Journal of Manufacturing Engineering, September 2018, Vol. 13, Issue. 3, pp 122-129

EXPERIMENTAL INVESTIGATION ON EDM MACHINING PARAMETERS OF AL/ALUMINA COMPOSITE AND OPTIMIZATION BY GENETIC ALGORITHM

***Vijayalakshmi P[1], Suresh S[2], Iniyaraja B[3] and Sivalingam A[4]**

[1] PG scholar, [2] Assistant Professor, Department of Mechanical Engineering, Jayalakshmi Institute of Technology,Thoppur
[3,4] Assistant Professor, Department of Mechanical Engineering, Sona College of Technology, Salem

ABSTRACT

Metal Matrix Composites (MMCs) are extremely difficult to Machine using conventional manufacturing processes due to heavy tool wear caused by the presence of the hard particle reinforcement in the metallic matrix. Electro Discharge Machining (EDM) is capable of machining geometrically complex or hard material components. Since the machining cost is so high, it becomes necessary to find out the best combination of parameters before the material is put in to production. The machining information for the particle-reinforced material using EDM is inadequate. This paper presents details and results of an investigation in to the machinability and selection of optimal parametric combination for Alumina (Al_2O_3) particle reinforced aluminium matrix composites using Electro Discharge Machining process. Genetic Algorithm is used to optimize the objectives such as Metal Removal Rate (MRR) and Surface Roughness (R_a) with parameters Current(I),Pulse on Time(T ON),Pulse off Time(T OFF),Gap control voltage(V)and Flush Pressure(P). The deviation of actual results from the predicted results are in the negligible range.

Keywords: *Keywords: EDM, Alumina and Genetic Algorithm*

1. Introduction

Joze Valemtinicic et.al discussed in his work how to achieve the high removal rate and low electrode wear when roughing by the sinking electrical discharge machining process (EDM)[1].The selection of the machining parameters is based on the acquisition of only one process attribute. M.Rozenek et.al conducted the experimental investigations of the effect of machining parameters (discharge current, pulse-on time, pulse-off time, voltage) on the machining feed rate and surface roughness during wire electrical discharge machining (WEDM) of metal matrix composite $AlSi_7Mg/SiC$ and $AlSi_7Mg/Al_2O_3$[2-3]. J.C.Su J et.al used neural network to establish the relationship between the process parameters and machining performance [4-6]. Genetic algorithms with properly defined objective functions were then adapted to the neural network to determine the optimal process parameters.

2. Material Selection

The material selected for the experimental study is as follows, Material: LM4 Al/ 10% wt. Al_2O_3 Metal matrix composite. Composition of Aluminium alloy (LM4) are Copper 2.0-4.0%; Magnesium 0.15% max. ; Silicon 4.0-6.0%; Iron 0.8% max.; Manganese 0.2-0.6%; Nickel 0.3% max.; Lead 0.1% max.; Tin 0.1% max.; Titanium 0.2% max.; Aluminium remaining.

**Corresponding Author - E- mail: bsrivijai@gmail.com*

3. Electro Discharge Machining (EDM)

EDM process parameters as shown in Table.1 are varied according to Taguchi design (L32) and experiment is conducted for the responses Metal Removal Rate(MRR) and Surface Roughness(R_a).

Table 1 Different Cutting parameters and their levels

S.NO	Symbol	Machining parameter	level		units
			Level 1	Level 2	
1	A	Gap current(I)	1	7	amp
2	B	Pulse on time (T ON)	6	7	µs
3	C	Pulse off time (T OFF)	7	6	µs
4	D	Gap control voltage(V)	1	6	volt
5	E	Flush pressure(FP)	5	15	kg/cm^2

 © SME

Three-axes electronic M2S-EMS5030 spark erosion EDM machine as shown in Fig.1 and Fig.2 is used for experimentation.

Figure 1 Spark Erosion EDM (EMS-5030)

The other machining conditions are as follows,

1.Electrode (tool) : 10.2 mm *φ*, copper (cathode)
2.Depth of cut : 2mm
 2 mm
3.Die-electric fluid : EDM oil
4.Die-electric temperature : 22–25 ◦C

Figure 2 Machining in EDM

4. Model Development

Regression analysis is performed to find out the relationship between factors and material removal rate. In conducting regression analysis, it is assumed that factors and the response are linearly related to each other, so the regression equation is as follows,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \quad \text{----- (1)}$$

Where, *Y* is the response and β_i is the regresses of *i*th factor and denotes residual.

