



JOURNAL ON COMMUNICATIONS

ISSN:1000-436X

Scopus®

REGISTERED

www.jocs.review

TOPSIS-Assisted Decision Making for Optimal Parameter Selection in Wire Electrical Discharge Machining

Sandip S Patel[1], Mitesh G Patel [2]

[1] Mechanical Engineering Department, Government Engineering College, Sector-28, Gandhinagar-382028, Gujarat, India.

[2] Mechanical Engineering Department, Government Engineering College, Patan-384265, Gujarat, India.

Abstract

This study presents a comprehensive methodology for the optimal selection of Wire Electrical Discharge Machining (WEDM) process parameters using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Experimental data were collected for various parameter settings, including pulse on time, pulse off time, peak current, spark gap voltage, wire feed rate, and wire tension, and their effects on material removal rate (MRR), surface roughness (SR), and kerf width (KW) were analyzed. The TOPSIS method, combined with Analytical Hierarchy Process (AHP) for weighting criteria, was employed to rank the parameter combinations based on their closeness to the ideal solution, maximizing MRR while minimizing SR and KW. The results identified the optimal parameter set that balances machining efficiency and product quality, demonstrating the robustness and computational simplicity of TOPSIS for multi-criteria decision-making in WEDM. This approach offers a practical and adaptable decision-support tool for advanced manufacturing processes, with potential for broader application in machining parameter optimization.

Keywords: WEDM, Multi-criteria Decision Making, TOPSIS, AHP, RSM, Machining Efficiency, Decision-Support Tool

1 Introduction

Wire Electrical Discharge Machining (WEDM) is a highly specialized non-traditional machining process extensively employed in modern manufacturing industries owing to its exceptional capability to machine intricate and complex geometries with high precision. [1]This process is particularly advantageous for machining hard-to-cut materials, such as superalloys, hardened steels, and exotic metals, which are otherwise challenging to process using conventional machining methods[2]. The operational principle of WEDM involves the generation of controlled electrical discharges between a thin wire electrode and the workpiece, resulting in the localized melting and vaporization of the material[3]. The precision and surface finish achievable through WEDM render it indispensable in sectors such as aerospace, automotive, medical device manufacturing, and die and mold making.[4]

The performance and overall efficiency of WEDM are profoundly influenced by a multitude of process parameters, including, but not limited to, pulse duration, discharge current, wire tension, wire feed rate, and voltage. These parameters directly affect critical output characteristics, such as the material removal rate (MRR), surface roughness, kerf width, and dimensional accuracy[5]. However, optimizing these parameters is complex because improving one performance criterion often adversely affects others. For example, increasing the discharge current might enhance the MRR, but it could deteriorate the surface quality or dimensional precision[6] [7]. This inherent trade-off among conflicting objectives necessitates a systematic and rational approach to parameter selection that effectively balances these competing requirements.

Multi-criteria decision-making (MCDM) techniques have gained prominence as robust tools for addressing multi-objective optimization challenges in machining processes. These methods facilitate the valuation and ranking of multiple alternatives by simultaneously considering various performance criteria [8]. Among the diverse MCDM approaches, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) stands out because of its conceptual simplicity, computational efficiency, and ability to provide a clear ranking based on the relative closeness of each alternative to the ideal solution[9]. TOPSIS evaluates each potential parameter set by calculating its distance from the ideal best and ideal worst solutions, thereby enabling decision-makers to identify the most balanced and optimal choice[10].

Incorporating TOPSIS into the decision-making framework for WEDM parameter optimization offers a structured and quantitative methodology for navigating the complex parameter space[2]. This integration supports practitioners and researchers in systematically analyzing experimental or simulated data to discern the parameter combinations that yield the best compromise among multiple performance objectives. By leveraging TOPSIS, the optimization process transcends heuristic or trial-and-error methods, leading to more reliable, reproducible, and efficient machining outcomes[11].

This study proposes a comprehensive TOPSIS-assisted decision-making methodology aimed at the optimal selection of WEDM process parameters. This study involved collecting relevant performance data under various parameter settings, applying the TOPSIS algorithm to rank these settings, and identifying the optimal combination that maximizes machining efficiency while ensuring superior product quality. The outcomes of this study have significant implications for enhancing productivity, reducing machining costs, and improving the functional performance of machined components. Furthermore, the methodology serves as a practical decision-support tool that can be adapted and extended to other machining processes facing similar multi-criteria optimization problems, thereby contributing to the broader field of advanced manufacturing technology.

