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Experimental Investigation to Optimize Machining Parameters of Steel Using EDM

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Abstract:

The current work is directing an exploratory study of EDM on SS316 using brass metal as the electrode. Copper and zinc are combined to form the alloy known as brass. Small tubular electrodes are made of brass materials. Brass is significantly simpler to process, but it does not have the same wear rate as copper or tungsten. Because new material may be introduced continually all across the EDM machining process, the EDM electrodes need not be resistant to wear or arc erosion. These uses current, pulse on time and pulse off time as input parameters. Gap voltage, dielectric, and cutting depth were fixed parameters in the experiments performed. The resulting observations are material removal rate, tool wear rate, and surface roughness determined to quantify the occurrence of EDM. To collect and evaluate the impact of various process parameters to improve response variables such as material removal rate (MRR), tool wear rate (TWR), and surface roughness (SR) according to the three level and three variable (L9) Taguchi orthogonal matrix.

Keywords — **Electrical Discharge Machining, U-Shaped Copper Electrode, AISI316, Material Removal Rate, Surface Roughness.**

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1.INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate an electrical spark and material removal mainly occurs in geo thermal energy. EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on a job-shop basis. Work material to be machined by EDM has to be electrically conductive.[1-4]

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig. 1.Both tool and work piece are submerged in adi electric fluid. Kerosene/EDM oil/deionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases.[5-6]

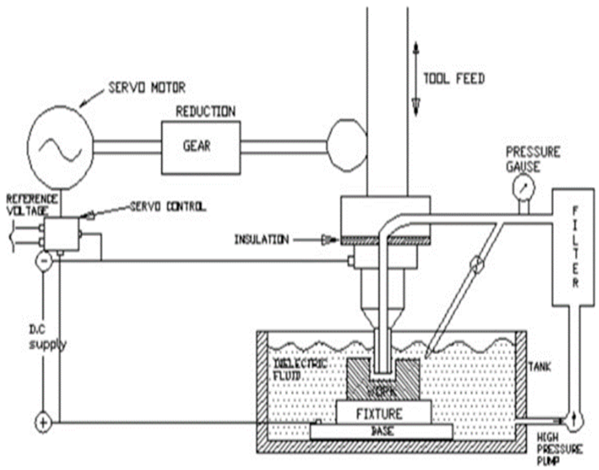

Fig.1Electrical discharge machine

The electric setup of the Electric discharge machining. The tool is mead cathode and work piece are anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark in interval of from 10 of micro seconds. And positive ions and electrons are accelerated, producing a discharge channel that becomes conductive. It is just at this point when the spark jumps causing collisions between ions and electrons and creating a channel of plasma. A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as are sult of which a very high temperature is reached and at such high pressure and temperature that so me metal is melted and eroded.

Such localized extreme rise in temperature leads to material removal. Material removal occurs due to instant vaporization of the material as well as due to melting. The molten metal is not removed completely but only partially as the potential difference is withdrawn; the plasma channel is no longer sustained. As the plasma channel collapse, it generates pressure or shock waves, which evacuates the molten material forming a crater of removed material around the site of the spark

