SELECTION OF THE WIRE CUT ELECTRICAL DISCHARGE MACHINING PROCESS PARAMETERS USING AHP/TOPSIS METHOD

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Abstract: In this present study a multi response optimization method using AHP/TOPSIS method is proposed for wire electrical discharge machining (WEDM) operations. Experimentation was planned as per Taguchi's L27 orthogonal array. Each experiment has been performed under different Process Parameters conditions of Pulse on Time (Ton), Pulse off Time (Toff), Flushing Pressure (FP), Wire Tension (Wt), Servo Voltage (SV) and Wire Feed Rate (WF) in Wire Cut Electrical Discharge Machining (WEDM) Operations. The Response Process Parameters are measure in Wire Cut Electrical Discharge Machining (WEDM) Operations Such as Material Removal Rate, Kerf Width and Surface Roughness have been considered for Each Experiment. Molybdenum Wire with 0.25mm Diameter and High Carbon High Chromium Die Steel (HCHCR) were used as tool and Work Materials in the Experiments. The Machining parameters are optimized with the multi response characteristics of the material removal, kerf width rate and surface roughness using the AHP/TOPSIS.

Keywords*:* WEDM, Taguchi Method, Orthogonal Array, AHP, TOPSIS.

I.INTRODUCTION

Wire cut EDM (electrical discharge machining) is an exceptionally precise, efficient and economical manufacturing route in many applications, allowing customers to design parts for optimum function, without the many restrictions of other metalworking processes. Wire cut EDM produces exceptionally precise, parallel sidewalls, allowing stacking when machining multiple parts from sheet material. Usually, the desired machining parameters are determined based on experience or handbook values. However, it does not ensure that the selected machining parameters result in optimal or near optimal machining performance for that particular electrical discharge machine and environment [1]. WEDM is considered as a unique adoption of the conventional EDM process which comprises of a main worktable, wire drive mechanism, a CNC controller, working fluid tank and attachments. Wire electrode usually made of thin copper, brass, molybdenum or tungsten of diameter 0.05-0.30 mm, which transforms electrical energy to thermal energy, is used for cutting materials. The wire is stored and wound on a wire drum which can rotate at1500rpm. The wire is continuously fed from wire drum which moves though the work piece and is supported under tension between a pair of wire guides located at the opposite sides of the work piece. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. Also the work piece and the wire electrode (tool) are separated by a thin film of dielectric fluid that is continuously fed to the machining zone to flush away the eroded particles. [1].

II. DESIGN OF EXPERIMENT BASED ON TAGUCHI METHOD:

The experimental layout for the machining parameters using the L27 orthogonal array was used in this study. This array consists of six control parameters and three levels. Minitab automatically creates the design and stores it in the worksheet.

"Table No:2.1 Input Variables with Different Levels"

Machining Process Parameters		Level 1	Level 2	Level 3
1	Pulse On Time (µs)	115	120	125
2	Pulse Off Time (µs)	45	50	55
3	Flushing pressure (kgf/cm2)	10	12	14
4	Wire Tension(gms)	600	900	1200
5	Servo Voltage (volt)	20	25	30
6	Wire Feed Rate (m/min)	4	6	8

"Table No: 2.2 Experimental Design Using L27 Orthogonal Array"

Exp. No	Ton (µs)	Toff (µs)	Fp (Kgf/ cm2)	Wt (gms)	SV (volt)	Wf (m/min)	MRR (mm3/ min)	KW (mm)	SR (µm)
1	115	45	10	600	20	4	6.3682	0.2565	2.498
2	115	45	10	600	25	6	6.2817	0.2585	2.458
3	115	45	10	600	30	8	5.9658	0.2604	2.335
4	115	50	12	900	20	4	5.6581	0.2585	2.807
5	115	50	12	900	25	6	5.5327	0.2623	2.812
6	115	50	12	900	30	8	5.5937	0.2711	2.714
7	115	55	14	1200	20	4	5.2816	0.2665	2.786
8	115	55	14	1200	25	6	5.1930	0.2724	2.680
9	115	55	14	1200	30	8	5.1124	0.2764	2.763
10	120	45	12	1200	20	6	8.3161	0.2700	3.375
11	120	45	12	1200	25	8	7.9069	0.2677	3.403
12	120	45	12	1200	30	4	7.4141	0.2661	3.370
13	120	50	14	600	20	6	7.1922	0.2702	3.399
14	120	50	14	600	25	8	6.9960	0.2716	3.434
15	120	50	14	600	30	4	7.0043	0.2813	3.417
16	120	55	10	900	20	6	5.8348	0.2589	3.470
17	120	55	10	900	25	8	5.3332	0.2550	3.504
18	120	55	10	900	30	4	5.0727	0.2552	3.388
19	125	45	14	900	20	8	8.4101	0.2623	3.536
20	125	45	14	900	25	4	8.1089	0.2638	3.485
21	125	45	14	900	30	6	8.1004	0.2656	3.450
22	125	50	10	1200	20	8	7.6840	0.2589	3.505
23	125	50	10	1200	25	4	7.4889	0.2616	3.489