Despite the demonstrated effectiveness of TOPSIS in multi-criteria decision-making for machining processes, existing research on WEDM parameter optimization often relies on heuristic or single-objective approaches that inadequately address the inherent trade-offs among conflicting performance criteria such as material removal rate, surface quality, and dimensional accuracy. There is a lack of comprehensive, systematic methodologies that integrate TOPSIS specifically for WEDM to simultaneously evaluate multiple process parameters and their combined effects on diverse output characteristics. Furthermore, prior studies have not sufficiently validated the practical applicability of TOPSIS-assisted frameworks through extensive experimental data or explored its adaptability to varying material types and machining conditions. This gap highlights the need for a robust, quantitative decision-support tool that can optimize WEDM parameters holistically, enhancing machining efficiency and product quality in a reproducible and scalable manner.

2 Material & Method:

A sequence of preliminary trials has been performed according to RSM. The experimental setup, workpiece material and measuring apparatus, design of experiments, and selection of input process variables and their level have been explained in the subsequent sections. The selection of input variables—specifically spark gap time, discharge voltage, and wire advance rate—was determined through a series of pilot studies to ensure a broad operational range [12].

2.1 Workpiece material

SKD 11 [19] required for experimentation was procured from M/s Bansidhar steel corporation, Rakhiyal, Ahmedabad[13]. Table 1 shows chemical composition of SKD 11 material. During to perform the experiments, the height of the workpiece material is 12 mm, and as a tool electrode, 0.25 mm diameter of the brass wire is used.

Table 1. Chemical liquidation of SKD 11[13]

Element	C	Mn	Si	V	Mo	Cr	Fe
Standard Weight %	1.40 – 1.60	0.60	0.60	1.10	0.7 -1.2	11.0 -13.0	Balance
Actual Weight%	1.55	0.35	0.25	0.9	0.8	12.0	Balance

2.2 Experimental setup and performance measuring devices

The experiments are performed on 4 axes Electronica Sprint cut-734 WEDM machine available at Jay Tech Industries, Odhav, Ahmedabad. The different input control parameters are varied during the experimentation like Toff, Ton, WF, IP, WT, and SV; to study their effects on MRR, SR and KW. The wire is connected to the ve terminal while the workpiece is connected with the +ve terminal. The wire diameter is kept constant throughout the machining process. A fixture is used to grip the workpiece on the machine table to reduce any possibility of misalignment. The electrode and workpiece are separated from the dielectric fluid. The material removal rate (MRR) determines the productivity and economics of machining. It is found using the subsequent relation[14].

MRR (mm^3/min) = Average machining rate × thickness of plate × width of cut[14] (1)

Width of cut = (D_s-A_s) D_s = Desired work piece size = 10 mm, A_s = Actual work piece size obtained after machining, which is measured using digital vernier calliper with a least count of 1µ. It is measured at two arbitrary places on sides AB, BC, and CD, and the mean of these six values represents the real size of a workpiece. The centerline average (CLA) surface roughness parameter (Ra) is used to quantify the surface roughness of the machined surface. Ra is measured using a contact type Mitutoyo Surftest SJ 410 roughness tester, having at least a count of 0.001 lm. The cutoff length is 0.8 mm, and the evaluation length is 4 mm. Ra is measured at three places upright in the direction of cut and the mean of the three readings denotes average SR. the set up for surface roughness measurement is as shown in Fig. 1. The kerf is measured using the infinite focus alicona machine as the sum of the wire diameter and twice wire – work piece gap [15]. The kerf value was expressed in three different spot and each spot will give ten sreadings; the average of these reading will be taken as kerf width.

KW= D+2δ [15] (2)

Where, Overcut (δ) = dimensional deviation (DD) – 0.5×wire diameter (d)

DD = 0.5(WP-Wa) Where, Wp = Programmed path, Wa = Actual job profile.