The derived regression equation for Metal Removal Rate(MRR):

MRR = - 0.393 + 0.0389 Current + 0.0388 T ON + 0.0245 T OFF + 0.0325 Voltage - 0.0102 Pressure -- (2)

Coefficient of determination R^2 = 95.3%

R^2(adj) = 94.4%

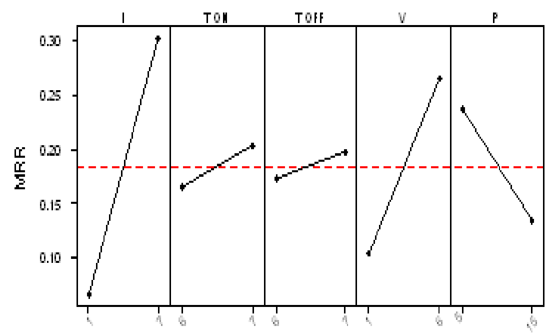

Figure 3 Main effects plot for MRR

The regression equation for Surface Roughness (R_a):

Ra = - 4.68 + 0.583 Current + 1.44 T ON + 0.219 T OFF + 0.0463 Voltage+ 0.0204 Pressure ----------(3)

Coefficient of determination R^2 = 87.8%

R^2(adj) = 85.5%

For maximum MRR, the current intensity is most significant. Gap Control voltage also affects the MRR. For better surface finish the current intensity is most significant. Pulse on Time is also significant.

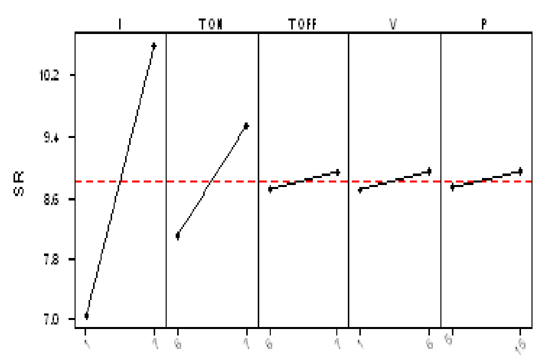

Figure 4 Main Effects plot for Surface Roughness (R_a)