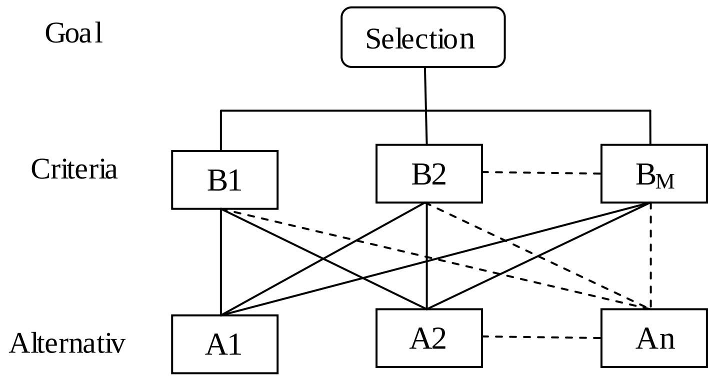
24	125	50	10	1200	30	6	7.7415	0.2758	3.429
25	125	55	12	600	20	8	7.2994	0.2759	3.427
26	125	55	12	600	25	4	7.0054	0.2808	3.446
27	125	55	12	600	30	6	7.1029	0.2936	3.399

III.METHODOLOGY: AHP/TOPSIS

Analytic Hierarchy Process (AHP)/Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)

The AHP is an effective decision making method to solve multi-dimensional and complex problems. AHP performs pair wise comparison matrices to decompose and solve a multiple criteria decision making problems with different and conflicting criteria. AHP method is based on three main principles: structure of the model; comparative judgment of the criteria and/or alternatives; synthesis of the priorities.
Steps of the AHP method as follow [4]:

Step 1: Developing the hierarchical structure.
A decision problem is structured as a hierarchy structure With the AHP, the goal, decision criteria and alternatives are arranged in a hierarchical structure similar to a family tree.



"Figure 3.1 A hierarchy of the decision making problem [4]"

Step 2: Perform the pair wise comparisons.
In this step, comparison matrices are formed and pair wise comparisons are conducted. Decision criteria are compared in the corresponding level using fundamental comparison scale. The table below shows the comparison scale used by AHP.

$$A1_{MxM} = \begin{matrix} B1 \\ B2 \\ B3 \\ - \\ - \\ BM \end{matrix} \begin{bmatrix} 1 & a_{12} & a_{13} & -- & -- & a_{1M} \\ a_{21} & 1 & a_{23} & -- & -- & a_{2M} \\ a_{31} & a_{32} & 1 & -- & -- & a_{3M} \\ -- & -- & -- & 1 & -- & -- \\ -- & -- & -- & -- & 1 & -- \\ a_{M1} & a_{M2} & a_{M3} & -- & -- & 1 \end{bmatrix}$$

Where aij denotes the comparative importance of attribute i with respect to attribute j and Bi denoted the criteria in the matrix, aij = 1, when i = j and aji =1/aij.

