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EXPERIMENTAL INVESTIGATION TO DETERMINE INFLUENCE OF PROCESS PARAMETERS ON SURFACE QUALITY WIRE CUT EDM

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Abstract: Wire-cut Electrical Discharge Machining (WEDM) is extensively used in machining of conductive materials producing intricate shapes with high accuracy. This study exhibits that WEDM process parameters can be altered to achieve betterment of Material removal rate (MRR), Surface Roughness (SR) and Electrode Wear. The objective of our project is to investigate and optimize the potential process parameters influencing the SR and Electrode Wear while machining of aluminum alloys using WEDM process. This work involves study of the relation between the various input process parameters like Pulse-on time(Ton), Pulseoff time(Toff), Pulse Peak Current(IP), Wire material and Work piece material and process variables. Based on the chosen input parameters and performance measures L-9 orthogonal array is selected to optimize the best suited values for machining for aluminum alloys by WEDM.

I. INTRODUCTION

A machining methodology usually used for Non Ferrous metals, discharge Machining (commonly called "EDM Machining") makes it attainable to figure with metals that ancient machining techniques square measure ineffective. a vital purpose to recollect with EDM Machining is that it'll solely work with materials that square measure electrically semi conductive.
With smart EDM Machining instrumentality it's attainable to chop tiny odd-shaped angles, elaborated contours or cavities in hardened steel also as exotic metals like Ti, hastelloy, kovar, inconel, and inorganic compound.

Fig1 : wire cut EDM machine

The EDM method is usually utilized in the Tool and Die business for mold-making, but in recent years EDM has become a integral half for creating image and production elements. this is often seen within the part and natural philosophy industries wherever production quantities stay low.

When the gap between the 2 electrodes is reduced, the intensity of the electrical field within the volume between the electrodes becomes bigger than the strength of the insulator (at least in some point(s)), that breaks, permitting current to flow between the 2 electrodes. This development is that the same because the breakdown of a condenser (condenser) (see additionally breakdown voltage). As a result, material is off from each the electrodes. Once the present flow stops (or it's stopped – betting on the sort of generator), new liquid insulator is typically sent into the inter-electrode volume facultative the solid particles (debris) to be frenzied and also the insulating properties of the insulator to be restored . Adding new liquid insulator within the inter-electrode volume is usually stated as flushing. Also, when a current flow, a distinction of potential between the 2 electrodes is restored to what it absolutely was before the breakdown, so a brand new liquid insulator breakdown will occur.

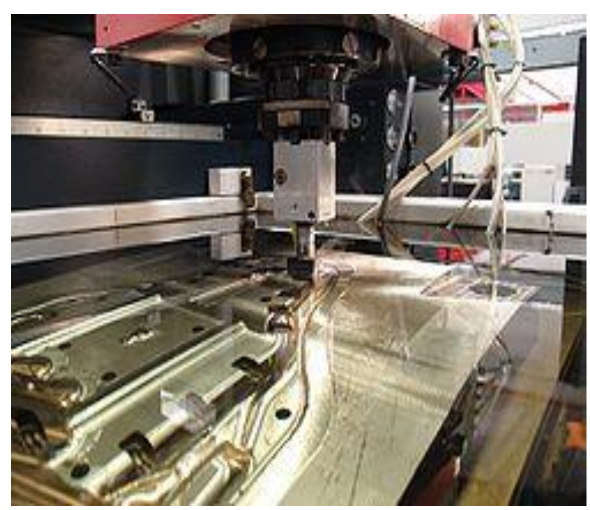


Fig2. small EDM machine

The principle of wire cut EDM machine

Electrical discharge machining could be a machining methodology primarily used for onerous metals or people who would be terribly troublesome to machine with ancient techniques. EDM usually works with materials that square measure electrically semiconductive, though strategies for machining insulating ceramics with EDM have additionally been planned. EDM will cut complex contours or cavities in pre-hardened steel while not the requirement for warmth treatment to melt and re-harden them. This methodology is used with the other metal or metal alloy like Ti,hastelloy, kovar, and metal. Also, applications of this method to form crystalline diamond tools are according.