 © SME

5. SEM images

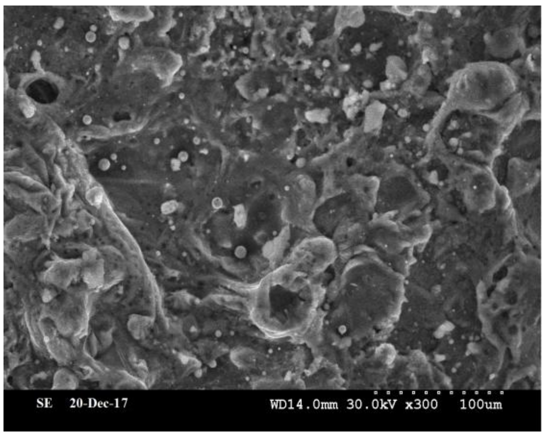

Figure 5 Spot-I Al/Al_2O_3

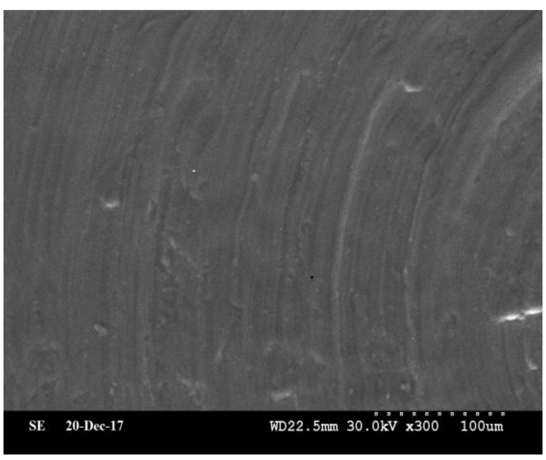

Figure 6 Pure Al

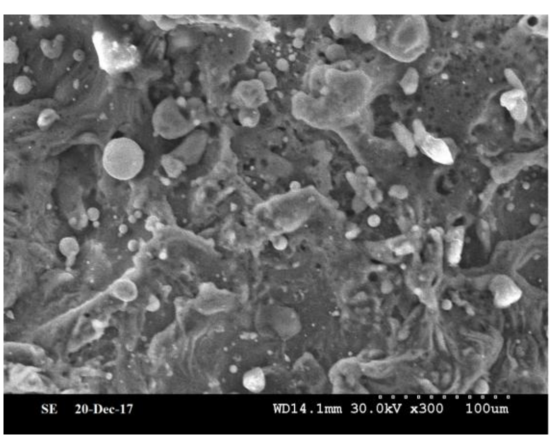

Figure 7 Spot-II Al/ Al_2O_3

Photographs of EDM machined surface of Al/Al_2O_3 composite is shown in Fig. 5 and Fig. 7. It is observed that no flakes, no crater and no particle pull outs on the machines surface as it is there in most machining process. Fig. 6 shows the microstructure of Pure Aluminium alloy surface.

6. Genetic Algorithm

Genetic Algorithm (GA) was developed by John Holland algorithms inspired from the evolution of biological systems. Each individual parameter is represented as a Gene. Combination of all the parameters (Genes) treated as a Chromosome. Group of chromosomes are called population. GA works on the basis of the survival of the fittest principle. Fitness function is the objective function of the problem. The GA operators such as Selection, Cross over and Mutation are performed to obtain the new child offspring.

6.1 Initialization

In our problem, Population size and number of generations considered are 30 and 100 respectively.

Table 2 Parameter values and chrosomes

Parameters	Range	Variables
Current(C)	1 -7 amps	Gene(X_1)
Pulse on Time (T ON)	6 -7µs	Gene(X_2)
Pulse off Time (T OFF)	7 -6µs	Gene(X_3)
Gap control Voltage(V)	1 -6volts	Gene(X_4)
Flushing Pressure(P)	5 -15Kg/cm^2	Gene(X_5)

Variables (Genes) assumed their values in the range of 0-1000.

Parameters are initialized based on the expression,

Parameter Value(X_1) =Min.value+DE_{X1}+DC_{X1} ------ (4)

Where,

DE_{X1}= (Max.value-Min.value)/1000.

DC_{X1}=Variable assumed in the range of 0-1000.

Chromosome No.1 in Table 2 is considered for explanation of working of GA. Chromosome is 483 715 682 995 506.

Current (c) = [1+ (7-1)/1000×483] = 3.898 amp
Pulse on time (T ON) = [6+ (7-6)/1000×715]
= 6.715 μs
Pulse off time (T OFF) = [6+(7-6)/1000×682]
= 6.682 μs
Gap control Voltage (V) = [1+(6-1)/1000×995]
= 5.975 volt
Flushing Pressure (P) = [5+ (10-5)/1000×506]
=10.06kg/cm^3 Parameter values for other chromosomes are calculated and the results are presented in Table 2.

6.2 Evaluation of Chromosomes

Metal removal rate (MRR) and Surface Roughness (R_a) values for above parameters are obtained by the Eqn. (1) and (2) respectively.

MRR = -0.393 + 0.0389 Current + 0.0388 T ON + 0.0245 T OFF + 0.0325 Voltage- 0.0102 Pressure
= 0.122

R_a = -4.68 + 0.583 Current + 1.44 T ON + 0.219 T OFF + 0.0463 Voltage+ 0.0204 Pressure
= 7.894

MRR and R_a values for other chromosomes are obtained and listed in Table 2. MRR_{max} is at Chromosome No.13 and MRR_{min} is at Chromosome No.4 R_{amax} is at Chromosome No.29 and R_{amin} is at Chromosome No.4.

