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Optimization of Process Parameters And Dielectric Fluids on Machining En 31 By Using Topsis

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ABSTRACT
The electric discharge machining is the one of the most desirable machining process for the materials which are having high hardness and good thermal conductivity. The EDM process surpassed through the technological barriers by overcoming limitations like processing speed, material conductivity, dimensional accuracy, and surface finish and so on. However, environmental impact due to release of toxic emissions aerosols during the process, poor operational safety due to fire hazard, electromagnetic radiation and non-bio degradable waste are the major problems concerned with conventional dielectric fluids (i.e. kerosene, hydro carbon, etc.,). To reduce the problems with conventional die electric fluids waste palm oil blended with kerosene is used. The process is mostly used in situations where intricate, complex shapes need to be machined in very hard materials. The objective of this work is to study the influence of four design factors current (I), voltage (V), pulse on(P on), and pulse off(P off) which are the most relevant parameters to be controlled by the EDM process over machining characteristics such as material removal rate (MRR) characteristics of surface integrity such as average surface roughness (Ra). Multi Objective optimization of process parameters is done by using TOPSIS.
***Keywords*:** Electric discharge Machining (EDM), Material Removal Rate (MRR), Surface roughness (Ra), Technique for order of preference by similarity to ideal solution TOPSIS.

I. INTRODUCTION

Electric discharge machining (EDM) process has gone through considerable changes in terms of technology and application. Technological changes were came into existence to meet modern society needs by easy manufacturing system with competitive environment to meet customer requirement with cheap cost and maintaining quality standards. As the technology goes on increasing impact on the environment also increasing [1]. The major changes or improvements were done at the areas of die electric fluid and process parameter optimization. EDM processes have gone through considerable changes in terms of types of dielectric fluids used and modes of dielectric supply. Hydrocarbon oils,

Water-based solutions, synthetic and mineral oil, and gaseous dielectric fluids have been experimented with wet, powder mixed, dry and near-dry modes of dielectric supply. EDM process has expanded its stems into the manufacture of simple to the most complex geometrical profiles, meso- to micro-manufacturing, processing of low to high melting temperature materials, processing of soft to the hardest materials and generating rough to mirror finished surface accuracies.

Lazarenko had the idea of exploiting the destructive effect of electrical discharge and developed a controlled process for machining materials that are conductors of electricity. This was in 1943; erosion by electrical discharges was born.

Researchers [2] observed from the experimental results that the graphite powder and surfactant added dielectric fluid significantly improved the MRR, reduces the surface roughness (SR), tool wear rate (TWR) and recast layer thickness (RLT) at various conditions. Presence of [3] metal partials in dielectric fluid diverts its properties, which reduces the insulating strength of the dielectric fluid and increases the spark gap between the tool and work piece. As a result, the process becomes more stable and metal removal rate (MRR) and surface finish increases. The EDM process is mainly used for making dies, moulds, parts of aerospace, automotive industry and surgical components etc. This paper reviews the research trends in EDM process by using water and powder mixed dielectric as dielectric fluid. The results showed that [4] using tap water as dielectric fluid for machining can obtain high MRR, decrease the machining cost and have no harmful to the operators and the environment. The next area of improvement is process parameters optimization. Material Removal Rate (MRR), Tool Wear Rate (TWR), Electrode
Wear Ratio (EWR) and Surface Roughness (SR) have been investigated using chromium powder mixed to the dielectric. [5] Analysis of variance (ANOVA) and F-test were performed to determine the significant parameters at a 95% confidence interval. Predicted results have been verified by confirmatory tests which show an improvement in

the preference values using TOPSIS and GRA respectively.

[6]The parameters were optimized using multi-objective optimization technique of desirability approach and the significance of each parameter was analyzed by Analysis Of Variance (ANOVA). In addition, Fuzzy Logic Model (FLM) was used to better understand the input and output responses. With the desirability approach, it was sought to optimize the values for copper electrode for maximum MRR and minimum TWR and SR. Overall, the rectangular tool geometry emerged successful. A comparison of the performances of the electrode by desirability approach and ANOVA showed that the current was the most influencing factor, followed by pulse on time and pulse off time. It was also observed that the rectangular tool geometry provided better results as compared to other tool geometries. Validation tests for FLM were carried out and show closer relationship with the experimental results. [7] To find out the combination of process parameters for optimum surface roughness and material removal rate (MRR) in electro discharge machining (EDM) of EN31 tool steel using artificial bee colony (ABC) algorithm. The process parameters were varied based on central composite design (CCD). Second order response equations for MRR and surface roughness are found out using response surface methodology (RSM). For optimization, both single and multi-objective responses (MRR and surface roughness: Ra) are considered. From ABC analysis, the optimum combinations of process parameters are obtained and corresponding values of maximum MRR and minimum Ra are found out. In the present paper we were replaced the conventional die electric fluid with waste palm oil blended with kerosene and Experiments were carried out based on Taguchi L9 orthogonal array and grey relational analysis, and then verified the results through a confirmation experiment.

