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"Optimization Of Parameters For Wedm Machine For Productivity Improvement"

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Abstract: *Optimization of operating parameters is an important step in machining, particularly for operating unconventional machining procedure like Wirecut Electro Discharge Machining. Since wire-cut EDM has experienced explosive growth in application users demand and need maximum productivity and through-put, increased accuracy, and predictable performance. Also machines and job requirements vary greatly, which can make selection of the correct operation parameters a daunting task. As a result, experimentation is necessary if optimum results are to be achieved. Although this reference is not intended to be all-encompassing, it should be a useful guide for selection of parameters. A suitable selection of machining parameters for the process relies heavily on the operator's technologies and experience and they do not provide the optimal machining conditions. In every manufacturing process, material removal rate needs to be maximized while controlling quality by controlling electrode wear rate. In this work, an attempt has been made to optimize the machining parameters for minimum electrode wear rate and maximum material removal rate in WEDM process. Experiments were performed under different cutting conditions of Wire feed (WF), wire tension (WT), discharge current of the machine and discharge voltage (V). Experiments were executed as per Taguchi's L-9 orthogonal array. The output responses were optimized using signal-to-noise (S/N) ratio in addition to Desirability function approach to convert a multi objective optimization problem to a single objective optimization problem.*

Keywords: *Wire Electro Discharge Machining,WEDM, Electrode wear rate, Material removal Rate, Taguchi's orthogonal array, S/N Ratio,Desirablity Function Approch , Wire Feed*

Nomenclature	
Ip	Discharge Current
WF	Wire Feed
WT	Wire Tension
V	Discharge Voltage

I. Introduction

Case study highlights EDM of metal in which best optimal process environment has been determined to satisfy productivity requirements. Material Removal Rate (MRR) during the process has been considered as productivity estimate with the aim to maximize it. Whereas Electrode wears Rate (EWR) machining has been chosen with the requirement to minimize it. These two contradicting requirements can be simultaneously satisfied by selecting an optimal parameter setting. Desirability Function (DF) approach coupled with Taguchi method will be used to solve the problem.

1.1. Wire Electro Discharge Machine (WEDM)

Wire electrical discharge machining involves complex physical process including heating and cooling. The electrical discharge energy, affected by the spark plasma intensity and the discharging time, will determine the crater size, which in turn will influence the machining efficiency and surface quality. Hence, the operating parameters including pulse on time, pulse off time, table feed rate, flushing pressure, wire tension, and wire velocity etc. should be chosen properly so that a better performance can be obtained. However, the selection of appropriate machining parameters for WEDM is difficult and the operation has more roles to play.

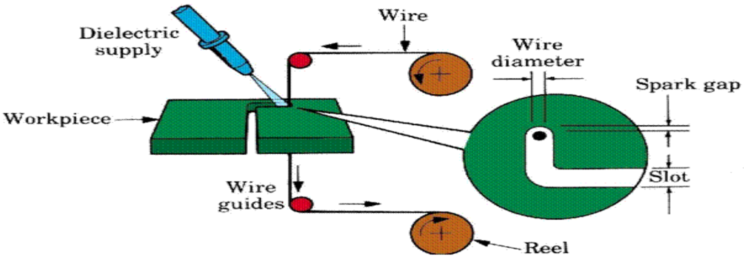

Fig. 1. Schematic of Wire EDM

II. Experimental Details

2.1. Specifications:-

The work piece material – Aluminum alloy A1050A
Machine - Electronica- EMS 5535-R50 ZNC series 2000 machine with NC control in Z- direction.
Tool electrode used – An electrolytic brass wire with a diameter of .25 mm used (positive polarity)
EDM dielectric fluid usd – Commercial grade Dielectric water (specific gravity 0.863 and freezing point 94

2.2. Design Of Experiment:-

It is also impossible to study all the factors and determine their main effects (i.e., the individual effects) in a single experiment. Taguchi technique overcomes all these drawbacks. The main effect is the average value of the response function at a particular level of a parameter. The effect of a factor level is the deviation it causes from the overall mean response. The Taguchi method is devised for process optimization and identification of optimal combinations of factors for given responses.

Wire feed (WF), wire tension (WT), discharge current of the machine and discharge voltage (V) have been treated as controllable process factors. Table 4.1 reveals domain of experiments. Design of Experiment (DOE) has been selected as per Taguchi's Orthogonal array (Table4.2), in which interactive effect of process parameters have been neglected. The experimental data has been furnished in table 1.

Table 1: Domain of Experiments

Factors	Notation(units)	Code	Levels of Factors		
			1	2	3
Discharge Current	Ip (A)	A	4	6	8
Wire Feed	WF (m/min)	B	4	5	6
Wire Tension	WT(N)	C	6	10	14
Discharge Voltage	V (Volt)	D	35	45	55

Table 2: Design of Experient (DOE)

Sr. No	Design of Experiment (L9 orthogonal array)			
	A	B	C	D
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

2.3 Experimental procedure

The material removal rate (MRR) of the work piece was measured by dividing the weight of work piece before and after machining (found by weighing machine) against the machining time that was achieved. The data from the experiment is collect and put into table 4.3 in order to analyze the material removal rate (MRR).

Similarly the Electrode Wear rate (EWR) of the work piece was measured by the difference of the weight of wire bundle before and after machining (found by weighing machine) against the machining time that was achieved. The data from the experiment is collect and put into table 4.4 in order to analyze the Electrode Wear rate (EWR).

