RSM Method. In this experiment An endeavor has been create to display substance evacuation rate, cathode eroding rate, and Plane harshness along reaction surface philosophy (RSM) method in a die sinking EDM procedure. They found that EDM is an adequate process to machine EN 353 steel with good MRR and TWR. With the end goal to show signs of improvement surface finish set peak current and pulse on time at low levels.

Nibu Mathew and Dinesh Kumar (2014) Investigated of Apparatus Eroding Rate of Dissimilar Apparatus substance throughout EDM of H11 Steel at back Polarity. To analyze convenience of terminal construct along Powder Metallurgy in correlation with traditional copper terminal through electric release machining. Furthermore, they observe that Powder metallurgy apparatus terminal provide greater TWR when contrasted with traditional electrode and TWR expand with the expansion in pinnacle current, hole voltage and obligation cycle.

Harpreet Singh and Amandeep Singh (2012) have studied that impact of Pulsation start/Pulsation Off period stop synthesis Of AISI D3 Die Steel Utilizing Copper and Brass terminal In EDM. In this investigation they discovered Material evacuation rate is expanded with expansion in pulse stop period. A substance expulsion rate is diminished with expand in pulse start period if there should arise an occurrence of brass terminal and reduction in cooper terminal.

Rajneesh Kumar et al. (2014) has Optimize the impact of EDM Process variables on Tool Wear. To look into the assortment of appliance eroding, comparative eroding with the shifting synthesis variables (Ton, release current and hole voltage) in die sinking EDM. Tool wears diminishes with increase in Ton. And also Relative wear increases with increase in Ton time. In current Apparatus eroding enlargement with expand in current during Comparative eroding diminish with expand in current. In voltage Tool sport diminishes with expand in voltage during comparative eroding rise with voltage.

Sreenivasa Rao M and Venkaiah N (2015) attempted to study the invariable enhancement in synthesis of Nimonic-263 combination utilizing RSM and molecule flood improvement. In this investigation they found that Response Surface Methodology is used to explore the effect of WEDM procedure variable for intance; pulse start period, pulse stop period, crest current and control system for voltage in synthesis of Nimonic-263 alloy. It has been seen that, implementation of the PSO is better than that of RSM.

H. Singh and R. Garg (2009) In this experimentation they have examined that the impact of process variables on material evacuation rate in WEDM. The substance evacuation rate (MRR) particularly rise with expand in pulse start period (Ton) and pinnacle current (IP) during diminishes with expand in pulse stop period (Toff) and control system for voltage (SV).They found that the substance expulsion rate (MRR) specifically rise in pulse start period (TON) and crest current (IP) during diminishes with expand in pulse stop period (TOFF) and control system for voltage (SV).

G. Prasanthi1 and D. Sudhakara (2016) In this investigation enhancement of delay Current in WEDM of P/M Cool Worked appliance Steel by Taguchi Method. To discover the significant variables and combination of factors impacting the

machining procedure to achieve the best gap current. The estimations of gap current acquired through confirmation experiments are within the 95% of □□□□ of particular reaction trademark.

Faiyaz Kausar1 et al. (2015) did Enhancement of Machining Parameter for Surface Roughness on WEDM of En36 Alloy Steel. To look at the impact of different WEDM variables on the surface roughness of EN36 alloy steel and discover the arrangement of attribute to upgrade the surface unpleasantness of EN36. It is seen that current has the beat effect and diverse attributes have generally less effect during machining.

B. Satyanarayana and G. Srikar (2014) In this study Repeated-reaction enhancement Of CNC WEDM Operative variable For synthesis Inconel 718 Using Taguchi Grey Relational Analysis. This research introduces the examination of substance evacuation rate, kerf thickness, and wire eroding ratio of WEDM operation on INCONEL 718 by utilizing Grey Relational Analysis. The kerf thickness is impacted by Pulse start-period pursued by Wire rigidity, Water stream rate, Pulse stop-time and in conclusion Wire Feed. The Material eroding Rate (MRR) is for the most part affected by Pulse on- Time pursued by Pulse Off-Time, Wire Tension, Wire Feed and Water stream rate. The WWR is mostly impacted by Pulse start period pursued by Wire Feed, Wire rigidity, Pulse stop period and Water stream rate.