1.1 WASTE PALM OIL BLENDED WITH KEROSENE AS DIELECTRIC FLUID

Waste palm oil blended with kerosene was alternate die electric fluid in EDM. The waste palm oil pocess some important properties to provide sustainable and economical machining. It was Eco-friendly, since it provides very less emissions than the kerosene. The potential properties of waste palm oil blended with kerosene to be as a die electric fluid as given in below.

[1] Higher flash point, excellent biodegradability, higher oxygen content, Low carbon atom chain, nontoxic, higher breakdown voltage, higher viscosity, Lower toxic emissions & lower volatility and toxic emissions.

Many researches said that waste vegetable oils as dielectric fluid in EDM had significant performance by improving sustainability and material removal rate (M.R.R).

Waste palm oil was blended with kerosene and sodium dicolus sulphate was used as the surfactant. Ultra solidification and agitation was done for proper blending of waste palm oil with kerosene. The agiator and ultrasonicator were shown in fig.1.1

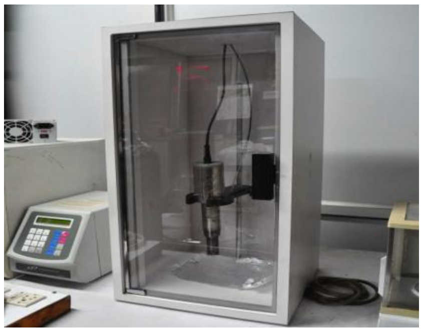

Fig.1.1 Agitator and Ultrasonicator

Table 1.1 properties of waste palm oil blended with kerosene and kerosene based dielectric fluids.

Property	Waste palm oil blended with	Kerosene
Density (gm/ml)	0.845	0.80
Viscosity at (40 °C)	6.56	2.71
Thermal conductivity	0.168	0.15
Specific heat (J/kg·K)	1.9	2.01
Flash point (°C)	130	81
BD voltage (kV/2.5 mm)	22	18
Dielectric Constant	3.4	4.7

Some values of the dielectric are taken from literature.

II. EXPERIMENTATION

2.1 SELECTION OF WORK PIECE

For the present work copper as electrode having excellent electrical and thermal conductivity. The properties of the electrode are given in table 2.1. The work piece material is die steel EN 31 with the dimension of 120×100×10 mm which is utilized for manufacturing of various products in our day to day life. The chemical composition of the work piece as shown in the below table2.2

Table 2.1. Properties of the Electrode material used.

Composition	Density (gm/cm^3)	Melting point	Thermal resistivity	Hardness
99.9% copper	8.904	1083^o C	9µΩcm	HB 100

Table 2.2 chemical composition of die steel (EN31)

Composition	**C**	**Mn**	**Si**	**S**	**P**	**Cr**
Percentage	**1.07**	**0.57**	**0.32**	**0.04**	**0.04**	**1-1.6**

Mechanical properties are
Modulus of Elasticity 197.37 GPa
Yielding Strength 528.97 MPa
Ultimate Tensile Strength 615.4 MPa

In this study, the Die Sinking EDM machine is used and the experimental setup is shown in Fig. 1. A copper rod with the diameter of 16 mm and the height of 70 mm was used as electrode in this study. In addition, waste palm oil blended with kerosene was employed as a dielectric fluid in this investigation. Experimental levels of the machining parameters are shown in table 2.3

Table 2.3.Experimental levels of the machining Parameters

Parameter	Level 1	Level 2	Level 3
Spark current	4	12	20
Gap voltage	30	50	70
Pulse on	125	175	225
Pulse off	100	150	200

2.2 Design of Experiments:
Taguchi's Technique was implemented to find the impact of
Process variables on the EDM performance. For the conduction of experiments L9 taguchi orthogonal array was used to complete the runs. The important input parameters selected are peak current 'Ip' (Amp), Pulse on time 'Pon'(µs), Pulse off time 'P_{off}' and Gap voltage 'Vg'(V) varying at three levels based on certain pilot experiments performed for selection of process parameters. The influence of input parameters on response variables like MRR and Ra was given in the table 2.4 for palm oil blended with kerosene and table 2.5 give kerosene as die electric fluid.

