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Multi-Objective Optimization of PMEDM Process Parameter by Topsis Method

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ABSTRACT

In this study, MRR, SR, and HV in powder mixed electrical discharge machining (PMEDM) were multi – criteria decision making (MCDM) by TOPSIS method. The process parameters used included work piece materials, electrode materials, electrode polarity, pulse–on time, pulse–off time, current, and titanium powder concentration. Some interaction pairs among the process parameters were also used to evaluate. The results showed that optimal process parameters, including ton = 20 µs, I= 6 A, tof = 57 µs, and 10 g/l. The optimum characteristics were MRR = 38.79 mm^3/min, SR = 2.71 µm, and HV = 771.0 HV.

Keywords: *PMEDM, TOPSIS, MRR, HV, SR*

1. INTRODUCTION

Conductive powder is often mixed into dielectric fluid in electrical discharge machining (EDM) because it is an effective solution for improving productivity and the machined surface quality after machining [1]. Many types of powder materials have been used, such as Al, Si, SiC, etc. [2]. They are mixed into dielectric fluid to improve the material removal rate (MRR), surface roughness (SR), and electrode wear ratio (EWR) in EDM. Recently, the Taguchi method has been combined with several other methods, such as grey relational analysis (GRA), TOPSIS, particle swarm optimization (PSO), and fuzzy logic [3]. This has contributed to improving the efficiency of the optimization problem in PMEDM.

Recent research has shown that Taguchi combined with several other methods, such as GRA, TOPSIS, and PSO, can MCDM in EDM, and results have been good.

Taguchi-GRA has been used to simultaneously optimize MRR, EWR, and OC expenditures in micro-EDM of CP Ti [4]. SR and kerf width have been optimized simultaneously in WEDM using Taguchi–GRA [5]. Taguchi–GRA was used to simultaneously optimize MRR, SR, recast layer thickness (RLT) and micro hardness (HV) in PMEDM of H11 die steel [6]. Many quality indicators have been optimized by Taguchi–GRA in dry EDM using a Cu electrode of AISI D2 steel [7]. In addition, the surface topography of H11 steel was significantly improved. The TOPSIS method has been used to MCDM in both traditional machining (milling, turning, drilling, grinding), non-traditional machining (EDM, abrasive jet machining, micromachining) and many other areas [8]. TOPSIS algorithms can simultaneously optimize a large number of quality characteristics, and its optimal results are better than other methods, such as Taguchi and GRA.

This study presents the results of simultaneous optimization of the MRR, SR, and HV in PMEDM. The Taguchi–TOPSIS method, seven process parameters, and three kinds of interactions between them were studied.

2. Experimental setup and methods

In this study, an electrical discharge machine, the AG40L (Sodick, Inc. USA), was used to perform the experiment. Ti powder was mixed into the dielectric fluid (oil HD-1) during the experimental process. Work piece dimensions were 45×27×10 mm. The electrode materials were Cu and Gr. Seven factors were considered as shown in Table 1. Experimental results are shown in Table 2.

The weight different of work pieces before and after the performance trial were measured by an electronic scale, AJ 203 (Shinko Denshi Co. LTD – Japan). Its accuracy was ±0.001 g. The SRwas measured by a strain gauge transducer contact, SJ – 301 (Mitutoyo – Japan). The surface hardness (HV) was measured by 1106 Met Indenta (Buehler Motor, USA). The surface morphology was verified by scanning electron microscope (SEM) JEOL 6490 (Jeol - Japan).

Table 1. Input parameters and levels

Factors	Symbols	Level		
		1	2	3
Pulse-on time (µs)	A	5	10	20
Current (A)	B	8	4	6
Pulse-off time (µs)	C	38	57	85
Powder concentration Ti (g/l)	D	0	10	20

Table 2. Results of experiments

Exp.	A	B	C	D	MR (mm^3 / min)	SR (µm)	HV (HV)
1	1	1	1	1	10.262	3.56	482.4
2	1	1	2	2	8.643	2.96	602
3	1	1	3	3	2.766	2.46	591.3
4	1	2	1	2	10.211	3.72	507.0
5	1	2	2	3	14.283	3.55	810.3
6	1	2	3	1	0.036	1.43	566
7	1	3	1	3	37.599	4.60	524.3
8	1	3	2	1	23.598	3.24	727.1
9	1	3	3	2	44.02	4.29	673.0
10	2	1	1	2	19.586	4.27	490.3
11	2	1	2	3	4.025	2.11	772.3
12	2	1	3	1	17.407	3.03	699.2
13	2	2	1	3	10.391	3.33	599.2
14	2	2	2	1	0.355	1.92	624.3
15	2	2	3	2	26.748	4.37	641.7
16	2	3	1	1	30.09	4.65	470.8
17	2	3	2	2	62.561	4.36	846.6
18	2	3	3	3	16.739	2.70	685.8
19	3	1	1	3	0.999	2.45	498.4
20	3	1	2	1	20.954	4.33	672.8
21	3	1	3	2	4.955	2.36	560.9
22	3	2	1	1	0.209	2.09	441.9
23	3	2	2	2	6.652	2.72	560.9
24	3	2	3	3	18.79	3.65	672.8
25	3	3	1	2	10.544	3.25	453.0
26	3	3	2	3	25.126	3.30	680.8
27	3	3	3	1	54.091	5.55	791.6