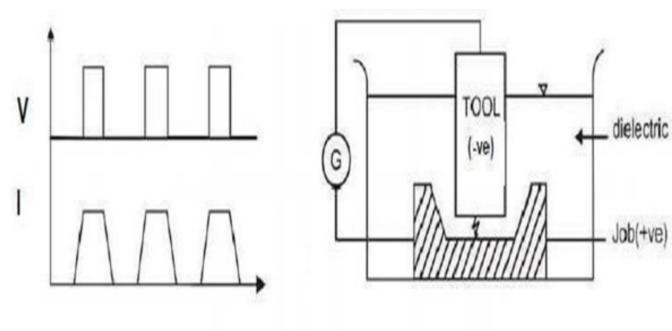

Fig.2 Working principle of EDM process

Joseph Priestley. The erosive effect of electrical discharges was first notedin 1770 by English physicist. Electrical Discharge Machining is a one of theelectricalenergiesbasedUnconventionalMachiningTechniques.Theelectrical energy is directly used to remove or cut the metals. It's also called as Spark Erosion Machining or Electro Erosion Machining. The metal is removed by electrical spark discharge between the tool (Cathode)and the work piece (Anode). Electrical Discharge Machining is used in mold and die-makingindustries,Automobileindustries,andthe makingofAerospacecomponents. EDM has become an important and cost-effective method ofmachining extremely tough and brittle electrically conductive materials. It iswidelyusedintheprocessofmakingmoldanddiesan dsectionsofcomplex geometry and intricate shapes. The workpiece material selected inthisexperimentisconsidereditswideusageinindustr ialapplications.

Machine Process	Electric Discharge Machine											
	P20 toolsteel	AISI304	Incinel718	AISID3	EN19	AISI420	TIi-6AI-4V	AISIH13	Tungstencarb idecobalt	AISI1020	AISI1045	C40 Steel
Electric Discharge Machine	1[7]	3[1,2,3]	1[10]	1[13]	2[15,16]		1[19]	1[25]	1[26]	1[25]	1[27]	1[29]
Turning	1[8]	1[4]	1[12]			1[18]	1[20]				1[28]	
Welding												
Drilling		1[6]										
Milling	1[9]	1[5]		1[14]		1[17]	1[21]			1[23]		
DieCasting												
CNC Lathe												
Grinding			1[11]									1[30]
ReviewPaper												

Table 1. Listofpublished papers

Inthepresentsection,thereviewofrecentlypubli shedinvestigationsandreported in open literature has been carried out on the material selection is different accordingtoitsproperties.Thedetailsoftherecentlypu blishedinvestigationsrelatedtodifferentmaterialwor konthedifferentmachiningprocesseshavebeen arranged in Table 1 the review has been carried out considering three criteria viz.(1) Reviewofparticularmachiningprocessonthematerial s,(2)Reviewofparticularmaterialsareworkondiffere ntmachiningprocessand(3)Reviewofavailableliterat ureintermsofoutcomes.

Sanjeev et al. have taken a shot at the metal expulsion component in ElectricalDischargeMachiningismostlyahardmateri alwherewarmvitalityiscreatedinaplasmachanneland isdispersedhoweverworkpiece,instrument, and dielectric. The procedure is for the most part utilized incircumstanceswere the machiningofhardmaterials,unpredictableparts ,complex shapes. The target of this work is the advancement of the cutting parameters for Electric release machining of AISI 316 hardened steel to accomplish better surface done with utilizing the terminal is utilized in this work as a device is Copper and Taguchi's system. Taguchi Parameter Design is a suitable and proficient technique for improving the quality and execution yield of assembling forms. It is a reasonable instrument for addressing this difficulty.

Ashok et al. In this paper, a researcher has worked on a micro hole in workpiece material they took SS316H as the workpiece material and studied on microhole through the EDM process. Micro hole by EDM process is a nonconventionalmachining process and for a machine tool is used as an electrode but duringmachining wear of the tool is significantly showed and for that they optimizedthe input process parameter by Taguchi method. An electrode is taken in thisstudy of copper of 300µm diameter. A varying parameter in this study iscurrent, pulse off time, pulse on time. And after optimization they made aconclusionthatElectrodeToolwearsrateof the experimentandpredicatedvalues difference were up to 0.00021 mg could be achieved by this processand a combination ofA3B1C3 i.e., current of 0.8 Amps,T-on6µs, T-off8µs.from Signal to noise ratio the optimum parameters combination value is32.207

Dhar et al. assesses the impact of current (c), beat on time (p) and air holevoltage on MRR, TWR, ROC of EDM with SiC composites. This test hasdone utilizing the PSLEADERZNCEDMmachine and a tube-shapedmetalterminal of 30 mm breadth. For optimization three elements, three levels fullfactorialplanwasutilizingandanalyzingtheresults .Theybuiltupasecond Request, a non-direct scientific model for establishing the relationship among machining parameters. The critical of the models were checked using technique ANOVA and find the MRR, TWR and ROC increment huge in a non-linear fashion with increment in a current.