EDM is usually enclosed within the 'non-traditional' or 'non-conventional' cluster of machining strategies along side processes like chemistry machining (ECM), water jet cutting(WJ, AWJ), optical maser cutting and opposite to the 'conventional' cluster (turning, milling, grinding, drilling and the other method whose material removal mechanism is actually supported mechanical forces).[10]
Ideally, EDM is seen as a series of breakdown and restoration of the liquid insulator intermediate the electrodes. However, caution ought to be exerted in considering such {a statement|a press release|an Associate in Nursingnouncement} as a result of it's an perfect model of the method, introduced to explain the elemental concepts underlying the method. Yet, any usage involves several aspects that will additionally have to be compelled to be thought-about. for example, the removal of the rubble from the inter-electrode volume is probably going to be continuously partial. so the electrical proprieties of the insulator within the inter-electrodes volume is completely different from their nominal values and may even vary with time. The inter-electrode distance, usually additionally stated as spark-gap, is that the ending of the management algorithms of the precise machine used. The management of such a distance seems logically to be central to the present method. Also, not all of the present between the insulator is of the perfect sort delineated above: the spark-gap is short-circuited by the rubble. The system of the conductor could fail to react quickly enough to stop the 2 electrodes (tool and workpiece) from returning into contact, with a sequent short. this is often unwanted as a result of a brief circuit contributes to material removal otherwise from the perfect case. The flushing action is inadequate to revive the insulating properties of the insulator so the present continuously happens within the purpose of the inter-electrode volume (this is stated as arcing), with a sequent unwanted amendment of form (damage) of the tool-electrode and work. Ultimately, an outline of this method in an exceedingly appropriate method for the precise purpose at hand is what makes the EDM space such a fashionable field for any investigation and analysis.

II. LITERATURE REVIEW

The main objective of this work is to demonstrate the optimization of Wire Electrical Discharge Machining process parameters for the machining of H13 HOT DIE STEEL, with multiple responses Material Removal Rate (MRR), surface roughness (Ra) based on the Grey–Taguchi Method. taguchi'sL27(21x38) Orthogonal Array was used to conduct experiments, which correspond to randomly chosen different combinations of process parameter setting, with eight process parameters: TON, TOFF, IP, SV WF, WT, SF, WP each to be varied in three different levels. Data related to the each response viz. material removal rate (MRR), surface roughness (Ra) have been measured for each experimental run; With Grey Relational Analysis Optimal levels of process parameters were identified. The relatively significant parameters were determined by Analysis of Variance. The variation of output responses with process parameters were mathematically modeled by using non-linear regression analysis. The models were checked for their adequacy. Result of confirmation experiments showed that the established mathematical models can predict the output responses with reasonable accuracy.

III. PROBLEM DESCRIPTION

Taguchi Method Taguchi, a Japanese scientist, developed a technique based on Orthogonal Array(OA)of experiments. The assimilation of DOE with parametric optimization of the process can be accomplished in the Taguchi method. An OA give sa set of well-balanced experiments, and Taguchi's signal-to-noise. (S/N) ratios, that are logarithmic functions of the craved output, serve as an objective functions for optimization. It comforts to learn the whole parameter space with a small number (minimal experimental runs) of experiments. OA and S/N ratios are used to study the effects of control factors and noise factors and to determine the best quality characteristics for particular applications.

IV EXPERIMENTAL SETUP

The experiments were carried out on a wire-cut EDM machine (ELEKTRA SPRINTCUT 734) of DUN technologies, hyderabad, India.The WEDM machine tool has the following specifications

Design	Fixed column with moving Table
Table size	440 x 650 mm
Max. workpiece height	200 mm
Max. workpiece weight	500 kg
Main table traverse (X, Y)	300, 400 mm
Auxiliary table traverse (u, v)	80, 80 mm
Wire electrode diameter	0.25 mm (Standard), 0.15, 0.20 mm (Optional)
Generator	ELPULS-40 A DLX
Controlled axes	X Y, U, Vsimultaneous
Interpolation	Linear & Circular
Least input increment	0.0001mm
Input Power supply	3 phase, AC 415 V, 50 Hz
Connected load	10 KVA

WORKPIECEMATERIAL SELECTION

Due to the different melting point, evaporation and thermal conductivity, different materials show different surface quality and MRR at the same conditions of machining. aluminum is the work piece material which is used in this experiment. The aluminum plate of 200mm x 50mm x 15mm size has been used as a work piece material and a profile of 10mm x 50mm x 15mm is been cut with the wire(Brass and Brass coated Nickel) traversing the through the kerf made and the performance analysis of output parameters with respect to input parameters is measured.

EXPERIMENTAL SETUP AND PROCEDURE

Experiments have been performed in order to investigate the effects of one or more factors of the process parameters on the surface finish of the wire cut machined surface.