2.3. CONDUCT OF EXPERIMENTS:
Die steel (EN31) material particulate was using Copper tool with 16mm diameter and the ELECTRONICA- ELECTRAPULS PS 50ZNC (die-sinking type) EDM machine were used. Waste palm oil blended with kerosene and kerosene are used as dielectric fluid. External flushing was used to flush away the eroded materials from the sparking zone. For a four factors are tackled with a total number of 9 experiments performed on die sinking EDM. The calculation of material removal done by using electronic balance weight machine. This machine capacity is 1000 gram and accuracy is 0.001 gram. Surface roughness of each hole was measured by using Taly Surf instrument.

Fig.2.1 Die Sinker EDM Model: PS 50ZN

Table 2.4 For waste palm oil blended with kerosene as dielectric fluid.

S.No	Current (a)	Voltage	Pulse on(µse	Pulseoff(µsec	MRR(mm^3/min)	Ra (µm)
1	4	30	125	100	12.7388	1.2900
2	4	50	175	150	15.2866	1.2700
3	4	70	225	200	25.4777	1.400
4	12	30	175	200	38.2165	1.3900
5	12	50	225	100	42.0382	1.2533
6	12	70	125	150	40.7643	1.1566
7	20	30	225	150	52.2292	1.7366
8	20	50	125	200	54.7707	1.8966
9	20	70	175	100	63.6942	1.7400

Table 2.5 For kerosene as dielectric fluid.

S.No	Current (a)	Voltage	Pulse on(µs)	Pulseoff(µs)	MRR(mm^3/min)	Ra (µm)
1	4	30	125	100	12.7388	0.8633
2	4	50	175	150	12.9895	0.7966
3	4	70	225	200	13.2278	0.9766
4	12	30	175	200	25.4777	1.7500
5	12	50	225	100	29.0456	2.5100
6	12	70	125	150	33.7621	1.5266
7	20	30	225	150	45.8734	2.9933
8	20	50	125	200	50.1554	2.0433
9	20	70	175	100	63.4042	1.7633

Fig.2.2 Work pieces after machining with waste palm oil blended with kerosene and kerosene as dielctric fluids.

Fig.2.3 Measuring of surface roughness by using taly surf meter.

III. MULTI OBJECTIVE OPTIMIZATION

Technique for order of preference by similarity to ideal solution (TOPSIS):

TOPSIS is a multi-objective optimization technique used to determine the most suitable alternative from a finite set. The principle of the technique is that the selected criteria should be nearest from positive best solution and farthest from negative best solution, the finest solution being the one having the most relative closeness to the ideal solution. The steps involved in carrying out TOPSIS are expressed as:

Step1: Objective Function table consists of MRR & Ra

Step 2: Determination of normalized matrix.

$$N_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}} \quad (8)$$

Step 3: The weighted normalized decision matrix is constructed by multiplying the normalized decision matrix by its associated weights.

$$W_{ij} = \mathbf{N}_{ij} \times W_j \quad (9)$$

Step 4: a) Determine matrix ***A***3 and ***A***4 such that ***A***3 = ***A***1× ***A***2 and ***A***4= ***A***3/***A***2,

where $A_2 = 1/\ [W_1, W_2, \ldots \ldots \ldots, W_N]$

b) Calculate the maximum Eigen value (λmax), which is the average of matrix ***A***4.

c) Determine the consistency index

$$CI = \frac{\lambda_{max} - N}{N-1}$$

The smaller value of *CI* the smaller is the deviation from the consistency. Evaluate the random index (*RI*) for the number of attributes used in decision-making.

Determine the consistency ratio (*CR* = *CI*/*RI*).

Step 5: Determination of the positive ideal solution (s_i**) and the negative ideal solution (s_i*).

$$s_i^{**} = \{(\max Wij \mid j \in J), (\min Wij \mid j \in J')\} \quad (10)$$

$$s_i^{*} = \{(\min Wij \mid j \in J), (\max Wij \mid j \in J')\} \quad (11)$$

J = 1, 2, 3,…, *n* − where *J* is associated with the benefit criteria *J'* = 1, 2, 3,…, *n* − where *J'* is associated with the cost criteria.