Normalized values Nsl and Nfl for the objective functions MRR and Ra respectively are computed based on the Eqn.(4) and (5)

$$r_{sk} = \frac{\left(Z_{sk} - Z_k^{\min}\right)}{\left(Z_k^{\max} - Z_k^{\min}\right)}$$

for maximization objectives ------ (5)

$$r_{sk} = \frac{\left(Z_k^{\max} - Z_{sk}\right)}{\left(Z_k^{\max} - Z_k^{\min}\right)}$$

for minimizing objectives ------ (6)

Nsl = (0.122111-0.007663)/ (0.243475-0.007663) = 0.485336

Nfl = (9.889663-7.894905)/ (9.889663-5.479952)
= 0.452356

Sum of Normalized values gives the fitness value. Maximum of sum values provides the best fitness value.
Sum of Normalized values = (0.485336+0.452356) = 0.937692.

6.3 Selection for Reproduction

The new Fitness value for the Chromosome No.1 is calculated by the expression, $nf(x) = e^{-cf(x)}$ where c is taken as 0.05.

nf(0.0.937692)=$e^{-0.05*0.937692}$ =0.954198

The probability of chromosomes is determined by using the following expression.

$$P_i = \frac{nf_i}{\sum_{i=1}^{ps} nf_i} \qquad \text{------- (7)}$$

Where, ps = Population size, iChromosome

P_i = Probability of i^{th} Chromosome

Probability and cumulative probability is listed in Table 3. Random number (r_{rsp}) is generated for reproduction process. From Table 3,chromosomes are selected corresponding to the cumulative probability value, which are the next higher value than r_{rsp}. Chromosome No.15 having the cumulative probability 0.499509 which is immediate higher than the r_{rsp} value of 0.483. It comes in the place of Chromosome No.1 and renamed as Chromosome No.1'**.** Table 3 represents the selected chromosomes for reproduction.

6.4 Cross Over

Cross over probability is assumed as 0.62 and a random number (rco) is generated for each chromosome selected for reproduction. The chromosome is selected for cross over operation, only if rco is less than or equal to cross over probability. Single point cross over is considered in this work. A random number (rcp) is generated within in the number N<No. of parameters considered. So the random value 1, 2, 3 and 4 is generated for each chromosome for cross over.

The genes after and before cutting point (rcp) are interchanged and presented in Table 4. Chromosome No.1' is considered for the discussion of cross over operator function. Its random number (rco) 0.483 is less than cross over probability 0.62 and is selected for cross over.

The cutting point random number (rcp) generated is 1 and hence gene 76 and genes 122 436 605 884 are interchanged and forms new chromosome 122 436 605 884 76. Those chromosomes not selected for the cross over will be retained as such after cross over.

