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OPTIMIZTION OF EDM PROCESS PARAMETERS ON C70600 AND C71500 BY USING TOPSIS METHOD

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Abstract: ***In present days of competitive environment all the companies across the world are trying to reach the market demand and increase the profits with out increasing the cost of the product.It can be achieved by reducing the losses with of high productivity and good surface finish.So it can be done by optimizing the process.Machining of hard metals,complex shapes with of traditional manufacturing is difficult.It is replaced by unconventional machining process.EDM is one of the unconventional machining processes used to machining hard metals,complex shapes with of metal erosion technique by using all electro conductive materials.***

In EDM machine cutting paramets selection plays a crucial role to optimizing the process.Output parameters are affected by cutting parameters, considered in these experiment are discharge current, pulse on time, duty cycle. Output parameters are considered as material removal rate and surface roughness woring on C70600, C71500 workpiece materials by using brass, copper, tungsten carbide tools. Taguchi L27 orthogonal array is used to designing the experiments.

TOPSIS(technique for order of preference by similarity to ideal solution) method and GRA(gray relation analysis) optimization technique will be used to optimizing the process.It is used to choose the best level of the design variables.Consequently,it reduces the differentiation in product and process to the least.Finally the best tool-work-piece combination is obtained.This obtained results provides useful information to control the process responses and ensure higher productivity.Accuracy and enhanced surface quality.

I. INTRODUCTION

EDM is also called as spark machining, spark eroding machining. EDM established for alloys of more strength thermal resistant and complicated-to-machine materials .EDM machining used for any material that should be an electrical conductor. Metal removal takes place with the help of sparks generated by EDM having temperature of 8000ºC to 12000 ºC. EDM for eliminating unwanted material in the form of fragments and fabricate shape of tool-surface as metal portion i.e., frequent electrical sparks of tool and work piece product in the presence of dielectric-liquid. In EDM, work piece as anode connected with +ve terminal & electrode as cathode connected with -ve terminal. Dielectric fluids that are used kerosene, distilled water, transformer oil, etc.

EDM is often included in the ‘non-traditional’ or ‘non-conventional’ group of machining methods together with processes such as electrochemical machining(ECM), water jet cutting (WJ, AWJ), laser beam machining and opposite to the 'conventional' group like turning, milling, grinding, drilling and any other process whose material removal mechanism is essentially based on mechanical forces. The layout of EDM

II .LITERATURE REVIEW

KuwarMausam et al. (2015) investigated the effect of four values of inputs namely peak current, gap voltage, pulse-on-time and duty cycle in EDM for machining on carbon fiber based two phase epoxy composites. Here GA is run for 15 generations using MATLAB 2010[1].Asuthosh Kumar Pandey et al. (2014) optimized the tool wear ratein micro electric discharge machining taking into account material AISI 304 stain less steel, pulse on time, peak current and flushing pressure were selected as input parameters. Using RSM Mathematical models is developed to correlate the response and the parameters[2]. R.Rajesh et al. (2012) performed the machining on Al alloy with grade HE9 in EDM with electrolytic copper as tool. In these outputs namely MRR and SR are optimized effected by process parameters are working current, working voltage, oil pressure, spark gap Pulse on Time and Pulse off Time. Multiple regression analysis and Genetic algorithm optimization technique is used to optimize the out parameters[3]. Shashikant et al. (2014) Optimized the surface roughness (SR) in die sinking machine taking into account EN19 material, pulse on time, pulse off time, current and voltage as input parameters. Experiments are conducted as per L31 orthogonal array based on RSM optimization technique**.** It is observed in these is current and pulse on time are more influencing surface roughness[4].Lakshmannp et al. (2016) optimized the surface roughness (SR) in electric discharge machine considering aset of input parameters such as current, pulse ON time and voltage[5].

Periyakgounder Suresh et al. (2014) determined the best cutting parameters to achieve maximize material removal rate and minimize the tool wear rate for SS 316L metal machined with brass as tool. L9 orthogonal array was used to design the input parameters like, Current, pulse on time and pulse off time[6].