Table 3: Experimental Data

Sr. No	Experimental Data	
	MRR(gm/min)	EWR(gm/min)
1	0.012	0.0111
2	0.013	0.0005
3	0.004	0.0020
4	0.003	0.0003
5	0.009	0.0001
6	0.015	0.0002
7	0.031	0.0032
8	0.004	0.0021
9	0.001	0.0002

III. Data Analysis using Desirability Function (DF) Approach & S/N Ratio

In this approach, individual responses are transformed to corresponding desirability values. Desirability value depends of acceptable tolerance range as well as target of the response. If the response reaches its target value, which is the most desired situation, its desirability is assigned as unity. If the value of the response falls beyond the prescribed tolerance rage, which is not desired, its desirability value is assumed as zero. Therefore, desirability value may vary with zero to unity. Experimental data (Table 3) i.e. MRR and EWR (for each experiment) can be converted to corresponding desirability values. For MRR Higher-the- Better (HB) and for EWR Lower-the-Better (LB) criteria have been chosen respectively. Corresponding S/N ratio of overall desirability has been computed using Higher the Better criteria.

Table 4. Calculation of Overall Desirability

Sr. No	Individual Desirability values of		Overall Desirability	Corresponding S/N Ratio
	MRR(HB)	EWR(LB)		
1	0.6333	1.0000	0.8167	-3.0121
2	0.6000	0.0364	0.3182	5.1753
3	0.9000	0.1727	0.5364	0.6396
4	0.9333	0.0182	0.4758	1.6811
5	0.7333	0.0000	0.3667	3.9434
6	0.5333	0.0091	0.2712	6.5626
7	0.0000	0.2818	0.1409	12.2500
8	0.9000	0.1818	0.5409	0.5663
9	1.0000	0.0091	0.5045	1.1708

IV. Analysis and Discussion

The mean S/N ratio for each level of the machining parameters is summarized and called the mean S/N response table. In addition, the total mean S/N ratio for the nine experiments is also calculated and listed in Table 5. The S/N ratio corresponds to the smaller variance of the output characteristics around the desired value.

Table 5: Response Table for S/N Ratios

Level of Factors	**Factors** Discharge Current	Wire Feed	Wire Tension	Discharge Voltage
1	0.9343	3.6397	1.3723	0.7007
2	4.0623	3.2283	2.6757	7.9960
3	4.6624	2.7910	5.6110	0.9623
Delta (Max-Min)	3.7281	0.8487	4.2387	7.2953
Rank	3	4	2	1

Mean response table for S/N Ratio of overall desirability has been shown in above Table, which indicates that discharge Voltage, discharge current and wire tension are most important factors influencing overall desirability. Next important process factor seems to be the wire Feed which influences lesser then other factors.

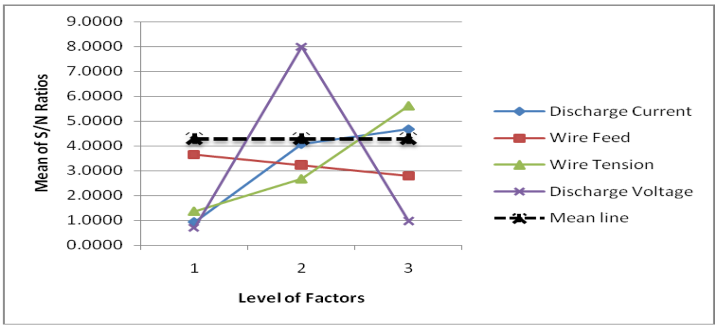

Figure 2. S/N Ratio Curve

Optimal setting has been evaluated by choosing highest mean S/N ratio value for each process parameters which is shown in table no 5.5.

Table 6: Selection of optimal Parameters

Level of Factors	Factors			
	Discharge Current[A]	Wire Feed[B]	Wire Tension[C]	Discharge Voltage[D]
1	0.9343	3.6397	1.3723	0.7007
2	4.0623	3.2283	2.6757	7.9960
3	4.6624	2.7910	5.6110	0.9623
Delta	3.7281	0.8487	4.2387	7.2953
Rank	3	4	2	1

Here in above table as one can see that predicted optimal combination becomes: A3, B1, C3, D2. Which as below,

Table 7: Result of optimal Parameters

Physical requirement Max.MRR, Min. EWR	Optimal Combination Found			
	I_p (A)	WF (m/min)	WT (N)	V (Volt)
	4	6	6	35

In order to validate the results obtained, the confirmation experiments were conducted at above indicated optimum machining parameters. The confirmation experiment was conducted for Material removal rate and results obtained having 0.041 gm/min MRR which is more than values of MRR in table 3.

V. Conclusion

The present work investigated and optimized the machining parameter, i.e., Discharge Current, Discharge voltage, Wire tension and Wire feed for MRR and EWR of WEDM of Aluminium. The optimization of process parameters with the aim of higher MRR and lower EWR for improvement of productivity is determined by using S/N ratio and Desirability Function Approach. The important conclusion summarized below:

- The optimum parameter can be considered for which maximum material removal rate and minimum electrode wear obtained are as following,

Physical requirement Max.MRR, Min. EWR	Optimal Combination Found			
	I_p (A)	WF (m/min)	WT (N)	V (Volt)
	4	6	6	35

- Operation parameters Discharge Current, Discharge Voltage and Wire tension have major influence on Max MRR & Min EWR ie on productivity.
- The use of Taguchi's Orthogonal Array design of experiment provides limited number of well balanced experimental runs resulting saving in experimental cost as well as experimentation time.
- Desirability function approach has been found efficient to convert a multi objective optimization

problem to a single objective optimization problem.

- The proposed approach can be utilized for quality improvement and off-line quality control.
- The methodology can be helpful for automation of the WEDM process.

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