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PARAMETRIC OPTIMIZATION OF EDM OF AISI-4147 USING TAGUCHI APPROACH

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ABSTRACT:- *Electric discharge machine is a non-conventional machining. In which there is no contact between tool and work piece. By EDM process machining of hard material components that are difficult to machine such as heat treated tool steels, ceramics, composites, carbides, heat resistance steel which are used in die and mould producing industries, aero space and nuclear industries. EDM is a non-contact type technique of material removal and in this spark is used to remove the material from the work piece. Since the EDM is an attractive means of making tool and dies with high accuracy in dimension and surface finish quality of micro scale parts.*
The present experimental research studies the process parameters that are influencing the machining performance and its productivity. A combined approach is used for the optimization in parameters and performance characteristics which are based on Taguchi method. The experiments are based on Taguchi"s L9 orthogonal array. The reaction graph and reaction table of each near of machining constraints are took from Taguchi method to select the optimum levels of machining factors. In the work, the machining parameters for thesis are current, pulse on time and pulse off time, which are optimized for minimum tool wear rate (TWR), maximum material removal rate (MRR) and minimum surface roughness during electro discharge machining of AISI 4147. Analysis of Variance is also used to findout variable affecting the various responses mentioned above.

Keyword *: ISI-4147, EDM , TANGUCHI METHOD, MRR, TWR & SURFACE ROUGHNESS*

1. INTRODUCTION

EDM or electric discharge machining is completed when a release revenue place between terminal and cathode, due to release the powerful heat energy is produced near the zone. That is necessary to melt and evaporate the provisions in the sparkling region. To improve the effectiveness of the process, a die electric fluid (hydrocarbon or mineral oils) is used in this work bit and the tool is submerged. It has been experiential in the course that if both the conductors are of equal material, the electrode joined to helpful terminal mostly corrodes at a earlier rate than the other. Due to this, the work piece is normally made the anode. A proper slit, recognized as flash slit, should be continued between the tool and the slog sides to complete the process. Since the flash follows at the place where the device and the effort surface are the close enough and after each spark the spot changes (due to the material elimination later each flash), the spark trips all over the shallow. This is the reason of uniform material deletion very above the outward, and to finish work piece adapts to the tool apparent.

This is a very common machining method for exact solid metals. For which it is dreadful to device by straight machining procedures. It has been widely used in extant commerce, mainly for spiteful of intricate reliefs or delicate holes that are trying to machine by straight machining systems. But that there is only one dangerous control in EDM. That is working with electrically conductive tackles. Tools that can be machined by using EDM are nickel-based mixtures, exact solid tool braces, conductive fusions, High speed braces, conductive earthenware, etc.

1.2 EDM PRINCIPLE

EDM is a meticulous metal-removal method that is cast-off to eliminate metal by capitals of electric spark attrition. In this method an electrical spark is used as the critical tool to cut (erode) the work piece to crop the complete part to the chosen shape. EDM process complete in a liquid middling (dielectric fluid), the automatic feed adjustment device of the machine to the work piece and the tool electrode discharge gap among the exact, when the tool is realistic amongst the electrode and the work, a solid pulse voltage (up to the gap in the media breakdown voltage) sets up, when the lowest breakdown strength of dielectric insulation, as shown. Since the area of discharge is small and the discharge time is also very short, so a high concentrated energy takes abode among the tool and work piece, so that the instantaneous heat of the ejection area may arise up to 10000-12000 ℃, and tools for surface partial melting of the brass probe surface, or even vaporized. Due to Partial loving and vanishing of metal beneath the outcome of the volatile thrown into the employed liquid, small particles of metal was cooling, and these element quickly lapped away by the incessant application of working fluid in the work area, so that the surface may form a small pit. This process is constant continuously to achieve the surface ablation, and copy the tool anode on the work piece figure, so as to achieve forming operation.