The main aim of the project is to determine the influence of time on, time off, wire feed and input power. The investigation is based on surface roughness during machining of Aluminum alloy.

EXPERIMENTAL PROCEDURE

The selected work piece materials for this research work are Aluminum alloy materials. Experiments have been conducted on **wire cut edm**. The machine details are:

CNC wire cut edm machine

4.1.2 Technical Specification

Machine Tool	
Design	Fixed column, moving table
Table size	440 x 650 mm
Max. workpiece height	200 mm
Max. workpiece weight	500 kg
Main table traverse (X,Y)	300 x 400 mm
Aux. table traverse (u,v)	80 x 80 mm
Max. taper angle	± 30°/50 mm
Max. JOG speed	900 mm/min.
Resolution	0.0005 mm
Max. wire spool capacity	6 kg (up to DIN 160 / P5)
Wire electrode diameter	0.25 mm (std.) 0.15, 0.20 mm (opt.)
Pulse Generator	ELPULS-40 A DLX
Pulse peak voltage	1 Step
CNC Controller	EMT 100W-5
Controlled axes	X,Y,u,v simultaneous
Interpolation	Linear & Circular
Least input increment	0.001 mm
Least command input (X,Y,u,v)	0.0005 mm
Max. programmable dim. (X,Y,u,v)	± 99999.999 mm
Input power supply	3 phase, AC, 415 V, 50 Hz
Connected load	10 kVA
Average power consumption	6 to 7 kVA

An **electrolytic brass (Zinc coated)** wire with a diameter of 2mm has been used as a tool electrode (positive polarity) and work piece materials used are EN8 Steel, Aluminum alloy and Copper materials rectangular plates of dimensions 80×30 *mm* and of thickness 6 *mm.* Commercial grades EDM oil will be used as dielectric fluid. Lateral flushing with a pressure of 7MPa will be used. The influence of time on, time off, wire feed and input power rate have been treated as controllable process factors. A collection tank is located at the bottom to collect the used wire erosions and then is discarded. The wires once used cannot be reused again, due to the variation in dimensional accuracy.

Material Properties of Aluminum Alloy7475

Density	2.70 (g/cm^3)
Specific capacity	880 (J/kg °k)
Thermal conductivity	138 (W/m °k)
Electrical resistivity	0.0000045 Ω cm
Modulus of elasticity	71.3 G Pa

PROCESS PARAMETERS AND DESIGN

Input process parameters such as Pulse On time (TON), Pulse Off time (TOFF), Peak Current (IP), used in this thesis are shown in Table. Each factor is investigated at three levels to determine the optimum settings for the WEDM process. Wire feed is 3m/min, Wire Tension is 7 Kgf and Servo Feed is kept constant at 2.1 m/min.
The selection of parameters for experimentation is done as per taguchi design. An orthogonal array for three controllable parameters is used to construct the matrix of three levels of controllable factors. The L9 orthogonal array contains 9 experimental runs at various combinations of three input variables.

CONTROL PARAMETERS	UNITS
PULSE TIME ON	(µsec)
PULSE TIME OFF	(µsec)
PEAK CURRENT	(Amper)

The L9 orthogonal array for input parameters Pulse on time, pulse off time and peak current is shown in table below:

Experiments	Time		Peak current (IP)
	On	Off	
1	105	52	210
2	105	56	220
3	105	60	230
4	107	52	210
5	107	56	220
6	107	60	230
7	109	52	210
8	109	56	220
9	109	60	230

SURFACE FINISH RESULTS

In this project most important output performances in WEDM such as Surface Roughness (Ra) is considered for optimizing machining parameters. The surface finish value (in µm) was obtained by measuring the mean absolute deviation, Ra (surface roughness) from the average surface level using a Computer controlled surface roughness tester.

Surface Finish Tester – Model Surtronic 3+, Rank Taylor Hobson Ltd., Made in England which is periodically calibrated using Reference Specimen Type 112/1534. Lab Temperature 20 ±20^{0}C.

Experiments	Time		Peak current (IP)	Surface Finish Values R_a
	On	Off		
1	105	52	210	0.29
2	105	56	220	0.31
3	105	60	230	0.37
4	107	52	210	0.30
5	107	56	220	0.41
6	107	60	230	0.47
7	109	52	210	1.09
8	109	56	220	0.89
9	109	60	230	1.01

INTRODUCTION TO TAGUCHI TECHNIQUE

- Taguchi defines Quality Level of a product because the Total Loss incurred by society because of failure of a product to perform as desired once it deviates from the delivered target performance levels.
- This includes prices related to poor performance, in operation prices (which changes as a product ages) and any further expenses because of harmful aspect effects of the merchandise in use.