Table 3 Initialization and Evaluation of Chromosomes

Chromosome No.	Chromosomes					Parameters					Response		Normalisation		
	Gene 1	Gene 2	Gene 3	Gene 4	Gene 5	C	T ON	T OFF	V	P	MRR	Ra	Nsl	Nsf	Sum Normal
1	483	715	682	995	506	3.898	6.715	6.682	5.975	10.060	0.12211	7.89491	0.48534	0.45236	0.93769
2	502	77	23	122	91	4.012	6.077	6.023	1.610	5.910	0.12988	6.74256	0.51830	0.71368	1.23197
3	628	843	119	613	622	4.768	6.843	6.119	4.065	11.220	0.16669	8.50868	0.67440	0.31317	0.98757
4	13	218	685	713	540	1.078	6.218	6.685	4.565	10.400	0.00766	5.47995	0.00000	1.00000	1.00000
5	7	313	870	736	577	1.042	6.313	6.870	4.680	10.770	0.01333	5.61268	0.02403	0.96990	0.99393
6	739	950	904	334	103	5.434	6.950	6.904	2.670	6.030	0.22977	8.89797	0.94187	0.12489	1.16676
7	599	920	928	229	718	4.594	6.920	6.928	2.145	12.180	0.20239	8.46706	0.82577	0.32261	1.14838
8	328	800	413	201	18	2.968	6.800	6.413	2.005	5.180	0.12272	7.15505	0.48791	0.61265	1.10056
9	296	532	165	107	820	2.776	6.532	6.165	1.535	13.200	0.10427	6.82607	0.40967	0.69474	1.10441
10	330	398	92	222	234	2.980	6.398	6.092	2.110	7.340	0.09887	6.65778	0.38679	0.73290	1.11969
11	887	333	457	580	827	6.322	6.333	6.457	3.900	13.270	0.21754	8.72015	0.89003	0.26521	1.15525
12	273	987	315	238	238	2.638	6.987	6.315	2.190	7.380	0.11201	7.31630	0.44676	0.58357	1.03033
13	888	770	667	506	669	6.328	6.770	6.667	3.530	11.690	0.24348	9.30841	1.00000	0.13181	1.13181
14	524	356	451	319	215	4.144	6.356	6.451	2.595	7.150	0.14636	1.30114	0.58817	0.58700	1.17517
15	76	122	436	605	884	1.456	6.122	6.436	4.025	13.840	0.01835	5.60117	0.04531	0.97251	1.01782
16	589	277	600	927	71	4.534	6.277	6.600	5.635	5.710	0.19100	7.52855	0.52301	0.53543	1.05844
17	74	456	863	277	471	1.444	6.456	6.863	2.385	9.710	0.05765	5.92510	0.21198	0.59905	1.11103
18	887	10	952	403	283	6.322	6.010	6.952	3.015	7.830	0.22574	8.11469	0.92480	0.40252	1.32131
19	805	85	281	781	671	5.830	6.085	6.281	4.905	11.710	0.17411	8.08748	0.70586	0.40865	1.11455
20	756	821	377	893	83	5.536	6.821	6.377	5.465	5.830	0.18731	8.88477	0.76181	0.22788	0.98969
21	354	822	576	241	973	3.124	6.822	6.576	2.205	14.730	0.13239	7.51719	0.52594	0.53801	1.06695
22	514	307	27	343	94	4.084	6.307	6.027	2.715	5.940	0.13042	7.16731	0.52055	0.61736	1.13791
23	592	926	543	985	670	4.552	6.926	6.543	5.925	11.700	0.15296	8.60730	0.61615	0.29080	0.90696
24	166	756	571	804	711	1.996	6.756	6.571	5.020	12.110	0.05690	6.84213	0.20881	0.69110	0.89991
25	172	250	625	677	939	2.032	6.250	6.625	4.385	14.390	0.04671	6.15264	0.16560	0.84745	1.01305
26	77	648	127	502	210	1.462	6.648	6.127	3.510	7.100	0.03606	6.19474	0.12040	0.83791	0.95831
27	530	724	183	881	176	4.180	6.724	6.183	5.405	6.700	0.12674	7.96774	0.50497	0.43531	0.94081
28	203	341	114	288	138	2.218	6.341	6.114	2.440	6.380	0.06412	6.12842	0.23940	0.85295	1.09235
29	953	905	441	964	961	6.718	6.905	6.441	5.820	14.610	0.23522	9.88966	0.96500	0.00000	0.96540
30	83	292	730	241	570	1.498	6.292	6.730	2.205	10.700	0.05207	5.72924	0.18829	0.93447	1.13176

Table 4 Chromosomes after selection for reproduction

Chromosome No	Fitness	New Fitness	Probability	Cumulative Probability	Random No.	Old Chromosome	New chromosome	Chromosome After Selection For Reproduction				
1	0.93769	0.9542	0.03356	0.33550	0.483	15	1'	75	122	436	606	884
2	1.23197	0.94026	0.03306	0.06661	0.715	22	2'	514	307	27	343	94
3	0.93757	0.96132	0.03347	0.10303	0.632	21	3'	354	822	676	241	973
4	1.00001	0.96123	0.03345	0.13352	0.995	30	4'	83	292	730	241	572
5	0.99393	0.96162	0.03346	0.15693	0.506	16	5'	539	277	600	927	71
6	1.16676	0.94333	0.03317	0.20014	0.522	16	6'	539	277	600	927	71
7	1.14333	0.94420	0.03320	0.23334	0.077	3	7'	623	343	119	613	622
8	1.10056	0.9465	0.03323	0.26662	0.023	1	8'	433	716	632	995	506
9	1.10441	0.94623	0.03327	0.29939	0.122	4	9'	13	215	635	713	540
10	1.11969	0.94555	0.03325	0.33313	0.091	3	10'	525	343	119	613	622
11	1.16625	0.94327	0.03319	0.35632	0.628	15	11'	805	85	231	781	671
12	1.03033	0.94979	0.03339	0.39972	0.343	26	12'	77	648	127	502	210
13	1.13131	0.9449	0.03323	0.43294	0.119	4	13'	13	215	635	713	540
14	1.17517	0.94293	0.03315	0.46609	0.613	19	14'	305	85	231	731	671
15	1.01732	0.95033	0.03342	0.49951	0.522	19	15'	505	85	231	731	671
16	1.05344	0.94345	0.03335	0.53286	0.013	1	16'	433	715	632	995	506
17	1.11103	0.94596	0.03326	0.55612	0.218	7	17'	599	520	923	229	715
18	1.32731	0.93579	0.03392	0.59902	0.525	21	13'	354	822	576	241	973
19	1.11455	0.9458	0.03326	0.63227	0.713	22	19'	514	307	27	34	94
20	0.98969	0.95172	0.03345	0.66574	0.542	17	20'	74	456	363	277	471
21	1.06696	0.94305	0.03333	0.69907	0.037	1	21	433	715	632	995	506
22	1.13791	0.94469	0.03322	0.73222	0.313	10	22	330	393	92	222	234
23	0.90696	0.96667	0.03362	0.76539	0.370	27	23	530	724	133	331	175