FIGURE 1 Set up for surface roughness measurement

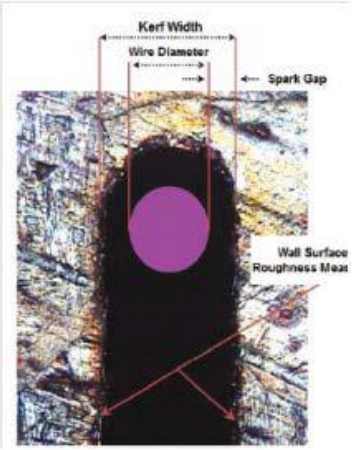


FIGURE 2 Kerf width measurement [16]

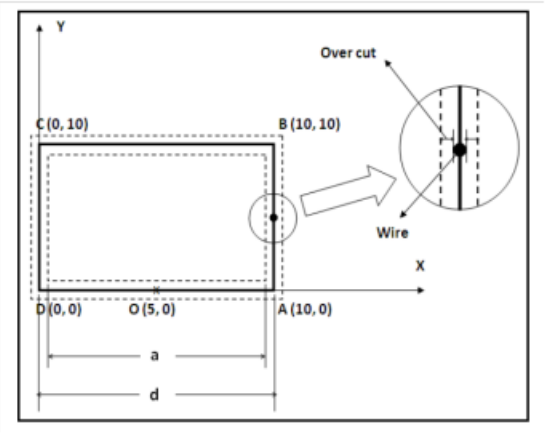


FIGURE 3 Overcut profile

2.3 Level of input process parameters selection

In the current research effort, the cause of different input process variables like Ton, Toff, SV, IP, WT, and WF on performance measures i.e. surface roughness, material removal rate and kerf width have been investigated. The input process variables and their level have been chosen based on the screening experiment, machine capability, literature survey, and manufacture's machine manual. The controlled input process variables and their levels in actual and coded values are listed in Table 2.

Table 2. Parameters range for the experiment (central composite)

Levels	A: Pulse on Time	B: Pulse off Time	C: Peak Current	D: Spark Gap Set Voltage	E: Wire Feed Rate	F: Wire Tension
-α	110	50	160	10	4	4
-1	112	52	170	20	6	6
0	115	54	180	30	7	7
+1	118	56	190	40	8	8
+α	120	58	200	50	10	10

2.4 Design of experiments

The response surface methodology approach was used to create the design of experiments and optimization process by Design expert 7.0. The RSM was used to develop a second-order regression equation relating to response characteristics and process variables [17]. The experimentation besides with regression investigation facilitates the modeling of the preferred response to numerous input process variables. The experimentation is planned to authorize evaluation of interaction and quadratic effects, also as a result, to provide any information regarding the shape of the response curve.

Fifty-two experiments of tests have been led by CCD of RSM utilizing half replication for six input parameters with a = 1.565 (a = k1/4) which is known as practical a and it is advantageous when the number of input variables is more than five [18]. The current design of 52 experiments consists of 32 factorial points (experimental runs 1 to 32), 12 axial points to form a CCD with a=±1.565 for estimation of curvature (experimental runs 33 to 44), and eight center points (experimental runs 45 to 52) at zero level for replication to estimate pure error. The performance measure for MRR, KW and SR is shown in Table 3.

Table 3. Experimentation plan matrix containing a set of input variables and process response

Std order	Run order	Factor A	Factor B	Factor C	Factor D	Factor E	Factor F	MRR mm^3/min	Surface roughness µm	Kerf width µm
		T_{on} (mu)	T_{off} (mu)	IP (A)	SV (V)	WF (m/min)	WT (mu)			
1	15	112	52	170	20	6	6	4.725	2.5925	3.65875