Alexia et al. In this research work, a new modeling of energy density in EDM proposed. Energy density model helped to quantify the material removal volume. They purposed technique on In cone l600 alloy using Cu- C electrode.Theexperimental resultsconfirmedthattheuseofnegativepolarity leads to a higher material removal rate, higher electrode wear andhighersurfaceroughness.Theoptimalconditionhasbeenobtainedamaximum MRR of 30.49 cub.mm/min with 8 A, 100 s and 0.6, respectively, for the current intensity, pulse time and duty cycle.

Gupta et al. This paper portrays the test investigation of the informationparameters of EDM i.e.,current, beatontime andheart beatoff time onyieldparameters material expulsion rate (MRR), instrument wear rate and surfaceunpleasantness (SR). The work piece materials are chosen AISI D2. Thealuminum utilized as instrument anode and EDM oil as a dielectric liquid.Taguchi, the technique was utilized to perform tests, L9 symmetrical clusterwas connected utilizing MINITAB programming. Flag to Noise proportionand ANOVA were utilized for parameter enhancement and to accomplishmax

MRR, min SR, and TWR. The outcomes show that the most incitingcomponent for MRR is Pulse off time. The paper anticipated, For TWR, themost impacting element is current. For SR, the most inciting component isbeat ontime.

Hang et al. EDM process is studied in this paper. Based on the solid-liquidtwo-phase flow equation, the mathematical model on the gap flow field withflushing and self-adaptive distribution is developed. In the 3D simulationprocess, the count of debris increases with a number of EDM discharge cycles,andthe distribution generated by the movement of a self-adaptive tool in the gapflowisconsidered.Themethodsofsmoothingandenmeshingarealsoapplied in the modeling process to enable a movable tool. Under differentdepth, flushing velocity, and tool diameter, the distribution of velocity field,pressurefieldofgapflow,anddebrismovementare analyzed.

Thestatisticalstudyofdebrisdistributionunderdifferentmachiningconditions is alsocarried out. A seriesof experiment as been conductedonaself-mademachinetoverifythe3Dsimulationmodel.Theexperimentresults show the burn mark at the whole bottom and the tapered wall, whichcorresponds well with the simulating conclusion. This study concluded thattheself-adaptivemovementofatoolcangeneratedisturbanceto themachiningregion,flushvelocity, debrisdistribution affects thegapflowfield andincreasethedepthofthehole. From the research papers in this classification, it is observed that fewworks have been reported on EDM on the material Al-Sic, EN-19, SKH57,AISI H13, AISID2 tool steel, and various composite materials. Studyon EDM of different materials and different mathematical models can beused tovalidatetheexperimentalresults.

The objective of the present work is an attempt to finding feasibility ofmachiningAISI316toolsteelusingCopperelectrodeandinternalflushing. The machining parameters elected for discharge current, pulseon time, and diameter of the tool using EDM following by the responsesMRR,SR,andovercut.ThisstudyofEDMoperationisthemostinfluentialparameter,and optimizationtechniquesaredone.

The residual plots for material removal rates and surface roughness aregenerated by the ANOVA optimization technique. On the basis of theANOVA optimization technique, the optimum solution occurs at peakcurrent value 6 (Amp), pulse on time 60 (s).and a pulse-off time of 24 swithacompositedesirabilityof0.8163for EDMmachiningofSS316H.

In this study, the low wear parameters of a narrow-slot structure with ahighaspectratiousingCopperelectrodeswereidentifiedbyanorthogonallydesignedexperiment.Differenttip wear characteristicsofthe electrode and their influence on the forming accuracy were analyzedbyEDM.