Step 6:

The separation measure is calculated. The separation of each alternative from the positive ideal one is given by:

$$S_i^{**} = \Sigma(\mathbf{W}ij - Aj^{**})^2, j = 1, \text{where } i = 1, 2,., m. (12)$$

Similarly, the separation of each alternative from the negative ideal one is given by:

$$S_i^{*} = \Sigma(\mathbf{W}ij - Aj^{*})^2, j = 1, \text{where } i = 1, 2,..., m. (13)$$

Step 7: The relative closeness is calculated to the ideal solution.

$$c_i^* = \frac{s_i^{**}}{s_i^{**} + s_i^*} \quad (14)$$

The larger the c_i^* value the better is the performance of the alternatives.

Step 8: Rank the relative closeness value.

For waste palm oil blended with kerosene as dielectric fluid:

Table 3.1 Rank order for the experiments with dielectric fluid as Palm oil blended with kerosene.

Experiment No.	Preference value	Order
1	0.856204248	1
2	0.840291631	2
3	0.725188947	3
4	0.492593032	4
5	0.414311527	6
6	0.433956404	5
7	0.262634554	7
8	0.246349585	8
9	0.139030065	9

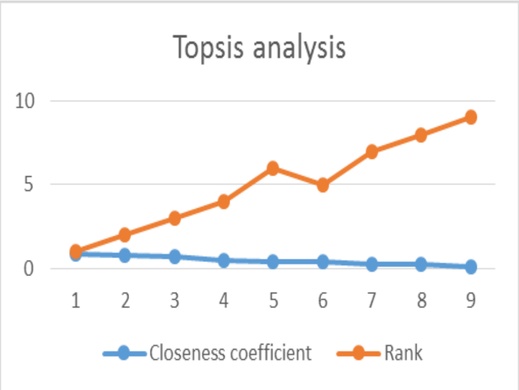

Fig. 3.1 Result analysis graph from TOPSIS with palm oil blended with kerosene as dielectric fluid

Table 3.2 Rank order for the experiments with dielectric fluid as kerosene.

Experiment No.	Preference value	Order
1	0.706910041	2
2	0.699407477	3
3	0.716186648	1
4	0.688461418	5
5	0.692663128	4
6	0.544486127	6
7	0.45685107	7
8	0.319088	8
9	0.154700108	9

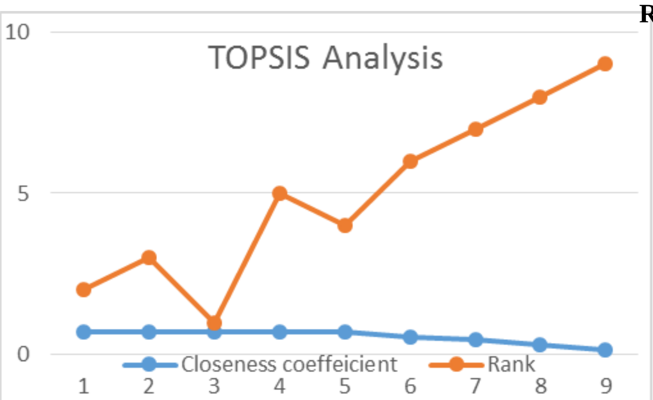

Fig.3.2 Result analysis graph from TOPSIS with kerosene as dielectric fluid.

IV. CONCLUSION

The main purpose of our work is to determine the optimum cutting parameter for Maximizing the MRR and Minimizing the Ra with eco-friendly manufacturing.

It is a multi-objective optimization technique. For this purpose an optimization technique called TOPSIS (Technique for order of preference by similarity to ideal solution) is used for the output responses ie MRR and Ra with process parameters. And the results are shown in tables 3.1 & 3.2.

- The optimum cutting parameters for palm oil blended with kerosene as dielectric fluid is Current 4 A, gap voltage as 30 V, pulse on is 125 µs and pulse off is 100µs
- The optimum cutting parameters with kerosene as dielectric fluid is Current 4 A, gap voltage as 70 V, pulse on is 225 µs and pulse off is 200µs

Experiments were conducted by the both dielectric fluids on the same work piece of die steel (EN31). And the result shows that machining by using waste palm oil blended with kerosene give better results than kerosene as dielectric. It is also known that emissions such as toxic gases, fumes and fire accidents are greatly reduced.

Future Scope

EDM is an emerging technology for providing economical and eco-friendly manufacturing. There are significant changes in response characteristics by change of dielectric fluids. In this paper waste palm oil blended with kerosene is taken and there is provision to select waste oil (waste vegetable oils, waste palm oil, etc.) directly as dielectric medium. Different optimization techniques are used for getting optimum parameters.

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