2	40	118	52	170	20	6	8	8.8566	3.2735	6.06505
3	26	112	56	170	20	6	8	3.9048	2.734	3.3194
4	9	118	56	170	20	6	6	8.1612	3.3165	5.73885
5	31	112	52	190	20	6	8	6.2946	3.083	4.6888
6	38	118	52	190	20	6	6	10.2936	3.585	6.9393
7	8	112	56	190	20	6	6	5.3721	2.9985	4.1853
8	45	118	56	190	20	6	8	8.187	3.4625	5.82475
9	34	112	52	170	40	6	8	3.9468	2.6785	3.31265
10	30	118	52	170	40	6	6	7.0452	3.016	5.0306
11	51	112	56	170	40	6	6	3.345	2.4295	2.88725
12	14	118	56	170	40	6	8	5.85	3.28	4.565
13	33	112	52	190	40	6	6	5.238	2.835	4.0365
14	27	118	52	190	40	6	8	8.1594	3.241	5.7002
15	11	112	56	190	40	6	8	4.2975	2.7165	3.507
16	36	118	56	190	40	6	6	6.9558	2.9955	4.97565
17	20	112	52	170	20	8	8	4.8078	2.6555	3.73165
18	35	118	52	170	20	8	6	6.8634	3.054	4.9587
19	24	112	56	170	20	8	6	3.546	2.4495	2.99775
20	6	118	56	170	20	8	8	5.9838	2.9705	4.47715
21	47	112	52	190	20	8	6	5.2896	2.538	3.9138
22	12	118	52	190	20	8	8	8.1474	2.9445	5.54595
23	46	112	56	190	20	8	8	4.1799	2.464	3.32195
24	28	118	56	190	20	8	6	7.1376	2.8915	5.01455
25	13	112	52	170	40	8	6	3.864	1.9665	2.91525
26	1	118	52	170	40	8	8	5.9904	2.4765	4.23345
27	18	112	56	170	40	8	8	2.814	1.876	2.345
28	48	118	56	170	40	8	6	4.668	2.541	3.6045
29	37	112	52	190	40	8	8	3.828	2.1085	2.96825
30	4	118	52	190	40	8	6	6.7362	2.577	4.6566
31	44	112	56	190	40	8	6	3.6684	1.9005	2.78445
32	22	118	56	190	40	8	8	5.4912	2.458	3.9746
33	32	110	54	180	30	7	7	3.2328	1.461	2.3469
34	41	120	54	180	30	7	7	6.012	2.611	4.3115
35	3	115	50	180	30	7	7	5.49	2.46	3.975
36	10	115	58	180	30	7	7	4.059	2.169	3.114
37	39	115	54	160	30	7	7	4.554	2.284	3.419
38	42	115	54	200	30	7	7	5.2632	2.499	3.8811
39	7	115	54	180	10	7	7	4.9944	2.625	3.8097
40	49	115	54	180	50	7	7	3.4311	1.686	2.55855
41	5	115	54	180	30	4	7	5.9463	2.398	4.17215
42	16	115	54	180	30	10	7	5.058	2.454	3.756
43	25	115	54	180	30	7	4	5.6421	2.58	4.11105
44	43	115	54	180	30	7	10	5.6625	2.52	4.09125
45	19	115	54	180	30	7	7	5.706	2.5135	4.10975
46	21	115	54	180	30	7	7	5.9643	2.5105	4.2374
47	17	115	54	180	30	7	7	5.7708	2.4605	4.11565
48	52	115	54	180	30	7	7	5.58	2.4235	4.00175
49	50	115	54	180	30	7	7	5.814	2.4925	4.15325
50	29	115	54	180	30	7	7	5.8764	2.467	4.1717
51	2	115	54	180	30	7	7	5.6079	2.415	4.01145
52	23	115	54	180	30	7	7	5.8458	2.3395	4.09265

3 TOPSIS Methodology

TOPSIS is a multi-criteria decision-making technique used to rank alternatives based on their distance from ideal and negative ideal solutions [19].

Step 1: Formation of Decision Matrix

The experimental results are arranged in matrix form.

Step 2: Normalization of Decision Matrix

The normalized value is calculated using:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (3)$$

Step 3: Weighted Normalized Decision Matrix

The weighted normalized matrix is calculated as: $v_{ij} = w_j \times r_{ij}$ (4)

Where: w_j is the weight assigned to each criterion.

Step 4: Determination of Ideal and Negative Ideal Solutions

Positive ideal solution: $A^+ = \{v_1^+, v_2^+, \ldots v_n^+\}$ (5)

Negative ideal solution: $A^- = \{v_1^-, v_2^-, \ldots v_n^-\}$ *(6)*

Step 5: Separation Measures

Distance from positive ideal solution: $S_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}$ (7)

Distance from negative ideal solution: $S_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}$ (8)

Step 6: Closeness Coefficient

$CC_i = \frac{S_i^-}{S_i^+ + S_i^-}$ (9)

Higher closeness coefficient indicates better performance.

4 Result and Discussion

TOPSIS method proposed by Hwang and Yoon in 1981 is one of the suitable techniques to handle multi response problems in manufacturing applications. The basic concept of this method is to identify the best alternative or appropriate alternative that has the shortest distance from the positive ideal solution and the farthest distance from negative ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes adverse criteria, whereas the negative ideal solution minimizes the benefit criteria and maximizes the adverse criteria. In the present study, maximizing MRR and minimizing SR and KW are considered as the objectives.

In this study, 52 x 3 performance matrix was prepared based on the experimental results enlisted in Table 3 . Then, apply Equation (3) to find normalized value of all attributes as shown in Table 4.