2. METHODOLOGY

The experimental work which consistsofthe formation of the L-18 orthogonal array based on the orthogonal array isreducesthetotalonofthe experiment,inthisexperimenttotal9runs.AndExperimentalsetup,selectionofworkpiece,tooldesign,andtakingallthe values and calculations of MRR, TWR. In this, the framework is developed inorder to experimentally investigate the electro-discharge machining process and getthe important process parameters that have a maximum effect on the responseparameters. Further, these process parameters are varied in a specified range andresponse is noted down. The purpose of the experimental study is to optimize theperformance parameters of die sinking electro discharge machine which includessurfaceroughness,materialremovalrate,andtoolwearratio.Inthischapterdetailedmethodologytostepsperformedandpathfollowedaregivenas

a. StudyofdieSinkingEDMmachinewithbenefitinvolves.

b. Formulationoftheobjectiveandresearch problem.

c. Identificationofappropriateworkpieceforexperimentwork.

d. Studytheprocessparametersandperformanceparameters.

e. Studyofoptimizationtechniques andselectingtheappropriate

f. ToperformtheexperimentonElectricDischargeMachining.

g. Gettheoutputresultandmeasuretheperformanceparameter.

h. Creatinga datatableandarrangingtheperformanceparameter.

i. Analyze all experiment data and optimization in MINITAB software with appropriate optimization techniques.

j. Plotting the effect of the process parameter on the performance parameter.

k. Presenting the optimized result in a different format.

2.1 MaterialsandMethods

Deep and narrow slots are the processing objects studiedin this work. Inordertofacilitatealargenumberofrepeatedexperiments,thesizeofthestructureis designed as 20×20×5 (length×width×depth\mm). The precision EDM machinetool was used as the experimental platform. EDM oil (EDM-3, Mobile®) is used asthe dielectric. The tool electrode is made of ISO-63EDM Copper produced byTOYO TANSO®. The work piece is made of AISI-316 steel). The finished slotswere cut using EDM. Section profiles were observed and measured using a stereomicroscope (Zeiss ZEISS-Stemi 2000c) to evaluate the contour and shape precisionafter processing. In addition, the KEYENCE VHX1000 Microscope was used toobserve the carbonaceous layer deposition formed on the tool electrode surface.SEM (HITACHI S4300) was used to microscopically characterize the carbon layerprofile.

2.2. EDM Machining Parameters and their Levels

S.NO	Current (A)	Pulseon time (µSec)	Pulseoff time(µSec)	Dielectric pressure (kg/cm^3)	Materialremoval rate(mg/min)	Surface roughness (µm)
1.	8	7	7	2	6.3	3.76
2.	12	7	7	2	112.4	10.14
3.	16	7	7	2	191.3	19.98
4.	20	7	7	2	351.4	20.76
5.	24	7	7	2	516.7	24.45
6.	24	7	7	3	916.8	20.23
7.	24	7	7	4	1051.3	17.12
8.	24	7	7	5	1181.8	16.67
9.	24	7	7	6	1321.33	16.65
10.	24	3	7	6	1611.9	11.67
11.	24	4	7	6	1516.1	12.48
12.	24	5	7	6	1481	12.9
13.	24	6	7	6	1421	16.6
14.	24	6	3	6	509.3	20.1
15.	24	6	4	6	510.6	20.2
16.	24	6	5	6	512.5	19.9
17.	24	6	6	6	511.6	20.01

In addition to Electrode as cutting tool and work piece material, maximumcurrent, pulse on time, and pulse off time are most important machining parameterswhich dominantly affect the performance characteristics.Therefore, itis essentialto select the most appropriate process parameters and tool electrode in order toimprove material removal efficiency, reduce process cost and produce high-qualityproducts. In EDM operation basically, there are three major parameters viz. pulseon time, pulse off time , peak current which plays a significant role to get desiredqualitylevel.Servofeedandservovoltageisalsoanimportantparameter.Therefore, the process parameters like peak current IP (Amp), pulse on time (µs),andpulseofftime(µs),andtheirassociatedlevelsareselectedbasedonpreliminaryliterature reviewandpropertiesofwork-piecegivenintable 2.