3. Results and discussion

Step1–The decision matrix: The indicators selected for optimization in PMEDM, the assigned quality characteristics, are as follows: x_{MRR} with MRR, x_{SR} with SR, and x_{HV} with HV.

$$X=\begin{bmatrix} MRR_1 & SR_1 & HV_1 \\ MRR_2 & SR_2 & HV_2 \\ . & . & . \\ . & . & . \\ . & . & . \\ MRR_{27} & SR_{27} & HV_{27} \end{bmatrix}$$

Step 2–The normalized decision matrix: The normalized values are showed in Table 3

Table 3. Normalized data

Exp	A	B	C	D	E	F	G	Vector normalization		
								x_{i1}	x_{i2}	x_{i3}
1	1	1	1	1	1	1	1	0.088	0.183	0.154
2	1	1	2	2	2	2	2	0.068	0.176	0.201
3	1	1	3	3	3	3	3	0.026	0.140	0.177
4	1	2	1	2	2	3	3	0.086	0.194	0.151
5	1	2	2	3	3	1	1	0.120	0.198	0.252
6	1	2	3	1	1	2	2	0.001	0.079	0.192
7	1	3	1	3	3	2	2	0.314	0.262	0.166
8	1	3	2	1	1	3	3	0.197	0.177	0.228
9	1	3	3	2	2	1	1	0.325	0.238	0.191
10	2	1	1	2	3	2	3	0.158	0.228	0.155
11	2	1	2	3	1	3	1	0.032	0.112	0.207
12	2	1	3	1	2	1	2	0.121	0.175	0.202
13	2	2	1	3	1	1	2	0.089	0.183	0.166
14	2	2	2	1	2	2	3	0.003	0.112	0.207
15	2	2	3	2	3	3	1	0.197	0.250	0.199
16	2	3	1	1	2	3	1	0.200	0.250	0.143

17	2	3	2	2	3	1	2	0.500	0.243	0.276
18	2	3	3	3	1	2	3	0.144	0.150	0.208
19	3	1	1	3	2	3	2	0.010	0.140	0.162
20	3	1	2	1	3	1	3	0.174	0.236	0.190
21	3	1	3	2	1	2	1	0.037	0.135	0.192
22	3	2	1	1	3	2	1	0.002	0.124	0.142
23	3	2	2	2	1	3	2	0.057	0.158	0.166
24	3	2	3	3	2	1	3	0.165	0.192	0.187
25	3	3	1	2	1	1	3	0.089	0.177	0.136
26	3	3	2	3	2	2	1	0.217	0.177	0.207
27	3	3	3	1	3	3	2	0.455	0.309	0.253

Step 3–The weighted normalized decision matrix: W_{MRR} = 0.2 for MRR, W_{SR} = 0.4 for SR, W_{HV} = 0.4 for HV. The weighted decision-making matrix is shown in Table 7.

Step 4–The positive ideal solutions (PIS) and negative ideal solutions (NIS): Shown in Table 4.

Table 4. PIS and NIS

	MRR	SR	HV
A+	0.0999	0.0317	0.1105
A-	0.0001	0.1237	0.0542

Step 5–The separation measures: Shown in Table 7.

Step 6–The relative closeness to the ideal solution: The relative closeness index is calculated using Eq.11, and shown in Table 7.

Step 7–Ranking: The results clearly show that the 17th run is getting the first rank and good performance of the alternative A_i (Table 5).

Table 5. TOPSIS values using vector normalization

Exp.	y_{i1}	y_{i2}	y_{i3}	S_i^+	S_i^-	C_i^*	Rank
1	0.01756	0.07332	0.06170	0.10438	0.16869	0.618	21
2	0.02736	0.07026	0.08024	0.08755	0.19857	0.694	12
3	0.00528	0.05603	0.07082	0.10546	0.22707	0.683	14
4	0.01714	0.07770	0.06048	0.10708	0.15418	0.590	25
5	0.02395	0.07901	0.10094	0.08998	0.22735	0.716	9
6	0.00015	0.03174	0.07670	0.10534	0.30825	0.745	5
7	0.06273	0.10462	0.06631	0.09300	0.14628	0.611	22
8	0.03947	0.07091	0.09113	0.07459	0.23051	0.756	2
9	0.06504	0.09521	0.07625	0.08012	0.17801	0.690	13
10	0.03162	0.09105	0.06207	0.10262	0.12609	0.551	26
11	0.00646	0.04487	0.08275	0.09837	0.27525	0.737	6
12	0.02427	0.07004	0.08088	0.08982	0.20423	0.695	11
13	0.01776	0.07332	0.06649	0.10206	0.17240	0.628	19
14	0.00054	0.04465	0.08271	0.10400	0.27556	0.726	8
15	0.03948	0.10003	0.07978	0.09623	0.14349	0.599	23
16	0.03999	0.10003	0.05721	0.10534	0.11101	0.513	27
17	0.09991	0.09740	0.11052	0.06566	0.29764	0.819	1
18	0.02873	0.05997	0.08323	0.08129	0.23817	0.746	4
19	0.00210	0.05581	0.06463	0.11070	0.22270	0.668	17
20	0.03474	0.09433	0.07605	0.09672	0.14151	0.594	24
21	0.00732	0.05384	0.07692	0.10095	0.24072	0.705	10
22	0.00033	0.04947	0.05699	0.11444	0.24021	0.677	15
23	0.01136	0.06325	0.06629	0.10388	0.20146	0.660	18
24	0.03296	0.07661	0.07475	0.08818	0.18163	0.673	16
25	0.01783	0.07070	0.05424	0.10688	0.17495	0.621	20
26	0.04348	0.07091	0.08295	0.07402	0.21779	0.746	3
27	0.09102	0.12366	0.10139	0.09281	0.1402	0.729	7