Table No: 3.1 Scale of Relative Importance [5]

Scale	Importance	Meaning of attributes
1	equal importance	Two attributes are equally important
3	moderate importance	One attribute is moderately important over the other
5	strong importance	One attribute is strongly important over the other
7	very importance	One attribute is very important over the other
9	absolute importance	One attribute is absolutely important over the other
2,4,6,8, compromise importance between 1,3,5,7 and 9		

Step 3: Determination of relative normalized weight; A relative normalized weight at each level of hierarchy structure [43] is calculated using Equation (1) and Equation (2).

$$GM_j = \left[\prod_{j=1}^{M} a_{ij} \right]^{\frac{1}{M}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{Eq.1}$$

$$W_j = \frac{GM_j}{\sum_{J=1}^{M} GMj} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq.2}$$

Step 4: Consistency Test.

If the judgment matrix or comparison matrix is inconsistent then judgment should be reviewed and improved it to obtain the consistent matrix. Hence, consistency test will be carried out using following steps.

- Calculate matrices: A3 = A1 x A2 and A4 = A3 /A2

  Where; A1= [aij] M×M

  A2= [W1, W2... Wj] T
- Calculate Eigen value ƛmax(Averageof Matrix A4)
- Calculate the consistency index: CI = (ƛmax- M) / (M - 1)

Table 3.2 Random Index (RI) for Different Matrix Order [5]

Attributes	3	4	5	6	7	8	9	10
RI	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

• Calculate the consistency ratio: CR = CI/RI, select value of random index (RI) according to number of attributes used in decision-making.

• If CR < 0.1, considered as acceptable decision, otherwise judgment of the analyst about the problem under study

TOPSIS method was introduced for the first time by Yoon and Hwang [2] and was appraised by surveyors and different operators. TOPSIS is a decision making technique. It is a goal based approach for finding the alternative that is closest to the ideal solution.

Step 5: Creating the decision matrix.

The method starts with a decision matrix of responses of different alternatives to evaluation criteria.

$$Xij = \begin{bmatrix} a_{11} & a_{12} & a_{13} & -- & -- & a_{1n} \\ a_{21} & a_{22} & a_{23} & -- & -- & a_{2n} \\ a_{31} & a_{32} & a_{33} & -- & -- & a_{3n} \\ -- & -- & -- & -- & -- & -- \\ -- & -- & -- & -- & -- & -- \\ a_{m1} & a_{m2} & a_{m3} & -- & -- & a_{mn} \end{bmatrix}$$

Step 6: Normalize the decision matrix D by using the following formula:

$$r_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{n} x^2_{ij}} \qquad \text{……… ……….Eq.3}$$

Step 7: Construct the weighted normalized decision matrix [3] by multiplying the normalized decision matrix by its associated weights. Here weightage of each output parameters are calculated using Analytical hierarchy process .The weighted normalized value vij is calculated as:

$$vij = wij * rij \qquad \text{……………..…………..Eq.4}$$

Step 8: Determine the positive ideal solution and negative ideal so

$$Vj^* = \left\{ \sum_{i=1}^{max} V_{ij} / j \in J, \sum_{i=1}^{min} V_{ij} / j \in J' \right\}$$

$$Vj = \left\{ \sum_{i=1}^{min} V_{ij} / j \in J, \sum_{i=1}^{max} V_{ij} / j \in J' \right\} \qquad \text{……….Eq.5}$$

Where J is associated with the benefit criteria, J = 1, 2, 3… n

Where J' is associated with the cost criteria, J' = 1, 2, 3… n

Step 8 (A): Determine Ideal Solution Vj*. Vj* = {V1*, V2* …Vn*}

Step 8 (B): Determine Negative Ideal Solution Vj. Vj = {V1, V2 …Vn}

Step 9: Calculate the separation measure.

Step 9 (A) The separation of each alternative from the positive ideal one is given by:

$$Si^* = \sqrt{\sum_{j=1}^{n} (vij - vj^*)^2} \qquad \text{………..Eq.6}$$

Where i = 1, 2… m

Step 9 (B): similarly, the separation of each alternative from the negative ideal one is given by:

$$Si = \sqrt{\sum_{j=1}^{n} (vij - vj)^2}$$

.........Eq.7

Where i = 1, 2… m

Step 10: Calculate the relative closeness to the ideal solution and rank the preference order

$$Ci^* = Si / (Si^* + Si)$$ Eq.8

Where i = 1, 2… m

IV.ILLUSTRATE EXAMPLE

Step 1: A Wire Cut Electrical Discharge machine process parameters selection problem can be decomposed procedure described in the hierarchy structure shown in Figure 1.6.