5.1.1 Taguchi strategies

- Help firms to perform the standard Fix!
- Quality issues square measure because of Noises within the product or method system
- Noise is any undesirable result that will increase variability
- Conduct in depth drawback Analyses

SELECTION OF OPTIMAL PARAMETER COMBINATION FOR BETTER SURFACE QUALITY IN WIRE CUT EDM USING TAGUCHI TECHNIQUE

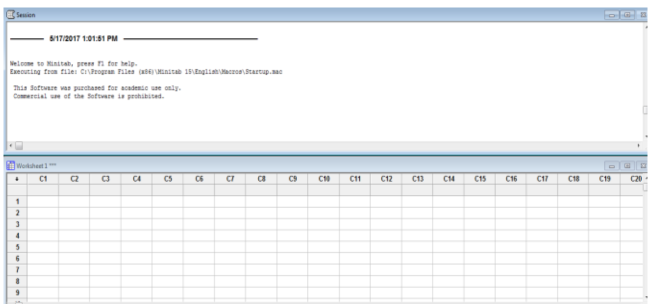
The Experimental results show the effect of three process parameters surface roughness.

EXPERIMENTAL RESULT

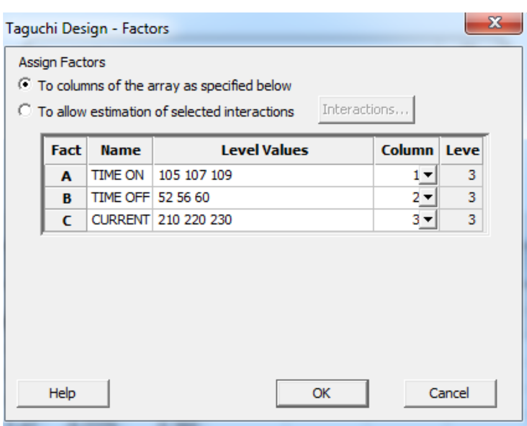
Experiments	Time		Peak current (IP)	Surface Finish Values R_a
	On	Off		
1	105	52	210	0.29
2	105	56	220	0.31
3	105	60	230	0.37
4	107	52	210	0.30
5	107	56	220	0.41
6	107	60	230	0.47
7	109	52	210	1.09
8	109	56	220	0.89
9	109	60	230	1.01

Design of Orthogonal Array

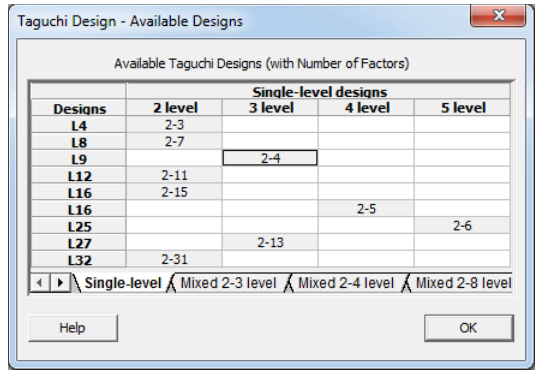
First Taguchi Orthogonal Array is designed in Minitab17 to calculate S/N ratio and Means which steps is given below:



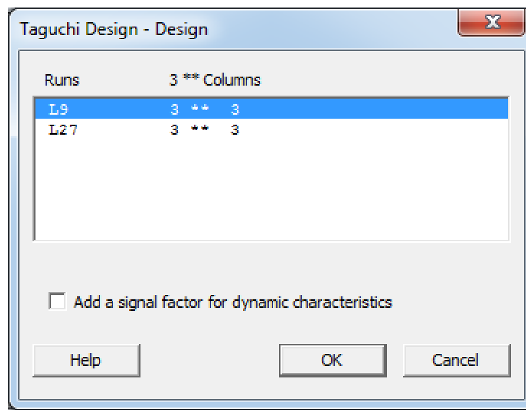
Stat – DOE – Taguchi – Create Taguchi Design
Select 3 – Level Design
Number of factors - 3