From the above tables, it is clear that the 17th running receives the 1st rank. Hence, the corresponding input parameters such as ton = 20 µs, I= 6 A, tof = 57 µs, and 10 g/l were found to be the optimum combination.

4. Conclusion

In this study, MRR, SR, and HV in PMEDM using Ti powder have been MCDM by the TOPSIS method. The results of multi-criteria optimization in PMEDM using powder Ti show that: Optimal results using the TOPSIS method show that the 17th experiment was the best. However, values of the S/N ratio show that the optimal combination is ton =5 µs, I = 4A, tof = 57 µs, and 10 g/l. Optimal values are MRR = 38.79 mm³/min, SR = 2.71 µm, and HV = 771 HV.

References

[1]. Anirban B, Ajay B (2012) Effect of process variables on microhardness, grain size and strain during machining of various die steels with powder-mixed electric-discharge machining using dummy treated experimental design. Proc IME Part B: Journal of Engineering Manufacture 226: 1192-1204.

[2]. Gangadharudu T, Soumya G (2016) Effect of impregnated powder materials on surface integrity aspects of Inconel 625 during electrical discharge machining. Proc IME Part B: Journal of Engineering Manufacture: 1-14.

[3]. Mai C, Hocheng H, Huang S (2012) Advantages of carbon nanotubes in electrical discharge machining, International Journal of Advanced Manufacturing Technologyl 59, pp 111–117.

[4]. Ramesh S, Jenarthanan MP, Bhuvanesh KAS (2018) Experimental investigation of powdermixed electric dis chargemachining of AISI P20 steel using different powde rs and toolmaterials.Multidiscipline Modeling in Materials and Structures, https://doi.org/10.1108/MMMS-04-2017-0025

[5]. Gangadharudu T, Gangopadhayay S, Biswas CK (2017) State of the art in powder-mixed electric discharge machining: A review. Proc IME Part B: Journal of Engineering Manufacture 231: 2511-2526.

[6]. Shalini Mohanty, Ankan Mishra, B.K. Nanda, B.C. Routara (2017) Multi-objective parametric optimization of nano powder mixed electrical discharge machining of AlSiCp using response surface methodology and particle swarm optimization. Alexandria Engineering Journal: 3-11, https://doi.org/10.1016/j.aej.2017.02.006.

[7]. Assarzadeh S, Ghoreishi M (2013) A dual response surface-desirability approach to process modeling and optimization of Al2O3 powder-mixed electrical discharge machining parameters, The International Journal of Advanced Manufacturing Technology 64: 1459–1477.

[8]. Phan NH, Dong PV, Vu NN (2018) Application of TOPSIS to Taguchi method for multi-characteristic optimization of electrical discharge machining with titanium powder mixed into dielectric fluid, The International Journal of Advanced Manufacturing Technology, Vol.98(5-8), pp 1179–1198.

[9]. Long BT, Cuong NN, Phan NH, Vijaykumar SJ (2016) Optimization of PMEDM process parameter for maximizing material removal rate by Taguchi's method, International Journal of Advanced Manufacturing Technology, Vol. 87(5-8), pp 1929–1939.

[10]. Long BT, Cuong NN, Phan NH, Toan ND (2016) Surface quality analysis of die steels in powder mixed electrical discharge machining using titanium powder in fine machining, Advances in Mechanical Engineering.

[11]. Long BT, Cuong NN, Phan NH, Toan ND (2018) Multi-Characteristic Optimization of PMEDM Process Using Taguchi Method and Grey Relational Analysis for Die Steel Materials, Proc IMechE, Part E: Journal of Process Mechanical Engineering, Vol.8(7).

[12]. Toan ND, Phan NH, Long BT, (2018) Die steel surface layer quality improvement in titanium µ-powder mixed die sinking electrical discharge machining, International Journal of Advanced Manufacturing Technology, https://doi.org/10.1007/s00170-018-2887-8

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