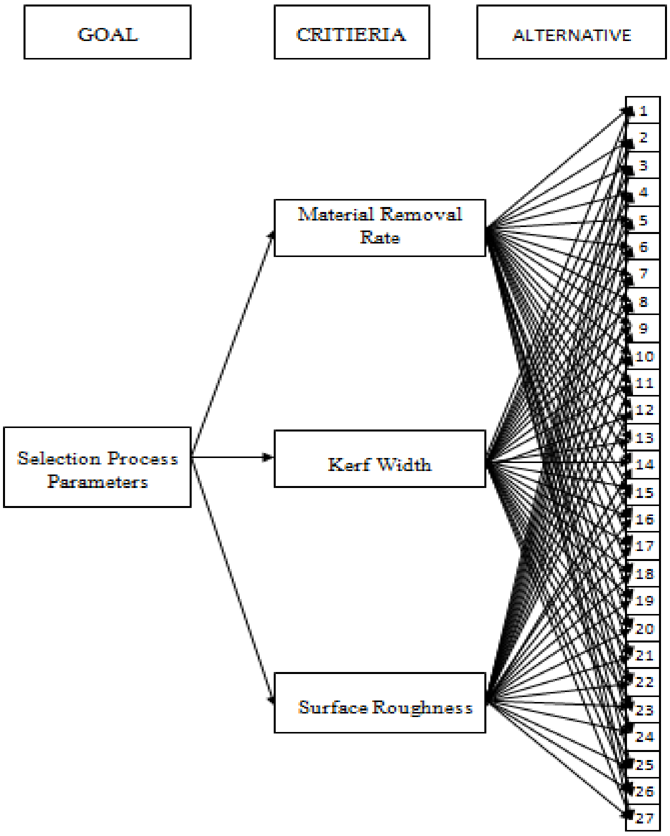


Figure: 4.1 A Hierarchy of Wire Cut Electrical Discharge Machining Process Parameters Selection Problem

Step 2: A relative importance of between attributes is assigned with respect to the goal. The judgments are entered using Scale of Relative Importance of the AHP method as shown in Table No: 4.1.

Table No: 4.1Pair Wise Comparison Matrix for Different Criteria

Attribute	B1	B2	B3
B1	1	2	4
B2	1/2	1	4
B3	1/4	1/4	1

Step 3: A relative normalized weight of attributes are calculated using Eq.1 and Eq.2 and its values are shown in the following Table No: 4.2.

$$GM_j = \left[\prod_{j=1}^{M} a_{ij}\right]^{\frac{1}{M}} \quad \text{………………….} \quad \text{Eq.1}$$

$$W_j = \frac{GM_j}{\sum_{J=1}^{M} GMj} \quad \text{……….................} \quad \text{Eq.2}$$

Table No: 4.2 Relative Normalized Weight of Attribute

ATTRIBUTE	W_j
(B1)= MATERIAL REMOVAL RATE	W1 = 0.5469
(B2)= SURFACE ROUGHNESS	W2 = 0.3445
(B3)= KERF WIDTH	W3 = 0.1085

Step 4: Now, this step demonstration of consistency test of the taken judgment is illustrated and its calculated values are given below [5].

$$A3 = A1 \times A2 = \begin{bmatrix} 1 & 2 & 4 \\ 1/2 & 1 & 4 \\ 1/4 & 1/4 & 1 \end{bmatrix} \times \begin{bmatrix} 0.5469 \\ 0.3445 \\ 0.1085 \end{bmatrix} = \begin{bmatrix} 1.6702 \\ 1.0521 \\ 0.3314 \end{bmatrix}$$

$$A4 = A3/A2 \quad = \begin{bmatrix} 1.6702 \\ 1.0521 \\ 0.3314 \end{bmatrix} \div \begin{bmatrix} 0.5469 \\ 0.3445 \\ 0.1085 \end{bmatrix} = \begin{bmatrix} 3.0538 \\ 3.0537 \\ 3.0533 \end{bmatrix}$$

- λmax = Average of matrix A4 = 3.0536
- CI = (λmax- M) / (M-1) = (3.0536 -3)/(3-1) = 0.0536/2 =0.2681
- CR = CI /RI = 0.2681 /0.58 = 0.046

As the value of CR is less than 0.1 the judgments are acceptable.