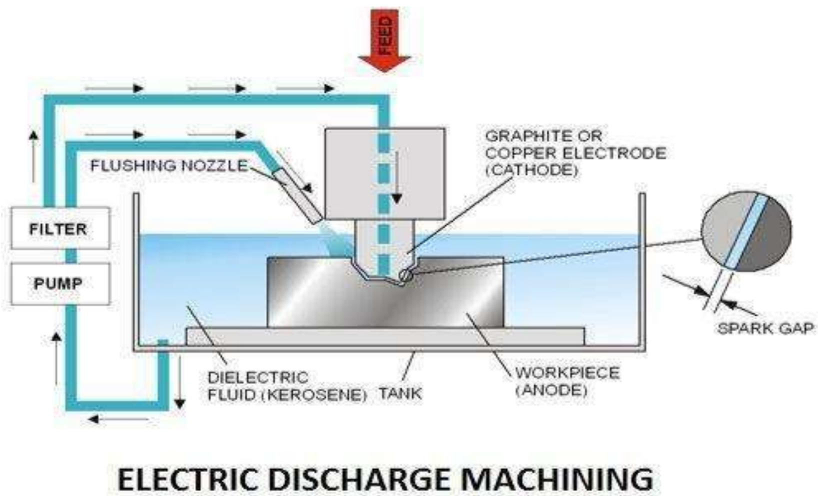

Figure 1.1: ELECTRO-DISCHARGE MACHINE SETUP

1.3 APPLICATIONS OF EDM

1.3.1 Prototype Production

The EDM course is most generally used by the mould-making device and perish trades, but is fetching a mutual method of making sample and production portions, expressly in the aerospace, automobile and electronics industries in which production quantities are relatively low.

1.3.2 Coinage Dies Making

For creation of dies, for producing jewelries and badges or blanking and piercing (through use of a pancake die) by the coinage (stamping) process.

1.3.3 Small Hole Drilling

Small hovels in EDM are recycled to drill rackets of holes into the principal and rambling edges of turbine edges used in jet device. Gas flow over these slight holes consents the machines to use developed diseases than else
Likely .The high illness, very hard, lone crystal alloys hired in these blades styles predictable machining of these shacks with great aspect quotient particularly difficult, if not impossible.

1.4 TAGUCHI METHOD

Taguchi has established a methodology for the presentation of designing tests, including a consultant's handbook. This procedure consists a design of experimentations from the exclusive world of calculator and brought it more fully into the world of manufacturing

His donations have also through, the physician work simpler by advocating the usage of fewer untried projects, and on condition that a unblemished thoughtful of the wide-ranging nature and the monetary significances of quality industrial in the world of engineering. Taguchi introduces his slant, using untried design for:

1 Designing and evolving products/methods so as to be robust to section variation;
2 Designing harvests/routes so as to be robust to ecological conditions;
3 Minimizing variation from place to place a objective value. This viewpoint of Taguchi is broadly pertinent. He anticipated that engineering optimization of a progression or artifact completed in a three step slant, i.e. system design, bound design and broadmindedness design. In system project the engineer applies logical, engineering familiarity to produce a basic handy prototype enterprise. In the product design period the assortment of the materials, segments, tentative product constriction values etc. are ornate. Since system design is an preliminary step, handy design may be far from optimum in terms of eminence and rate.

1.5 PROCEEDURES OF TAGUCHI METHOD

- To identify the objective meaning
- To hand-picked the factors to be estimated
- To identify the overwhelming factors and test disorders
- To select the levels of well-disciplined and uncontrollable factors
- To calculate the total degree of autonomy
- To select apposite orthogonal array
- Assignment of features to column
- Execution of research according to the trial environments in array
- To consider the result
- Approval results

1.6APPLICATION OF S/N RATIO

The change in the quality individualities of a product under examination, in response to a factor introduced in the untried design is the signal of the anticipated effect. However, when an experiment is conducted, there are numerous external factors not designed into the experiment which influence the outcome. These exterior factors are named the noise features and their effect on the product of the quality individual under test is termed as not under control.
The S/N ratio is deliberate to measure the quality appearances.

The Signal to Sound ratio (S/N ratio) expresses the throw around a object value. The larger the ratio, the smaller is the scatter. By knowing the S/N ratio of the samples before and after the experiment, Taguchi‟s loss function may be used to estimate the potential cost saving from the improved product

1.7 Role of ANOVA

Taguchi swaps the full factorial exploration with a lean, less select, quicker, partial factorial investigation. Since the partial investigate is only a sample of the full research, the analysis of the partial research must include an analysis of the assurance that can be placed in the grades. Opportunely, there is a basic standard arithmetic technique called Scrutiny of Variance (ANOVA) which is habitually used to afford a measure of self-confidence. The performance does not unswervingly scrutinize the data, but moderately govern the contradiction (variance) of the data. Self-assurance is measured from the alteration.

METHODOLOGY

2.1 TABLES FOR TAGUCHI DESIGN OF EXPERIMENT

Tables for Taguchi design of the experimentation are shown below:

Table 2.1: Process Parameters and their levels

S.No.	Parameters	Units	Level 1	Level 2	Level 3
1	Current	A	1	5	9
2	Pulse-on-time	Msec	10	15	20
3	Gap Voltage	V	100	125	150

Table 2.2: Experimentation L9 Orthogonal Array

S.No.	Current	Pulse on Time	Gap Voltage
1	1	10	100
2	1	15	125
3	1	20	150
4	5	10	125
5	5	15	150
6	5	20	100
7	9	10	150
8	9	15	100
9	9	20	125

2.2 EXPERIMENTATION SETUP

ELECTRONICA S-70 ZNC EDM machine was used for machining the samples. The machine is as shown in the figure below. EDM is a, non-traditional‟ or „non-conventional‟ collection of machining systems. Ideally, EDM can be as seen as a strings of interruption and renewal of the liquid dielectric in-between the conductors.