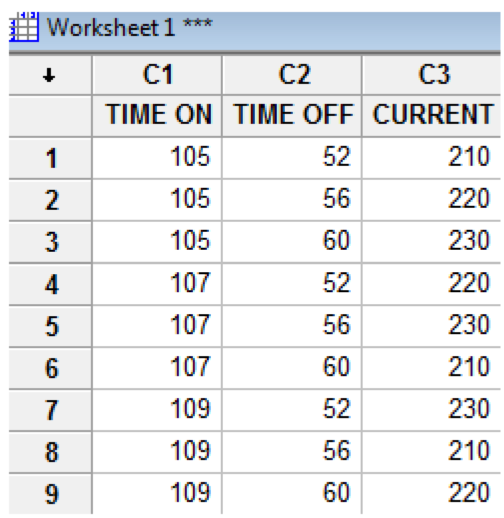
6.3 Display Available Designs
Select – L9 (2-4)



Select Designs
Select – L9



Select – Factors
Enter factors and their values


Worksheet 1 ***

↓	C1	C2	C3
	TIME ON	TIME OFF	CURRENT
1	105	52	210
2	105	56	220
3	105	60	230
4	107	52	220
5	107	56	230
6	107	60	210
7	109	52	230
8	109	56	210
9	109	60	220

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	TIME ON	TIME OFF	CURRENT	SURFACE FINISH	SURFACE FINISH 1
1	105	52	210	0.29	0.28
2	105	56	220	0.31	0.30
3	105	60	230	0.37	0.39
4	107	52	220	0.30	0.42
5	107	56	230	0.41	0.48
6	107	60	210	0.47	0.39
7	109	52	230	1.09	0.99
8	109	56	210	0.89	0.75
9	109	60	220	1.01	0.92

Taguchi – Analyze Taguchi Design – Select Responses

RESULTS

Effect of parameters surface roughness for S/N ratio
Effect of parameters on surface roughness for Means

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	TIME ON	TIME OFF	CURRENT	SURFACE FINISH	SURFACE FINISH 1	SNRA1	MEAN1
1	105	52	210	0.29	0.28	-10.9071	0.285
2	105	56	220	0.31	0.30	-10.3175	0.305
3	105	60	230	0.37	0.39	-8.4134	0.380
4	107	52	220	0.30	0.42	-9.2376	0.360
5	107	56	230	0.41	0.48	-7.1135	0.445
6	107	60	210	0.47	0.39	-7.4435	0.430
7	109	52	230	1.09	0.99	0.3105	1.040
8	109	56	210	0.89	0.75	-1.8188	0.820
9	109	60	220	1.01	0.92	-0.3378	0.965

RESULTS

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The surface roughness is considered as the quality characteristic with the concept of "the smaller-the-better". The S/N ratio for the smaller-the-better is:

7.1 $S/N = -10 *\log(\Sigma(Y^2)/n))$

Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration above Eqn. with the help of software Minitab 17.

The surface roughness measured from the experiments and their corresponding S/N ratio values are listed in Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	TIME ON	TIME OFF	CURRENT	SURFACE FINISH	SURFACE FINISH 1	SNRA1	MEAN1
1	105	52	210	0.29	0.28	-10.9071	0.285
2	105	56	220	0.31	0.30	-10.3175	0.305
3	105	60	230	0.37	0.39	-8.4134	0.380
4	107	52	220	0.30	0.42	-9.2376	0.360
5	107	56	230	0.41	0.48	-7.1135	0.445
6	107	60	210	0.47	0.39	-7.4435	0.430
7	109	52	230	1.09	0.99	0.3105	1.040
8	109	56	210	0.89	0.75	-1.8188	0.820
9	109	60	220	1.01	0.92	-0.3378	0.965

CONCLUSION

The objective of the present work is to investigate the effects of the various Wire cut EDM process parameters on the machining quality and obtain the optimal sets of process parameters so that the quality of machined parts can be optimized. Experiments are conducted on the pieces varying parameters. The materials used for machining are Aluminum alloy. The process parameters considered are Pulse Time on, Pulse Time off, Input Power, Wire Feed, Servo Voltage and Wire Tension. The range of values varied are Time on – 105 μsec, 107 μsec and 109 μsec, Time off – 52 μsec, 56 μsec, 60 μsec, Input power – 210amp, 220amp, 230amp. Wire feed, wire tension and servo voltage are kept constant. The optimization is done by using taguchi technique by considering L9 orthogonal array. Optimization is done using Minitab software.
we can conclude that at Time on -104 μsec, Time off – 50 μsec and Input power-210amp to get better surface finish values.

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