Step 5: Form a decision matrix [2]. The structure of the matrix can be expressed as follows:

"Table No: 4.3 decision matrix"

Exp. No	Ton (µs)	Toff (µs)	Fp (Kgf/ cm2)	Wt (gms)	SV (volt)	Wf (m/min)	MRR (mm3/ min)	KW (mm)	SR (µm)
1	115	45	10	600	20	4	6.3682	0.2565	2.498
2	115	45	10	600	25	6	6.2817	0.2585	2.458
3	115	45	10	600	30	8	5.9658	0.2604	2.335
4	115	50	12	900	20	4	5.6581	0.2585	2.807
5	115	50	12	900	25	6	5.5327	0.2623	2.812
6	115	50	12	900	30	8	5.5937	0.2711	2.714

7	115	55	14	1200	20	4	5.2816	0.2665	2.786
8	115	55	14	1200	25	6	5.1930	0.2724	2.680
9	115	55	14	1200	30	8	5.1124	0.2764	2.763
10	120	45	12	1200	20	6	8.3161	0.2700	3.375
11	120	45	12	1200	25	8	7.9069	0.2677	3.403
12	120	45	12	1200	30	4	7.4141	0.2661	3.370
13	120	50	14	600	20	6	7.1922	0.2702	3.399
14	120	50	14	600	25	8	6.9960	0.2716	3.434
15	120	50	14	600	30	4	7.0043	0.2813	3.417
16	120	55	10	900	20	6	5.8348	0.2589	3.470
17	120	55	10	900	25	8	5.3332	0.2550	3.504
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21	125	45	14	900	30	6	8.1004	0.2656	3.450
22	125	50	10	1200	20	8	7.6840	0.2589	3.505
23	125	50	10	1200	25	4	7.4889	0.2616	3.489
24	125	50	10	1200	30	6	7.7415	0.2758	3.429
25	125	55	12	600	20	8	7.2994	0.2759	3.427
26	125	55	12	600	25	4	7.0054	0.2808	3.446
27	125	55	12	600	30	6	7.1029	0.2936	3.399

Step 6:

Normalize the decision matrix D by using the following formula:

$$r_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{n} x^2_{ij}} \quad \text{...............Eq.3}$$

"Table No: 4.4 Normalize the decision matrix"

ALTERNATIVE	MRR	KW	SR
A1	0.1805	0.1846	0.1502
A2	0.1780	0.1860	0.1478
A3	0.1691	0.1874	0.1404
A4	0.1603	0.1860	0.1688
A5	0.1568	0.1888	0.1691
A6	0.1585	0.1951	0.1632
A7	0.1497	0.1918	0.1675
A8	0.1472	0.1960	0.1611
A9	0.1449	0.1989	0.1661
A10	0.2357	0.1943	0.2030
A11	0.2241	0.1926	0.2046
A12	0.2101	0.1915	0.2027
A13	0.2038	0.1944	0.2044

A14	0.1983	0.1954	0.2065
A15	0.1985	0.2024	0.2055
A16	0.1654	0.1863	0.2087
A17	0.1511	0.1835	0.2107
A18	0.1438	0.1836	0.2037
A19	0.2383	0.1888	0.2126
A20	0.2298	0.1898	0.2096
A21	0.2296	0.1911	0.2075
A22	0.2178	0.1863	0.2107
A23	0.2122	0.1883	0.2098
A24	0.2194	0.1985	0.2062
A25	0.2069	0.1985	0.2061
A26	0.1985	0.2021	0.2072
A27	0.2013	0.2113	0.2044

Step 7: Construct the weighted normalized decision matrix by multiplying the normalized decision matrix by its associated weights. Here weightage of each output parameters are calculated using Analytical hierarchy process.The weighted normalized value vij is calculated as:

$$vij = wij * rij \qquad \text{......Eq.4}$$

"Table No: 4.5 weighted normalized decision matrix"