III. EXPERIMENTATION AND OBSERVATION

Two different types of work pieces used to do this experiment(C70600,C71500).Three different types of material(copper,brass,tungsten carbide)for the used to machining the process. Chemical composition of the work pieces are as fallows. Below the tables: shown the chemical composition of C70600 and C71500.

Table1:Chemical composition of C70600

Element	Cu	Fe	Ni
Content%	88.7	13	10

Table 2:Chemical composition of C71500

Element	C	Ni
Content%	70.0	30.0

IV.EXPERIMENTAL SETUP

ELECTRONICA SE-35 type EDM machine was used to conduct the experiments shown in fig:1 and table 3 represents specification of the machine.

Fig 1:Electronica SE-35 EDM machine

To complete the machining experiment three levels of input parametes are consider and shown in below table:

Table3:Working conditions

Symbol	Factors	Level -1	Level -2	Level -3
X1	Current	6	8	10
X2	T_{On}	100	150	200
X3	T	10	11	12
X4	Tool material	Copper	Brass	Tungsten carbide

Table4:L27 OA table of experiments

S.NO	Current	Pulse on time	Duty cycle	Tool Material
1	6	100	10	Copper
2	6	100	10	Brass
3	6	100	10	Tungsten carbide
4	6	150	11	Brass
5	6	150	11	Tungsten carbide
6	6	150	11	Copper
7	6	200	12	Tungsten carbide
8	6	200	12	Copper
9	6	200	12	Brass
10	8	100	11	Copper
11	8	100	11	Brass
12	8	100	11	Tungsten carbide
13	8	150	12	Brass
14	8	150	12	Tungsten carbide
15	8	150	12	Copper
16	8	200	10	Tungsten carbide
17	8	200	10	Copper
18	8	200	10	Brass
19	10	100	12	Copper
20	10	100	12	Brass
21	10	100	12	Tungsten carbide
22	10	150	10	Brass
23	10	150	10	Tungsten carbide
24	10	150	10	Copper
25	10	200	11	Tungsten carbide
26	10	200	11	Copper
27	10	200	11	Brass

Calculation of MRR and SR

The ratio of weight loss of work piece without and with machining to machining time is MRR.

$$MRR = \left(\frac{W_i - W_f}{t}\right) gm/min$$

Where W_i = initial weight before machining of the work material

W_f = final weight after machining of the work material

t = machining time

Surface roughness is a quality of the machining surface related to the geometric irregularities of the surface R_a arthritic average height of surface above and below the center line it is measured by using Mitutoyo SJ-201 Talysurf shown in below fig:2.

Fig2:Mitutoyo Talysurf Equipment

TOPSIS:-

Method is used to determine the optimum parameter combination by analyzing the experimental data. TOPSIS method consists of following steps:

Step 1: The first step is to formulate decision matrix with "m" alternative and "n" attributes, the decision matrix calculated by using equation (1).

$$rij = \frac{xij}{\sqrt{\sum xij2=1}} \quad ——(1)$$

Step 2: Take weight ages for each response, after normalization of experimental data, the weighted normalized decision matrix is obtained by using equation (2) **.**

$$Vij = Wi \times rij ——(2)$$

Step 3:Now positive ideal solutions (best)and negative ideal solutions(worst)are needed to be calculated in this step. The solutions can be represented as:

Positive ideal (best) solution

$$a^{+} = \{(\max Vij,\ j \in J),\ (\min Vij,\ j \in J,,)\}$$
$$= \{V1+, V2+, V3+\ldots\ldots Vj+\ \ldots.Vn+\}\ \text{-----------}\ (3)$$

Negative ideal (worst) sol

$$a^{-} = \{(\min Vij,\ j \in J),\ (\max Vij,\ j \in J'')\}$$
$$= \{V1-, V2-, V3-\ldots\ldots Vj-\ \ldots.Vn-\}\ \text{----------}\ (4)$$

Step 5: Now we need to calculate Euclidean distance of each alternative from Positive ideal and Negative ideal solution by using the equation 5 and 6. These Positive and Negative separation ideal solution from table.