Table 2 Inputprocessparametersandtheirlevel

3. RESULT AND DISCUSSION

Discharge current, Ton, Toff, and dielectric pressure are examples of electric discharge machining parameters.MRR issignificantlyinfluencedby current,whichalsocausesMRR torise.Highercurrentmight result inmore spark,whichraisesthe temperature[14],causingmeltingandmaterialvaporisationtooccur. Although the MRR drops with an increase in Ton, other variables have less of an impact than other parameters.

3.1.MRR's impact

WhenthevalueofTon islow,therateofmaterialremovalincreasesbecausethe increaseinsparkenergy followstheincreaseinthevalueofTon.Theinterelectrodegapandenergytransferbarriersareobstructed asthevalueofTon,M.R.R.isincreased,causingadeclineinmaterialremovalrate.Ton,M.R.R.isafixed amount.

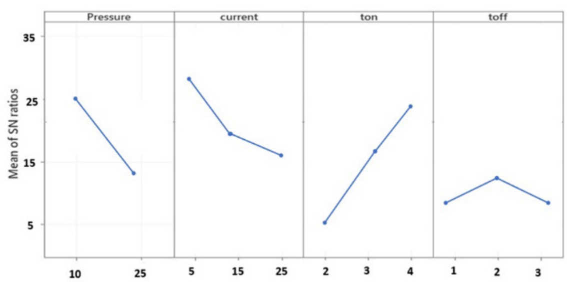

Fig.3Main effect plotformean.

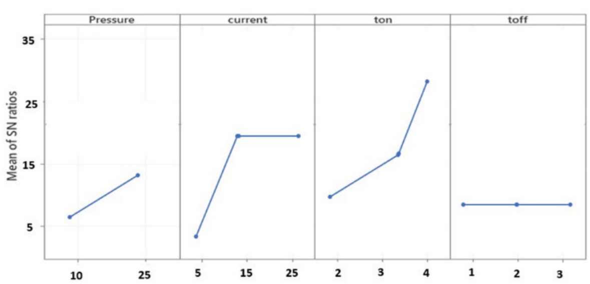

Fig.4 Main effect plotforS/NRatio:-

Figure4demonstratesthatthe mainparameterswiththe greatestimpactonthe rate ofmaterialremovalare thetonne anddischarge current(MRR). The materialiseliminatedbymelting andvaporisation, as demonstratedintheprecedingparagraph, as thecurrentincreases.This iscausedbythegrowingspark intensity.Asthe pulse ontimeisincreased,the diameterofthe plasma channel widens,reducingthe material removalrate,whichinturn causesthematerialremovalratetodecrease.Giventhatt heremoveddebris prevents the material from solidifying as the dielectric pressure rises, it is possible that the dielectric pressure hassomebearingonthe materialremoval.The intervalbetweenpulsesdoesn'tsignificantly affecttheresult.Thebetterthevalue,accordingtoAnalysisofVariance(ANOVA),forsurfaceroughness.As canbe seenfromthetableabove,Ton hasthegreatestinfluenceoverthe S.R.currentwhereasToffhasthe least.

4. CONCLUSION

Inthis study,whichmakes useofa flatbasecoppertool,theM.R.R. andS.R.ofstainless steelsare examined.Themachiningparametersthatwillbeusedf orthetestingarethedischargecurrent,Ton,Toff, anddielectricpressure.TheMinitab programwas usedtoapplytheL18orthogonalarray.Theresearchers wereabletovalidatetheirresultsbyutilisingANOVA. ThedischargecurrentandtheTonhaveabig impactontheMRR.Toffistheonewiththesmallestdegreeofsway.Thestrengthofthesparkincreasesdue toanincreaseindischargecurrent, whichraises temperature.Thiscauses materialtoberemovedintheform ofcavitiesthroughthemeltingand evaporationofthesubstance.

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