Wij(weight)	0.5469	0.1085	0.3445
Alternative	MRR	KW	SR
A1	0.0987	0.0200	0.0518
A2	0.0974	0.0202	0.0509
A3	0.0925	0.0203	0.0484
A4	0.0877	0.0202	0.0581
A5	0.0858	0.0205	0.0583
A6	0.0867	0.0212	0.0562
A7	0.0819	0.0208	0.0577
A8	0.0805	0.0213	0.0555
A9	0.0792	0.0216	0.0572
A10	0.1289	0.0211	0.0699
A11	0.1226	0.0209	0.0705
A12	0.1149	0.0208	0.0698
A13	0.1115	0.0211	0.0704
A14	0.1084	0.0212	0.0711
A15	0.1086	0.0220	0.0708
A16	0.0904	0.0202	0.0719
A17	0.0827	0.0199	0.0726
A18	0.0786	0.0199	0.0702
A19	0.1303	0.0205	0.0733

A20	0.1257	0.0206	0.0722
A21	0.1256	0.0207	0.0715
A22	0.1191	0.0202	0.0726
A23	0.1161	0.0204	0.0723
A24	0.1200	0.0215	0.0710
A25	0.1131	0.0215	0.0710
A26	0.1086	0.0219	0.0714
A27	0.1101	0.0229	0.0704

Step 8: Determine the positive ideal solution and negative ideal so

$$Vj^* = \left\{ \sum_{i=1}^{\max} V_{ij} / j \in J, \sum_{i=1}^{\min} V_{ij} / j \in J' \right\}$$

$$Vj = \left\{ \sum_{i=1}^{\min} V_{ij} / j \in J, \sum_{i=1}^{\max} V_{ij} / j \in J' \right\} \quad \text{..........Eq.5}$$

Where J is associated with the benefit criteria, J = 1, 2, 3… n
Where J' is associated with the cost criteria, J' = 1, 2, 3… n

Step 8 (A): Determine Ideal Solution A*.

Vj* = {0.1303, 0.0199, 0.0484}

Step 8 (B): DetermineNegative Ideal Solution A'.

Vj' = {0.0786, 0.0299, 0.0733}

Step 9: Calculate the separation measure.
Step 9 (A) The separation of each alternative from the positive ideal one is given by:

$$Si^* = \sqrt{\sum_{j=1}^{n} (vij-vj^*)^2} \quad \text{.................Eq.6}$$

Where i = 1, 2… m

"Table No: 4.6 Positive Ideal Solution"

Vj*	0.1303	0.0199	0.0484	
A*	Ideal Solution			Si*
A1	0.00099840497	0.00000001619071	0.0000112291448	0.0318
A2	0.00108495964	0.00000007811835	0.0000063099145	0.0330
A3	0.00143144448	0.00000018640849	0.0000000006695	0.0378
A4	0.00181516136	0.00000007811835	0.0000949100113	0.0437
A5	0.00198454781	0.00000033651653	0.0000971431067	0.0456
A6	0.00190117817	0.00000160578300	0.0000610820199	0.0443
A7	0.00234641337	0.00000082452194	0.0000868154157	0.0493
A8	0.00248135651	0.00000186266152	0.0000505680520	0.0503
A9	0.00260724259	0.00000282580539	0.0000779800304	0.0518

A10	0.00000198161	0.00000139548888	0.0004631006946	0.0216
A11	0.00006005659	0.00000100345620	0.0004879456207	0.0234
A12	0.00023679718	0.00000076194811	0.0004586531791	0.0264
A13	0.00035447217	0.00000142329662	0.0004842914691	0.0290
A14	0.00047819858	0.00000170624829	0.0005167309695	0.0316
A15	0.00047257697	0.00000424234745	0.0005008433077	0.0313
A16	0.00158922271	0.00000009899337	0.0005516808203	0.0463
A17	0.00226956418	0.00000000003869	0.0005852656210	0.0534
A18	0.00267054726	0.00000000066255	0.0004747646659	0.0561
A19	0.00000000241	0.00000033651653	0.0006177813004	0.0249
A20	0.00002132856	0.00000048068552	0.0005663753242	0.0243
A21	0.00002256093	0.00000070184329	0.0005323885835	0.0236
A22	0.00012551813	0.00000009899337	0.0005857669187	0.0267
A23	0.00020245617	0.00000027609266	0.0005703264772	0.0278
A24	0.00010634914	0.00000267049803	0.0005127357972	0.0249
A25	0.00029464365	0.00000269607777	0.0005101589477	0.0284
A26	0.00047183001	0.00000409884500	0.0005285713387	0.0317
A27	0.00040845762	0.00000914439824	0.0004848387163	0.0300