$$Si+ = \sqrt{\sum}(Vij-Vj+)^{\wedge}2 ——(5)$$
$$Si- = (Vij-Vj-)^{\wedge}2=1 ——(6)$$

Step 6:Now Calculation the relative closeness to the ideal solution for each alternative by using the equation given below.

$$Ci^{+} = \frac{Si^{-}}{Si^{+} + Si^{-}} \quad ——(7)$$

V.RESULTS

a. Experiments on C70600 MATERIAL

The experiments are conducted work piece cupronickel 70600 AND C71500 based on Taguchi L27 OA. The impact on the work piece by EDM is to see in fig.3 and its MRR and SR values in table.5

Table.5:Experimenttion results of C70600

S.NO	current	Pulse on time	Duty cycle	material	MRR	Surface roughness
1	6	100	10	copper	0.1307	2.0566
2	6	100	10	Brass	0.0638	1.7466
3	6	100	10	Tungsten carbide	0.0957	2.5366
4	6	150	11	Brass	0.0424	1.5733
5	6	150	11	Tungsten carbide	0.1861	2.1633
6	6	150	11	copper	0.1240	1.5566
7	**6**	**200**	**12**	**Tungsten carbide**	**0.1185**	**3.1966**
8	6	200	12	copper	0.1307	1.8333
9	6	200	12	Brass	0.0618	1.8166
10	8	100	11	copper	0.1183	1.9766
11	8	100	11	brass	0.0564	1.7766
12	8	100	11	Tungsten carbide	0.1471	1.7666
13	8	150	12	brass	0.0894	1.6211
14	8	150	12	Tungsten carbide	0.1279	2.2533
15	8	150	12	copper	0.1461	1.9066
16	8	200	10	Tungsten carbide	0.1398	2.4666
17	8	200	10	copper	0.1371	5.2533
18	8	200	10	brass	0.1246	1.6533
19	10	100	12	copper	0.1997	1.3533
20	10	100	12	brass	0.1939	2.1033
21	10	100	12	Tungsten carbide	0.1174	2.1833
22	10	150	10	brass	0.1023	2.3666
23	10	150	10	Tungsten carbide	0.1089	2.0733
24	10	150	10	copper	0.1585	2.2466

25	10	200	11	Tungsten carbide	0.1273	1.8733
26	10	200	11	copper	0.1491	1.5066
27	10	200	11	brass	0.1140	1.3233

Table.6:Normalized, weighted normalized decision matrix and Distance measures of alternatives from ideal solutions for C70600 material

S.NO	NOR-MRR	NOR-SR	W-MRR	W-SR	S+	S-	C+	RANK
1	0.0326	0.0491	0.01632	0.0245	0.0028	0.0091	0.7660	8
2	0.0200	0.0335	0.0100	0.0167	0.0635	0.0584	0.4793	16
3	0.0312	0.0430	0.0156	0.0215	0.0738	0.0054	0.0684	24
4	0.0244	0.0217	0.0122	0.0108	0.0598	0.0749	0.5557	9
5	0.0210	0.0590	0.0105	0.0295	0.0692	0.0717	0.5089	10
6	0.0293	0.0438	0.0146	0.0219	0.0733	0.0683	0.4821	12
7	**0.0401**	**0.0411**	**0.0200**	**0.0205**	**0.0025**	**0.0723**	**0.9659**	**1**
8	0.0336	0.0439	0.0168	0.0219	0.0007	0.0071	0.9066	5
9	0.0279	0.0177	0.0139	0.0088	0.0596	0.0545	0.4778	18
10	0.0413	0.0433	0.0206	0.0216	0.0042	0.0740	0.9457	3
11	0.0277	0.0379	0.0138	0.0189	0.0695	0.0018	0.0162	26
12	0.0748	0.0756	0.0374	0.0378	0.0371	0.0234	0.3870	22
13	0.0233	0.0388	0.0116	0.0194	0.0678	0.0627	0.4806	14
14	0.0368	0.0081	0.0184	0.0040	0.0592	0.0542	0.4777	19
15	0.0272	0.0013	0.0138	0.0006	0.0512	0.0462	0.4740	21
16	0.0289	0.0068	0.0144	0.0034	0.0546	0.0497	0.4757	20
17	0.0326	0.0176	0.0163	0.0088	0.0618	0.0294	0.3224	23
18	0.0462	0.0192	0.0231	0.0096	0.0695	0.0644	0.4811	13
19	0.0639	0.0303	0.0319	0.0151	0.0090	0.0788	0.8969	6
20	0.0390	0.0135	0.0195	0.0067	0.0630	0.0579	0.4791	17
21	0.0464	0.0368	0.0232	0.0184	0.0035	0.0733	0.9539	2
22	0.0240	0.0307	0.0120	0.0153	0.0641	0.0590	0.4795	15
23	0.0337	0.0834	0.0168	0.0417	0.0205	0.0068	0.4994	11
24	0.0503	0.0533	0.0251	0.0266	0.0138	0.0001	0.0080	27
25	0.0526	0.0516	0.0263	0.0258	0.0140	0.0003	0.0287	25
26	0.0469	0.0517	0.0234	0.0258	0.0112	0.0810	0.8779	7
27	0.0425	0.0460	0.0212	0.0230	0.0062	0.0759	0.9243	4