TABLE 4. Normalized assessment values (Yi)

SR.	MRR	SR	KW
1	0.113572296	0.136189242	0.121046
2	0.212881354	0.171963543	0.200656
3	0.093857588	0.143622522	0.109819
4	0.196166397	0.174222419	0.189864
5	0.151299932	0.161956194	0.155124
6	0.247421754	0.188327265	0.22958
7	0.129126293	0.157517239	0.138466
8	0.196786538	0.181892093	0.192706
9	0.094867119	0.140706995	0.109596
10	0.169341702	0.15843655	0.166432
11	0.080401975	0.127626524	0.095522
12	0.140613319	0.172305001	0.151028
13	0.125903003	0.148928255	0.133544
14	0.196123131	0.170256252	0.188585
15	0.103296708	0.142703212	0.116026
16	0.167192842	0.157359643	0.164614

17	0.115562516	0.139498759	0.123458
18	0.164971873	0.160432766	0.164054
19	0.085233304	0.128677164	0.099178
20	0.143829398	0.156046343	0.148122
21	0.127143284	0.133326248	0.129484
22	0.195834694	0.154680511	0.183482
23	0.100470019	0.129438879	0.109903
24	0.171562671	0.151896314	0.165901
25	0.0928769	0.103304202	0.096448
26	0.143988039	0.130095529	0.140059
27	0.067638612	0.098550055	0.077582
28	0.112202218	0.133483844	0.119251
29	0.092011587	0.110763748	0.098202
30	0.161914434	0.135374996	0.154059
31	0.088175368	0.09983709	0.092121
32	0.131989036	0.129123687	0.131496
33	0.077705083	0.07674927	0.077645
34	0.144507227	0.137161084	0.142642
35	0.131960192	0.129228751	0.131509
36	0.097564011	0.113941935	0.103024
37	0.109462061	0.119983116	0.113114
38	0.126508722	0.131277499	0.128402
39	0.12004772	0.137896533	0.12604
40	0.082471514	0.088568973	0.084647
41	0.142928031	0.125971766	0.138031
42	0.121576439	0.128913559	0.124263
43	0.135616138	0.135532592	0.13601
44	0.136106482	0.132380671	0.135355
45	0.137152068	0.132039213	0.135967
46	0.143360687	0.131881617	0.14019
47	0.138709631	0.129255017	0.136162
48	0.134123474	0.127311332	0.132394
49	0.139748007	0.130936041	0.137406
50	0.141247882	0.129596475	0.138017
51	0.134794091	0.12686481	0.132715
52	0.140512366	0.122898643	0.135401

In order to determine the relative normalized weight of each criterion of WEDM, a pair-wise comparison matrix as shown in Table 5 is developed using AHP method. The criteria weights are obtained as $W_{MRR} = 0.7305$, $W_{SR} = 0.1883$ and $W_{KW} = 0.0809$, respectively[20]. The value of CR is calculated as 0.0608 which is less than the allowed value of CR (=0.1), indicating the fact that there is a good consistency in the judgments made by the decision maker while assigning values in the pair-wise comparison matrix. then after the weighted normalized matrix, V52 x3, is calculated by Equitation (4) as shown in table 6.

Table 5. Pair-wise comparison matrix

CRITERIA	C1	C2	C3
C1	1	5	7
C2	1/5	1	3
C3	1/7	1/3	1

TABLE 6. Weighted normalized matrix (Vij)