Table 2.3 Technical Specifications of EDM

Sr. No.	Specification	Value
1	Model	S-70 ZNC
2	Dielectric Fluid	EDM Oil
3	Input Power Supply	Three phase AC 415 V, 4 wire system, 50 Hz
4	Electrode used	Copper
5	H X W X D machine size	1750 X 1060 X 525 mm
6	Maximum Load Lift	750 kg
7	Pulse on time	0.5 to 4000
8	Pulse frequency	0.1 to 500
9	Main Table Traverse (X,Y)	1100 X 650 mm

Figure 2.1: EDM Machine

Figure 2.2: Machining the work piece on EDM

2.3 WORK PIECE MATERIAL

The solid cast-off for this grind is AISI 4147 description of 5 mm thickness and 10 mm diameter.

Table 2.4 Properties of AISI 4147

Density (g/cm³)	Melting point (°C)	Yield strength (MPa)	Elastic modulus (GPa)	Possion's Ratio	Brinell Hardness
7.85	1427	470	196	0.3	217

Table 2.5 Chemical composition of the work piece material (AISI 4147) by weight

Material	Fe	C	Si	S	P	Mn	Cr	Mo
% Composition	96. 73 – 97.70	0.45 – 0.50	0.15 – 0.30	<=0.040	<=0.035	0.75 – 1.0	0.80 – 1.1	0.15 – 0.30

2.4 TOOL MATERIAL

The tool material used for this work is 100% Copper (Cu). The tool was prepared of dimensions as 2 inches length and 3 mm diameter.

Figure 2.3: Copper Tools

Figure 2.4: AISI 4147 machined work pieces

2.5 Material Removal Rate

The rate of material removal from the work piece is known as material removal rate. The material elimination rate is planned by dividing the work piece mass loss (in grams) to the product of solidity of the work piece (gm/cc) and the machining stage.

Higher the material removal rate higher is the productivity. Hence it is most desirable to increase the material removal rate. The formula for material removal rate is as shown under.

$$\textbf{MRR} = \frac{\textbf{(Work piece weight loss (gm)) X 1000}}{\textbf{Density (gm/cc) X Machining Time}}$$

2.6 Tool Wear Rate

The rate of tool gear from the tool secondhand to engine the work piece is recognized as tool wear speed. The tool wear rate is premeditated by dividing the tool burden loss (in grams) to the product of concentration of the tool factual (gm/cc) and the machining time. It is supreme required to disappearance the tool wear volume. The process for tool wear rate is as displayed below.

$$\textbf{TWR} = \frac{\textbf{(Tool weight loss (gm)) X 1000}}{\textbf{Density (gm/cc) X Machining Time}}$$

2.7 Surface Roughness

TR-200 is a transportable surface unevenness tester advanced by Time Assembly. This is used to amount the surface coarseness of various harvests treated or not processed and parades the outcomes on the LCD display.

FIGURE 2.5: TR200 SURFACE ROUGHNESS TESTER WITH WORKPIECE

2.8 MACHINING PARAMETERS

The peak current (Ip), pulse on time (Ton) and voltage (V) are the key variables that distress the course mechanism in EDM.

2.8.1 Peak Current (Ip)

It is the peak current which is supplied by the power source. If the current increases, the energy supplied increases. Higher energy increases the temperature of work surface and thus the material removal rate will be higher.

The relations of peak current are as follows:

1.Lower the peak current lower is the MRR. This is because the low acquittal dynamism is twisted between salaried gap due to deficient heating of work quantity and low pulse extent.

2.At high pulse length MRR increases with upsurge in the peak existing.

3.A rough surface is shaped at high peak present and/or pulse-on time. The converse is likewise true. A finer shallow texture is fashioned at low value of peak existing and/or pulsation extent and vice versa. This is due to as pulse energy per release is can be uttered as charts:

$$\mathbf{E= u(t).i(t)dt}$$

Where, u(t) is the discharge extent, i(t) is the release current and E is the pulse energy per release. Later the release voltage u(t) stays continual during the discharge pulse extent and discharge current. Thus from above formula of discharge energy we can say at low value of discharge current and/or pulse duration discharge energy will be low and at high value.