b. Experiment on C71500 material

The experiments are conducted workpiece cupronickle 71500 based on Taguchi L27 OA.The impact on the work piece by EDM is to see in fig.4 and its MRRand SR values in table.7

Fig.4:C71500 work piece after machining

Experimentation result of C71500 is shown in below table.7

Table.7:Experimenttion results of C71500

S.NO	current	Pulse on time	Duty cycle	material	MRR	SR
1	6	100	10	copper	0.1153	1.72
2	6	100	10	brass	0.0709	1.173
3	6	100	10	Tungsten carbide	0.1103	1.506
4	6	150	11	brass	0.0865	0.763
5	6	150	11	Tungsten carbide	0.0744	2.066
6	6	150	11	copper	0.1036	1.536
7	**6**	**200**	**12**	**Tungsten carbide**	**0.1417**	**1.44**
8	6	200	12	copper	0.1188	1.54
9	6	200	12	brass	0.0988	0.623
10	8	100	11	copper	0.1460	1.516
11	8	100	11	brass	0.0978	1.33
12	8	100	11	Tungsten carbide	0.2643	2.65
13	8	150	12	brass	0.0825	1.36
14	8	150	12	Tungsten carbide	0.1303	0.286
15	8	150	12	copper	0.0979	0.046
16	8	200	10	Tungsten carbide	0.1022	0.24
17	8	200	10	copper	0.1152	0.616
18	8	200	10	brass	0.1635	0.673
19	10	100	12	copper	0.2257	1.063
20	10	100	12	brass	0.1378	0.473
21	10	100	12	Tungsten carbide	0.1639	1.29
22	10	150	10	brass	0.0849	1.076
23	10	150	10	Tungsten carbide	0.1192	2.923
24	10	150	10	Copper	0.1779	1.87
25	10	200	11	Tungsten carbide	0.1859	1.81
26	10	200	11	Copper	0.1657	1.813
27	10	200	11	Brass	0.1502	1.613

Table.8:Normalized,weighted normalized decision matrix and Distance measures of alternatives from ideal solutions for C71500 material.