SR.	MRR	SR	KW
1	0.082964562	0.025644434	0.007359601
2	0.155509829	0.032380735	0.01219989
3	0.068562968	0.027044121	0.006676996
4	0.143299553	0.032806082	0.011543736
5	0.1105246	0.030496351	0.009431554
6	0.180741592	0.035462024	0.01395845
7	0.094326757	0.029660496	0.00841876
8	0.143752566	0.034250281	0.011716525
9	0.069300431	0.026495127	0.006663418
10	0.123704113	0.029833602	0.010119087
11	0.058733643	0.024032075	0.005807723
12	0.10271803	0.032445032	0.009182529
13	0.091972144	0.02804319	0.008119448
14	0.143267947	0.032059252	0.011465992
15	0.075458245	0.026871015	0.007054355
16	0.122134371	0.029630821	0.010008554
17	0.084418418	0.026267616	0.00750624
18	0.120511953	0.03020949	0.009974459
19	0.062262929	0.02422991	0.006029995
20	0.105067375	0.029383526	0.009005818
21	0.092878169	0.025105332	0.007872636
22	0.143057244	0.02912634	0.011155717
23	0.073393349	0.024373341	0.006682125
24	0.125326531	0.028602076	0.010086802
25	0.067846576	0.019452181	0.005864046
26	0.105183262	0.024496988	0.008515614
27	0.049410006	0.018556975	0.004716984
28	0.08196372	0.025135008	0.007250477
29	0.067214465	0.020856814	0.005970655
30	0.118278494	0.025491112	0.009366783
31	0.064412106	0.018799324	0.00560094
32	0.096417991	0.02431399	0.007994935
33	0.056763563	0.014451888	0.004720806
34	0.105562529	0.025827432	0.008672612
35	0.09639692	0.024333774	0.00799574
36	0.07127051	0.021455266	0.006263833
37	0.079962035	0.022592821	0.006877342
38	0.092414621	0.024719553	0.007806859
39	0.087694859	0.025965917	0.007663238
40	0.060245441	0.016677538	0.005146541
41	0.104408927	0.023720484	0.008392309
42	0.088811589	0.024274423	0.00755522
43	0.099067589	0.025520787	0.008269405
44	0.099425785	0.02492728	0.008229578
45	0.100189586	0.024862984	0.008266791
46	0.104724982	0.024833309	0.008523559
47	0.101327386	0.02433872	0.008278658
48	0.097977198	0.023972724	0.008049548
49	0.102085919	0.024655257	0.008354291

50	0.103181578	0.024403016	0.008391403
51	0.098467084	0.023888644	0.008069059
52	0.102644283	0.023141814	0.008232394

The ideal (best) and negative ideal (worst) solutions are calculated using "(5)," and "(6)," respectively as listed.

$A^{+}_{MRR} = 0.180741591555317$ $A^{-}_{MRR} = 0.0494100060850104$

$A^{+}_{SR} = 0.0354620239214862$ $A^{-}_{SR} = 0.0144518875730241$

$A^{+}_{KW} = 0.0185730032667697$ $A^{-}_{KW} = 0.00627638128637975$

Using "(7)," and "(8)," the separation measures of each criterion from the ideal and negative ideal solutions are computed as shown in Table 7 and the relative closeness co-efficient (CCi) value for each combination of factors of WEDM has been calculated by "(9)," as shown in Table 7.

TABLE 7. Separation Measures and closeness co-efficient (CCi) value

SR.	Si+	Si-	CCi
1	0.098693741	0.039633948	0.71347784
2	0.031290813	0.109902	0.221617604
3	0.113173752	0.029481836	0.793335569
4	0.041987741	0.098238734	0.299428054
5	0.072280156	0.06649659	0.520837661
6	0.021503574	0.135198549	0.137225799
7	0.088004353	0.051511129	0.63078557
8	0.042248937	0.09910463	0.298888369
9	0.112381129	0.029558503	0.791752995
10	0.059329884	0.078610697	0.430111892
11	0.12269414	0.021475396	0.85104068
12	0.080325833	0.060253889	0.571389898
13	0.090069356	0.048654128	0.649272589
14	0.041690832	0.097992152	0.298467505
15	0.106296679	0.034274993	0.756174254
16	0.060794993	0.077055391	0.441021574
17	0.097320607	0.041204352	0.702549259
18	0.062510622	0.075716549	0.452231075
19	0.119187067	0.023402476	0.835875227
20	0.077388944	0.061029298	0.559094978
21	0.088776524	0.048115737	0.648513828
22	0.040718918	0.096990098	0.295688108
23	0.108097456	0.031071448	0.776735699
24	0.05744784	0.07976623	0.418673103
25	0.113318071	0.023629407	0.827456427
26	0.076483635	0.059298687	0.563281242
27	0.131736618	0.013839991	0.904929841
28	0.099634233	0.0385105	0.721230777
29	0.11401667	0.02406376	0.825726499
30	0.063684569	0.072083658	0.469068281
31	0.116729736	0.020595065	0.85002662
32	0.085166135	0.051034677	0.625298291
33	0.124322681	0.01220013	0.910636693