2.82 Pulse on time (Ton)

It is the duration of time measured in micro seconds. As in EDM growth erosion incomes place in the form of mawkish and waning of both the tool and labor material at the same time passé, so with shorter pulse extent more material has to be melt and shorten. The resulting crater fashioned will be extensive as compared to the tinier pulse on time. But, in some untried research work it has been demonstrated that the optimum pulse length gives higher recital measures. It arrange that all MRR cannot be amplified by snowballing the pulse on time, a apposite amalgamation of peak current is also required for growing rate of eliminating undesirable material since the work piece. At relentless recent and rigid duty aspect, the MRR is moderated with growth in pulse on in unkindness of the fact. This is due to the cause because short rhythm causes less dying, where long pulse extent causes the plasma regularity to expand hastily

The relations of pulse on time are as follows:

1.Lower the pounding on time lower is the MRR. This is due to lacking heating of the material.
2.Tough the value of pulse on time vexing is the MRR achieved.
3.Surface lumpiness at low pulse on time and high peak recent is less than the external lumpiness at high pulse on time and low peak modern.

3. RESULTS

3.1 CALCULATION FOR MRR

The material elimination rate is the degree at which the substantial is uninvolved during machining. The bulk loss is considered by assessing the sample before and next machining. Machining time is celebrated while machining each example. The factual removal speed is calculated by subsequent method:

$$\textbf{MRR} = \frac{\textbf{(Work piece weight loss (gm)) X 1000}}{\textbf{Density (gm/cc) X Machining Time}}$$

3.1.1 Calculation of S/N ratio for MRR

The S/N ratio, which shortens the numerous data facts within a provisional, depends on the type of faces being appraised. For intention of S/N ratio for material elimination rate LARGER IS BETTER situation is opted. The calculation for the scheming of S/N ratio for material elimination rate is:

$$S/NLB = -10 \log (\Sigma (1/yi^2))$$

3.1.2 Calculation of Mean S/N ratio for MRR

Mean S/N ratio is calculated by using following formula

$$nf_i = (nf_1+nf_2+nf_3)/3$$

Where nf is mean S/N ratio for factor f at the level value i of the selected factor. nf_1, nf_2, nf_3 are S/N ratio for factor f at level u.

3.2 CONFIRMATION TEST

Confirmation tests have been performed for MRR, TWR and Hole Enlargement with their optimum levels of process variables.

Table 3.1: Confirmation of expected and actual values of MRR

Exp No.	Optimum Machining Parameters			MRR	
	Current (A)	Pulse on Time (μsec)	Voltage (V)	Actual	Expected
1	9	15	100	1.911	1.857
				Error (%)	2.82 %

Table 3.2: Confirmation of expected and actual values of TWR

Exp No.	Optimum Machining Parameters			TWR	
	Current (A)	Pulse on Time (µsec)	Voltage (V)	Actual	Expected
1	1	10	150	0.1638	0.1721
				Error (%)	5.06 %

Table 3.3: Confirmation of expected and actual values of Surface Roughness

Exp No.	Optimum Machining Parameters			Surface Roughness	
	Current (A)	Pulse on Time (µsec)	Voltage (V)	Actual	Expected
1	1	10	150	4.58	4.82
				Error (%)	5.24 %

4. CONCLUSION

This uncertain search for optimization of input machining parameters in Electrical Expulsion Machining of AISI 4147 using L9 orthogonal array of Taguchi method. Features like Modern, Pulse on Time and Voltage and their relations have been create. The product shows the recital of factors at different points to optimize the MRR, TWR and Outward Unevenness.

Following decisions are made thru the exploration:

- MRR initially rises at deliberate rate with modern but complex levels of up-to-date, MRR increases at a upper rate. Higher the present, amount of spark is improved and thus brass removal rate growths. Furthermore, current is the most weighty aspect for MRR.
- In situation of pulse on spell, the MRR rise with growth in its near but it has a short effort of 11.06%. The ejection energy is complex at higher stages of pulse on time hence we get higher material elimination rate. For lesser pulse on time, the release energy is insufficient thus the material elimination rate is low.
- MRR tends to reduction with rise in voltage. Voltage is the least impelling parameter for voltage and has a impact of only 8.96%.
- TWR growths with both peak recent and pulse on time. This is as of the bigger intensity of spark signal the tool. The smallest TWR is generated at 1 A and 10µsec.
- With voltage, reverse trend is observed and TWR get reduced with increase in its value. Voltage being the least influencing factor, has a lowest contribution of 8.42%.
- The surface roughness degrades as the current and pulse on time are increased. By growing the recent the exterior roughness growths as more strong sparks strike the external of the work portion.

Moreover, with voltage the external roughness drops and it is the least influencing stricture for shallow roughness.

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