Pujari Srinivasa Rao et al. (2016) have examined that impact of wire EDM circumstances on peer group of leftover strain in synthesis of aluminum 2014 T6 compound. In this experimentation they found that parametric investigation of wire EDM attribute on leftover strain in the synthesis of aluminum composite utilizing Taguchi technique. It was discovered that the entire primary commanded variables TON, IP and SV had demonstrated noteworthy impact.

3. EXPERIMENTAL PLANNING AND WORK

3.1 Research Gap

During Peer Literature Review the following research gaps have been found As per Literature survey very less work has been reported on the percentage contribution Current, Voltage, On-Time, Off-Time on Responses like MRR, Machine time, Tool wear rate and Wire wear rate.

Comparative Analysis of EDM and WEDM performance keeping in view the similar machining volume at basics parameter levels.

Regression Analysis of EDM and WEDM performance and to find out the significant input parameters.

3.2 Research Design

The design of experiment has been made using Taguchi L-9 array exhibit for four variables i.e Current, Voltage, start-time, stop-time having three levels. The Response yield regarding MRR, Tool wear rate, wire wear rate and Surface unpleasantness have been evaluated at defined Taguchi L-9 design of experiment. The ANOVA and regression analysis have been utilised for the performance analysis so as to find out the significant parameters level.

3.3 Problem formulation

In the present investigations performance comparison in terms of surface roughness, electrode wear and MRR have been made. The hole of 10mm diameters have been machined on H-11 Steel using cavity EDM and wire EDM and responses have recorded in terms of MRR, Tool wear rate, Wire wear rate and Surface Roughness. Parametric optimizations of Input parameters have been evaluated by Regression analysis and formulate the relation between the significant parameters.

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Experimental Setup Machines:

Figure 1: (a) Photographic View of EDM

(b) Photographic View of WEDM

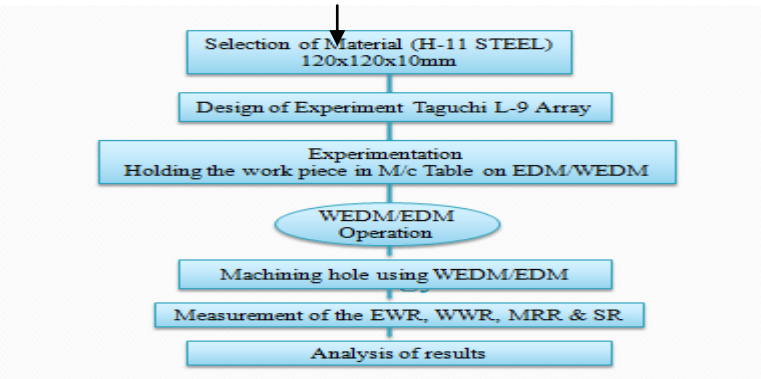
4.2 Design of Experimentation: Table no:-1 Design of Experiment

S.NO.	Current(A)	Voltage(V)	On time(μ sec)	Off-time(μ sec)
1	1	1	1	1

2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Taguchi L-9 design of experiment has been used in this study for conducting experiments. The standard table with details of parameters with their levels is given in table. In experimentation four parameters with three levels have been taken for examination reason.

4.3 Methodology of work:



4.4 Experimental Results

In this investigation the experimental results shows that the cavity EDM is consuming almost 5-7 times more current than WEDM and the MRR is 3-4 less than WEDM. The machining time of cavity EDM is 3-4 times more than WEDM and there has been improved surface roughness of wire EDM machining as compared to cavity EDM. The following results shows the impact of current, voltage, On-time and Off- time on the MRR, Surface roughness and TWR on cavity EDM and Wire EDM.

4.4.1 Effect of Process Parameters on Performance of Cavity EDM:

a) Influence of Current

Table -1 Regression Analysis of Current

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	19.7215	6.57385	7.68	0.026
tool wear(gm/hole)	1	6.2625	6.26254	7.32	0.043
MRR(mm^3/min)	1	3.8855	3.88545	4.54	0.086
Surface roughness (Ra)	1	0.0714	0.07142	0.08	0.784
Error	5	4.2785	0.85569		
Total	8	24.0000			

In EDM Regression analysis shows that Current effect the tool wear rate & Material removal rate because if we increase the current then it directly affect the tool wear rate & MRR.

b) Influence of Voltage:

Table -2 Regression Analysis of Voltage

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	52.358	17.453	0.16	0.919
tool wear(gm/hole)	1	2.627	2.627	0.02	0.883
MRR(mm^3/min)	1	11.091	11.091	0.10	0.763
Surface roughness (Ra)	1	1.724	1.724	0.02	0.905
Error	5	547.642	109.528		

Total	8	600.000			

In EDM effect of Voltage on Apparatus eroding rate, Substance eroding rate and SR is not much significant as compare to effect on current.

c) Influence of On-Time:

Table -3 Regression Analysis of On-Time

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	11554	3851.3	5.59	0.047
tool wear(gm/hole)	1	6446	6446.4	9.35	0.028
MRR(mm^3/min)	1	1756	1756.2	2.55	0.171
Surface roughness (Ra)	1	8554	8554.0	12.41	0.017
Error	5	3446	689.2		
Total	8	15000			

In EDM effect of On Time is very much of significant execution of EDM as far as Tool wear rate & Surface roughness.

d) Influence of Off-Time:

Table -4 Regression Investigation of Off-Time

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	3.4536	1.15120	0.28	0.838
tool wear(gm/hole)	1	2.4907	2.49071	0.61	0.471
MRR(mm^3/min)	1	0.0025	0.00255	0.00	0.981
Surface roughness (Ra)	1	0.5467	0.54673	0.13	0.730
Error	5	20.5464	4.10928		
Total	8	24.0000			

The following results show the impact of current, voltage, On- time and Off- time on the MRR, Surface roughness and WWR on WEDM.

4.4.2 Effect of Process Parameters on Performance of Wire EDM:

a) Influence of Current

Table -5 Regression Analysis of Current

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	21.599	7.1996	14.99	0.006
Wire wear ratio	1	3.397	3.3965	7.07	0.045
MRR(mm^3/min)	1	7.167	7.1667	14.92	0.012
Surface roughness (Ra)	1	3.731	3.7306	7.77	0.039
Error	5	2.401	0.4803		
Total	8	24.000			

In WEDM impact of Current is significant in terms of Wire eroding ratio, Material eroding rate and Surface roughness in terms of performance parameters.

b) Influence of Voltage:

Table -6 Regression Analysis of Voltage

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	9.607	3.202	0.03	0.993
Wire wear ratio	1	6.895	6.895	0.06	0.819
MRR(mm^3/min)	1	3.941	3.941	0.03	0.862
Surface roughness (Ra)	1	0.169	0.169	0.00	0.971
Error	5	590.393	118.079		
Total	8	600.000			

In WEDM effect of Voltage is not much effect on performance of WEDM as similar to the EDM.

c) Influence of On-Time:

Table -7 Regression Analyis of On-Time

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	4.6346	1.5449	5.66	0.046
Wire wear ratio	1	3.7983	3.7983	13.91	0.014
MRR(mm^3/min)	1	0.8436	0.8436	3.09	0.139

Surface roughness (Ra)	1	1.0039	1.0039	3.68	0.113
Error	5	1.3654	0.2731		
Total	8	6.0000			

In WEDM impact of On- time is also very much effective Wire wear ratio.

d) Influence of Off- time:

Table -8 Regression Analysis of Off-Time

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	3.8827	1.2942	3.06	0.130
Wire wear ratio	1	0.1326	0.1326	0.31	0.600
MRR(mm^3/min)	1	1.3184	1.3184	3.11	0.138
Surface roughness (Ra)	1	2.9442	2.9442	6.95	0.046
Error	5	2.1173	0.4235		
Total	8	6.0000			

In WEDM impact of Off Time is significant on the performance WEDM during Surface measurement.

5. CONCLUSION

As per Experimental Results the following conclusions have been drawn.

In EDM Regression analysis shows that Current effect the tool eroding rate & Material eroding rate because if we increase the current then it directly affect the tool wear rate & MMR.

In EDM effect of Voltage on Tool wear rate, Material removal rate and Surface roughness is not much significant as compare to effect on current.

In EDM effect of On Time is very much of significant execution of EDM as far as Tool wear rate & Surface roughness.

In EDM effect of Off Time is not very much remarkable as compare to On Time.

In WEDM effect of Current is significant in terms of Wire wear ratio, Material eroding rate and Surface roughness in terms of performance parameters.

In WEDM effect of Voltage is not much effect on performance of WEDM as similar to the EDM.

In WEDM effect of On time is also very much effective Wire wear ratio.

In WEDM effect of Off Time is significant on the performance WEDM during Surface measurement.

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