34	0.076293541	0.060119912	0.559281647
35	0.085189347	0.051022924	0.625416098
36	0.109996942	0.027576158	0.799552691
37	0.101396319	0.035463209	0.740878771
38	0.089192473	0.047529433	0.65236417
39	0.094029269	0.043885391	0.681793138
40	0.120848523	0.016144535	0.882150705
41	0.077155395	0.058305422	0.569577216
42	0.092728346	0.044079856	0.677798147
43	0.082684313	0.053956403	0.605122069
44	0.082252025	0.054058973	0.603414444
45	0.081485763	0.05474512	0.598144569
46	0.076982632	0.058982227	0.566195063
47	0.080290885	0.055615756	0.590779702
48	0.083577185	0.052351328	0.614861317
49	0.079577278	0.05644038	0.585051082
50	0.078457866	0.057379641	0.577586177
51	0.083080614	0.052776754	0.611528215
52	0.078843589	0.05644219	0.582792883

This relative closeness to ideal solution can be considered as the WEDM performance suitability index (WPSI). The alternatives are arranged in descending order of their WPSI. This can be arranged as: 33-27-40-11-31-19-25-29-36-3-9-23-15-37-28-1-17-39-42-38-13-21-7-35-32-48-51-43-44-45-47-49-52-50-12-41-46-26-34-20-5-30-18-16-10-24-4-14-8-22-2-6

From these values of index, it is understood that the WEDM process parameter designated as alternative 33 is the first right choice; alternative 27, the second choice; and alternative 6, the last choice for the given application under the given conditions. The optimal WEDM process parameters relative to alternative 33 are as: Pulse ON Time (A), 110 mu; Pulse OFF Time (B), 54 mu, Peak Current (C), 180 A; Spark Gap Set Voltage (D), 30 Volts; Wire Feed (E), 7 mm/min and wire tension (F), 7 mm/min; MRR, SR and KW are: 3.2328 mm^3/min, 1.461 µm and 2.3469 µm respectively. However, it may be mentioned that the ranking depends upon the judgements of relative importance made by the designer. The ranking presented may change if the designer assigns different relative importance values to the attributes.

TABLE 8. Optimum Process parameters for multi-objective optimizations and confirmation experiment results

Optimum Process Parameters						**Response Predicted**		
Ton	Toff	IP	SV	WF	WT	MRR	SR	KW
110	54	180	30	7	7	3.2328	1.461	2.3469

From the above discussions, it can be concluded that for the above considered decision making problems, the TOPSIS method fulfils almost all the conditions as cited by Hwang and Yoon [21], and hence, this method would be quite robust under diverse manufacturing environment.

5 CONCLUSIONS

The paper represents the selection of optimum process parameters in WEDM process by considering the experimental results in terms of linguistic variables in order to avoid the uncertainty involved in it for maximizing the material removal rate and minimizing the surface roughness and kerf of the desired work piece. The suggested multi-response approach using TOPSIS method in combination with response surface methodology is quite capable for any type of optimization problem involving any number of responses. The TOPSIS method can consider all the attributes along with their relative importance, and hence, it can provide a better

accurate evaluation of the alternatives. This method is computationally very simple, easily comprehendible, and robust which can simultaneously consider any number of quantitative and qualitative selection attributes, while offering a more objective and logical selection approach. Application of this method in a wider range of selection problems in real-time environment remains as a future research scope of this paper.