s.no	Normalised MRR	Normalised SR	Weighted MRR	Weighted SR	S+	S-	C+	RANK
1	0.0326	0.0491	0.0163	0.0245	0.0028	0.0091	0.7660	8
2	0.0200	0.0335	0.0100	0.0167	0.0635	0.0584	0.4793	16
3	0.0312	0.0430	0.0156	0.0215	0.0738	0.0054	0.0684	24
4	0.0244	0.0217	0.0124	0.0108	0.0598	0.0749	0.5557	9
5	0.0210	0.0590	0.0105	0.0295	0.0692	0.0717	0.5089	10
6	0.0293	0.0438	0.0146	0.0219	0.0733	0.0683	0.4821	12
7	**0.0401**	**0.0411**	**0.0200**	**0.0205**	**0.0025**	**0.0723**	**0.9659**	**1**
8	0.0336	0.0439	0.0168	0.0219	0.0007	0.0071	0.9066	5
9	0.0279	0.0177	0.0139	0.0088	0.0596	0.0545	0.4778	18
10	0.0413	0.0433	0.0206	0.0216	0.0042	0.0740	0.9457	3
11	0.0277	0.0379	0.0138	0.0189	0.0695	0.0011	0.0162	26
12	0.0748	0.0756	0.0374	0.0378	0.0371	0.0234	0.3870	22
13	0.0233	0.0388	0.0118	0.0194	0.0678	0.0627	0.4806	14
14	0.0368	0.0081	0.0184	0.0040	0.0592	0.0542	0.4777	19
15	0.0277	0.0013	0.0138	0.0006	0.0512	0.0462	0.4740	21
16	0.0289	0.0068	0.0144	0.0034	0.0546	0.0495	0.4757	20
17	0.0326	0.0176	0.0163	0.0088	0.0618	0.0294	0.3224	23
18	0.0462	0.0192	0.0231	0.0096	0.0695	0.0644	0.4811	13
19	0.0639	0.0303	0.0319	0.0154	0.0090	0.0788	0.896	6
20	0.0390	0.0135	0.0195	0.0067	0.0630	0.0579	0.4791	17
21	0.0464	0.0368	0.0232	0.0184	0.0035	0.0733	0.9539	2

22	0.0240	0.0307	0.0120	0.0153	0.0641	0.0590	0.4789	15
23	0.0337	0.0834	0.0168	0.0417	0.0205	0.0068	0.4994	11
24	0.0503	0.0533	0.0251	0.0266	0.0138	0.0001	0.0080	27
25	0.0526	0.0516	0.0263	0.0258	0.0140	0.0003	0.0287	25
26	0.0469	0.0517	0.0245	0.0258	0.0112	0.0810	0.8779	7
27	0.0429	0.0460	0.0285	0.0230	0.0062	0.0759	0.9243	4

Table 9:ANOVA table for MRR for the C70600 machining on EDM

Source	Degrees of freedom	Sum of squares	Mean squares	F-value	P-value	% of contribution
Regression	3	0.006475	0.002158	1.51	0.239	
Current	1	0.005598	0.005598	3.91	0.060	86.45
Pulse on time	1	0.000022	0.000022	0.02	0.902	0.33
Duty cycle	1	0.000855	0.000855	0.60	0.448	13.20
Error	23	0.032956	0.001433			
Total	26	0.039431				

Regression Equation
MRR = -0.020 + 0.00882 current - 0.000022 pulse on time + 0.00689 duty cycle

Table 10:ANOVA table for SR for the C70600 machining on EDM

Source	Degrees of freedom	Sum of squares	Mean squares	F-value	P-value	% of contribution
Regression	3	0.034322	0.011441	0.74	0.540	
Current	1	0.007753	0.007753	0.50	0.487	22.5890
Pulse on time	1	0.002169	0.002169	0.14	0.712	6.3195
Duty cycle	1	0.024399	0.024399	1.57	0.222	71.0885
Error	23	0.356537	0.015502			
Total	26	0.390859				

Regression Equation
Surface Roughness= -0.063 - 0.0104 current + 0.000220 pulse on time- 0.0368 duty cycle

Table 11:ANOVA table for MRR for the C71500 machining on EDM

Source	Degrees of freedom	Sum of squares	Mean squares	F -value	P -value	% of contribution
Regression	3	1.68529	0.56176	3.33	0.037	
Current	1	1.55964	1.55964	9.25	0.006	92.54
Pulse on time	1	0.00053	0.00053	0.00	0.956	0.031
Duty cycle	1	0.12512	0.12512	0.74	0.398	7.42
Error	23	3.87909	0.16866			
Total	26	5.56438				

Regression Equation
MRR = -4.99 + 0.1472 current + 0.00011 pulse on time + 0.0834 duty cycle