 © SME

24	0.39991	0.956	0.03361	0.79952	0.735	23	24'	592	926	543	935	372
25	1.01305	0.95061	0.03342	0.33292	0.577	13	25'	557	10	952	403	233
26	0.95331	0.95322	0.03352	0.86684	0.739	23	25	592	956	543	935	572
27	0.94045	0.9541	0.03350	0.89998	0.950	29	27'	953	525	441	964	951
28	1.09235	0.94685	0.03329	0.93327	0.904	25	23'	203	341	114	233	133
29	0.96500	0.95290	0.03352	0.96672	0.334	11	29'	887	333	457	580	527
30	1.13176	0.94493	0.03323	1.00000	0.103	4	30'	13	218	635	713	540

Table 5 Chromosomes after Cross over

Chromo-some No.	Chromosomes					Random No.	Selected	Selected Chromosomes for crossover					Cutting point	Chromo-some No.	Chromosomes after Crossover				
1'	76	122	436	605	354	0.453	Y	76	122	436	605	354	1	1"	122	436	605	884	76
2'	514	307	27	343	94	0.715	N							2"	514	307	27	343	94
3'	35	522	576	241	973	0.652	N							3"	354	522	576	241	973
4'	33	292	730	241	570	0.995	N							4"	33	292	730	241	570
5'	559	277	600	327	71	0.506	Y	559	277	600	927	71	2	5"	600	927	71	559	277
6'	559	277	600	927	71	0.502	Y	559	277	600	927	71	2	6"	600	927	71	539	277
7'	625	543	119	613	622	0.077	Y	525	243	115	613	622	3	7"	613	622	625	543	119
8'	433	715	652	995	506	0.230	Y	453	715	622	535	506	2	8"	632	995	506	433	715
9'	13	213	655	713	540	0.122	Y	13	213	685	713	540	2	9"	635	713	540	13	215
10'	623	243	119	613	622	0.091	Y	628	843	119	613	622	2	10"	119	613	622	628	843
11'	205	35	231	781	671	0.628	N							11"	305	35	231	751	671
12'	77	643	127	502	210	0.543	N							12	77	643	127	502	210
13'	13	213	655	713	540	0.119	Y	13	213	655	713	540	3	13"	713	540	13	213	655
14'	505	85	231	751	671	0.613	N							14"	305	55	251	751	671
15'	805	85	231	731	671	0.622	N							15"	305	35	231	731	671
16'	453	715	652	995	506	0.013	Y	453	715	652	995	506	2	16"	652	995	506	453	715
17'	599	920	925	229	712	0.218	Y	599	920	923	229	713	2	17"	923	229	716	595	920
18'	354	822	576	241	973	0.655	N							18"	354	522	576	241	973
19'	514	307	27	34	94	0.713	N							19"	514	307	27	34	94
20'	74	455	563	277	471	0.540	Y	74	456	563	277	471	2	20"	363	277	471	74	456
21'	483	715	652	995	506	0.101	Y	453	715	632	995	506	2	21"	652	995	506	483	715
22'	330	395	92	222	234	0.313	Y	330	395	92	222	234	2	22"	92	222	234	330	393
23'	530	724	153	881	176	0.370	N							23"	530	724	153	881	176
24'	592	926	543	985	670	0.736	N							24"	592	926	543	985	670
25'	867	10	952	964	253	0.577	Y	837	10	952	403	283	1	25"	10	952	403	283	887
26'	592	926	543	355	670	0.739	N							26"	532	926	543	985	670
27'	953	905	441	964	961	0.950	N							27"	953	905	441	964	961
23'	203	341	114	235	138	0.904	N							28"	203	341	114	235	132
29'	357	333	457	550	527	0.334	Y	837	333	457	550	527	3	29"	550	527	357	333	457
30'	13	213	655	713	540	0.103	Y	13	213	655	713	540	2	30"	555	713	540	13	218