6 References:

1. Abdullaha AC, Pusppanathana J, qah Saidina S, Nugrohob B, Idrisd N. Optimum Material Removal in Electrical Discharge Machining through Advanced Control Integration of PSoC Microcontroller. Jurnal Kejuruteraan. 2025;37(1):1-1. https://doi.org/10.17576/jkukm-2025-37(1)-01
2. Saha S, Maity SR, Dey S, Dutta S. Modeling and combined application of MOEA/D and TOPSIS to optimize WEDM performances of A286 superalloy. Soft Computing. 2021 Dec;25(23):14697-713. https://doi.org/10.1007/s00500-021-06264-5.
3. Sarala Rubi C, Prakash JU, Juliyana SJ, Čep R, Salunkhe S, Kouril K, Ramdas Gawade S. Comprehensive review on wire electrical discharge machining: a non-traditional material removal process. Frontiers in Mechanical Engineering. 2024 Jan 23;10:1322605. https://doi.org/10.3389/fmech.2024.1322605.
4. Jagadeesha T, Kunar S. Electric Discharge Machining. Advanced Machining and Micromachining Processes. 2025 Apr 8:47-63. https://books.google.co.in/books?id=E99MEQAAQBAJ&lpg=PT18&ots=xLeLk1hynf&lr&pg=PT18#v=onepage&q&f=false
5. Singh B, Misra JP. A CRITICAL REVIEW OF WIRE ELECTRIC DISCHARGE MACHINING. DAAAM International Scientific Book. 2016 Jan 1. https://doi.org/10.2507/daaam.scibook.2016.23.
6. Gadakh VS. Parametric optimization of wire electrical discharge machining using TOPSIS method. Advances in Production Engineering & Management. 2012 Sep 1;7(3):157. https://dx.doi.org/10.14743/apem2012.3.138.
7. Zhang J, Zheng Z, Huang K, Lin C, Huang W, Chen X, Xiao J, Xu J. Field-assisted machining of difficult-to-machine materials. International Journal of Extreme Manufacturing. 2024 Jun 1;6(3):032002. https://dx.doi.org/10.1088/2631-7990/ad2c5e.
8. Hagag AM, Yousef LS, Abdelmaguid TF. Multi-criteria decision-making for machine selection in manufacturing and construction: Recent trends. Mathematics. 2023 Jan 26;11(3):631. https://doi.org/10.3390/math11030631.
9. Sahoo SK, Goswami SS. A comprehensive review of multiple criteria decision-making (MCDM) methods: advancements, applications, and future directions. Decision making advances. 2023 Jun 28;1(1):25-48. https://doi.org/10.31181/dma1120237
10. Chaube S, Pant S, Kumar A, Uniyal S, Singh MK, Kotecha K, Kumar A. An overview of multi-criteria decision analysis and the applications of AHP and TOPSIS methods. International Journal of Mathematical, Engineering and Management Sciences. 2024;9(3):581. https://doi.org/10.33889/IJMEMS.2024.9.3.030.
11. Nguyen NT, Van Nam H, Nguyen AT, Le NT. A Hybrid Modeling and Optimization Framework for Finish Milling Using SVR, NSGA-II, and Entropy-Based TOPSIS. Engineering, Technology & Applied Science Research. 2025 Aug 2;15(4):24594-9. https://doi.org/10.48084/etasr.11422.
12. Diviya M, Joel JJ, Subramanian M, Balasubramanian T, Madhusuthan AV, Monish N, Hasan N. Parametric investigation of W-EDM factors for machining AM60B conductive biomaterial. Scientific Reports. 2024 Jan 2;14(1):216. https://doi.org/10.1038/s41598-023-50777-y.
13. Patel SS, Prajapati JM. Experimental investigation of surface roughness and kerf width during machining of blanking die material on wire electric discharge machine.

International Journal of Engineering, Transactions A: Basics. 2018 Oct 1;31(10):1760-6. https://doi.org /10.5829/ije.2018.31.10a.19.

14. Bobbili R, Madhu V, Gogia AK. Multi response optimization of wire-EDM process parameters of ballistic grade aluminium alloy. Engineering science and technology, an international journal. 2015 Dec 1;18(4):720-6. https://doi.org/10.1016/j.jestch.2015.05.004
15. Shandilya P, Tiwari A. Artificial neural network modeling and optimization using genetic algorithm of machining process. Journal of Automation and Control Engineering Vol. 2014 Dec;2(4). https://doi.org/10.12720/joace.2.4.348-352.
16. Alias A, Abdullah B, Abbas NM. Influence of machine feed rate in WEDM of titanium Ti-6Al-4 V with constant current (6A) using brass wire. Procedia Engineering. 2012 Jan 1;41:1806-11. https://doi.org/10.1016/j.proeng.2012.07.387
17. Kayaroganam P. Response surface methodology-research advances and applications. IntechOpen; 2023. https://doi.org/10.5772/intechopen.102317
18. Kayaroganam P. Response surface methodology in engineering science. 2021 Nov 10. https://doi.org/10.5772/intechopen.90965
19. hou Z, Chen D, Xie S (Shengquan). Springer Series in Advanced Manufacturing [Internet]. Thermoplastics and Thermoplastic Composites. 2007. 863–866 p. Available from: http://www.springer.com/series/7113%0Ahttp://linkinghub.elsevier.com/retrieve/pii/B9781856174787500118
20. Nayak BB, Mahapatra SS. Multi-response optimization of WEDM process parameters using the AHP and TOPSIS method. International Journal on Theoretical and Applied Research in Mechanical Engineering. 2013;2(3):109–15.
21. S. J. Chen and C. L. Hwang, “Fuzzy Multiple Attribute Decision Making,” Springer Verlag, Berlin Heildelberg, New York, 1992.