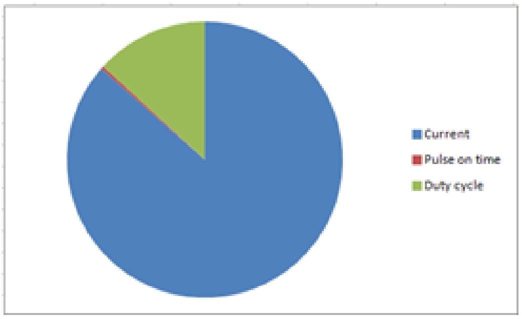
Table 12:ANOVA table for SR for the C71500 machining on EDM

Source	Degrees of freedom	Sum of squares	Mean squares	F - value	P - value	% of contribution
Regression	3	1.1944	0.3981	0.81	0.502	
Current	1	0.1358	0.1358	0.28	0.605	11.36
Pulse on time	1	0.3077	0.3077	0.62	0.437	25.76
Duty cycle	1	0.7510	0.7510	1.52	0.229	62.87
Error	23	11.3336	0.4928			
Total	26	12.5280				

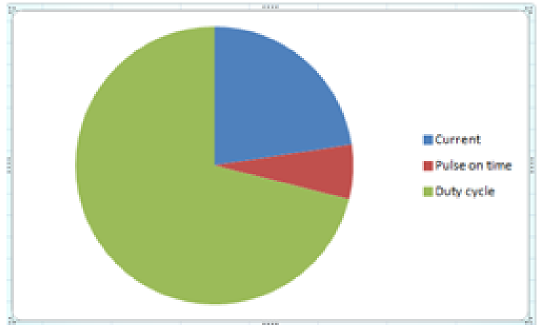
Regression Equation
SUR = 3.59 + 0.0434 current - 0.00261 pulse on time - 0.204 duty cycle

ANOVA Analysis for MRR and SR Graphs

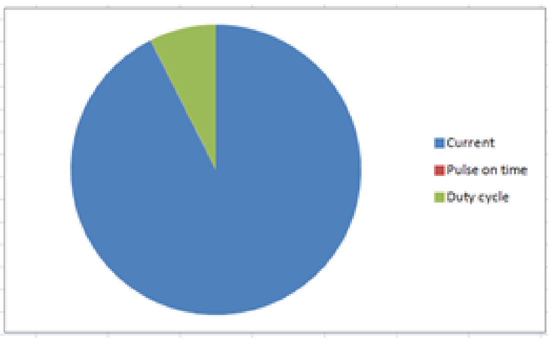
C70600 MRR



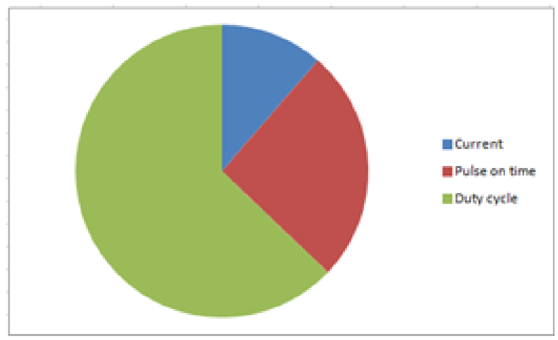
C70600 SR



C71500 MRR



C71500 SR



VI.RESULTS & CONCLUSION

Finally the investigational work is done in EDM. Based on the L27 Orthogonal array. $_{Ton}$, Duty cycle, Tool material and Current are taken as input parameters. The effects of process EDM process are optimized and obtained maximum material removal rate (MRR)and best Surface roughness ($R_{a)}$by using TOPSIS technique.

1)For both materials C70600 and C71500 are optimized at current 6,duty cycle 12,pulse on time 200 the tool material of Tungsten carbide and the ideal solution is 0.9659.

2) a.By using of ANOVA ANALYSIS from table9 i observed MRR is mostly influenced by the current for C70600 material.
b.From table10 i observed SR is mostly influenced by the duty cycle for C70600 material.
c.From table11 i observed MRR is mostly influenced by the current for C71500 material.
d.From table12 i observed SR is mostly influenced by the duty cycle for C71500 material.

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