Step 9 (B): similarly, the separation of each alternative from the negative ideal one is given by:

$$Si = \sqrt{\sum_{j=1}^{n} (vij\text{-}vj)^2} \qquad \text{.......................Eq.7}$$

Where i = 1, 2… m

"Table No: 1.11 Negative ideal solution"

Vj'	0.0786	0.0229	0.0733	
Vj'	Negative Ideal Solution			Si
A1	0.0004041086	0.0000082527	0.0004643598	0.0296
A2	0.0003519854	0.0000074011	0.0005012246	0.0293
A3	0.0001922539	0.0000065959	0.0006212992	0.0286
A4	0.0000827243	0.0000074011	0.0002297596	0.0179
A5	0.0000511473	0.0000058559	0.0002263183	0.0168
A6	0.0000655695	0.0000030026	0.0002918802	0.0190
A7	0.0000106290	0.0000043763	0.0002428150	0.0161
A8	0.0000035600	0.0000026739	0.0003164442	0.0180
A9	0.0000004081	0.0000017397	0.0002582246	0.0161
A10	0.0025293156	0.0000033076	0.0000114259	0.0504
A11	0.0019316360	0.0000039931	0.0000078990	0.0441
A12	0.0013185457	0.0000045246	0.0000121369	0.0365
A13	0.0010806058	0.0000032652	0.0000083716	0.0330
A14	0.0008899630	0.0000028688	0.0000047015	0.0300

A15	0.0008976714	0.0000008842	0.0000063528	0.0301
A16	0.0001400659	0.0000072112	0.0000019941	0.0122
A17	0.0000164841	0.0000089627	0.0000005009	0.0051
A18	0.0000000005	0.0000088462	0.0000096777	0.0043
A19	0.0026779685	0.0000058559	0.0000000020	0.0518
A20	0.0022166879	0.0000053208	0.0000012130	0.0472
A21	0.0022043181	0.0000046753	0.0000033359	0.0470
A22	0.0016399675	0.0000072112	0.0000004863	0.0406
A23	0.0014040976	0.0000061234	0.0000010373	0.0376
A24	0.0017129192	0.0000018655	0.0000050910	0.0415
A25	0.0011926533	0.0000018442	0.0000053514	0.0346
A26	0.0008987016	0.0000009515	0.0000036455	0.0301
A27	0.0009915990	0.0000000006	0.0000082999	0.0316

Step 10: Calculate the relative closeness [2] to the ideal solution and rank the preference order

$$Ci^* = Si /(Si^*+Si) \qquad \text{.......................................Eq.8}$$

Where i = 1, 2… m

"Table No: 4.7 Relative Closeness to the ideal solution"

Alternative	C* = (si/(si*+si)	Rank
A1	0.4824	16
A2	0.4703	17
A3	0.4308	18
A4	0.2904	20
A5	0.2695	21
A6	0.2999	19
A7	0.2455	23
A8	0.2630	22
A9	0.2374	24
A10	0.7002	1
A11	0.6530	5
A12	0.5807	8
A13	0.5327	11
A14	0.4869	14
A15	0.4903	13
A16	0.2089	25
A17	0.0870	26
A18	0.0713	27
A19	0.6757	2
A20	0.6603	4
A21	0.6662	3

A22	0.6035	7
A23	0.5747	9
A24	0.6245	6
A25	0.5493	10
A26	0.4867	15
A27	0.5128	12

VI. CONCLUSION

TOPSIS/AHP-method-based expert says- team has been developed which helps in choosing the most suitable WEDM process parameters from among a large number of available alternative WEDM process parameters while machining a desired shape feature on a given study material.According to performed experimental design, it is clearly observed from Table 4.7 and the AHP/TOPSIS Method which indicates the 10 experiment gives the best multi- performance features of the WEDM process among the 27 experiments.

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