6.5 Mutation

A value of 0.05 is assumed as mutation probability and a random number is (r_m) is generated for each gene of all chromosomes. If r_m is less than or equal to mutation probability, then the corresponding gene is mutated with neighbour gene and it is shown in detail in Table 5. Chromosome No.2" is selected to explain the function of mutation operator.

The random number (r_m) for third gene is 0.023 lesser than mutation probability 0.05. So the gene 27 mutate with the gene 343. The new Chromosome is 514 307 343 27 94. Similarly all other chromosomes are inducted in to mutation operator and new population is obtained and is evaluated as in section 6.2.

 © SME

Table 6 Chromosomes after Mutation

Chromosome No.	Chromosomes before Mutation					Random No.					Chromosome No.	Chromosomes after Mutation				
1"	122	436	505	334	76	0.483	0.715	0.532	0.995	0.505	1"	122	436	605	2	76
2"	514	307	27	343	94	0.502	0.077	0.023	0.122	0.091	2"	514	307	343	27	94
3"	354	322	576	241	973	0.623	0.343	0.119	0.613	0.622	3"	354	322	679	241	373
4"	33	292	730	241	570	0.013	0.213	0.635	0.713	0.540	4"	292	83	730	241	570
5"	600	927	71	539	277	0.007	0.313	0.370	0.736	0.577	5"	527	600	71	565	277
6"	600	927	71	539	277	0.739	0.950	0.904	0.334	0.103	6"	600	327	71	533	277
7"	613	622	623	543	119	0.599	0.920	0.923	0.229	0.713	7"	613	622	623	243	119
8"	632	995	506	483	715	0.323	0.300	0.413	0.201	0.013	8"	715	995	505	433	682
9"	685	713	540	13	213	0.296	0.532	0.165	0.107	0.820	9"	685	713	540	13	213
10"	119	513	522	523	343	0.330	0.393	0.092	0.110	0.222	10"	119	513	622	3	523
11"	305	35	231	731	671	0.234	0.337	0.333	0.457	0.500	11"	305	35	221	731	671
12"	77	643	127	502	210	0.327	0.273	0.937	0.315	0.233	12"	77	643	127	502	210
13"	713	540	13	213	635	0.233	0.233	0.770	0.667	0.506	13"	713	540	13	215	535
14"	805	35	231	721	671	0.669	0.524	0.356	0.451	0.319	14"	805	65	281	731	671
15"	305	35	231	731	671	0.215	0.076	0.122	0.436	0.605	15"	305	65	261	731	671
16"	632	995	506	423	715	0.234	0.539	0.277	0.640	0.927	16"	682	335	506	433	715
17"	923	229	713	599	920	0.710	0.074	0.456	0.363	0.277	17"	923	229	706	599	920
18"	354	322	575	241	973	0.471	0.337	0.010	0.952	0.403	18"	354	322	201	576	973
19"	514	307	27	343	94	0.233	0.305	0.085	0.231	0.731	19"	514	307	27	343	94
20"	363	277	471	74	456	0.671	0.756	0.321	0.377	0.393	20"	363	277	471	74	456
21"	632	995	506	433	715	0.083	0.354	0.322	0.576	0.241	21"	632	995	506	433	715
22"	92	222	234	330	393	0.973	0.514	0.307	0.027	0.343	22"	92	222	234	335	330
23"	530	72	123	331	176	0.094	0.592	0.926	0.543	0.935	23"	530	724	163	331	176
24"	592	926	543	935	670	0.670	0.166	0.756	0.571	0.304	24"	592	926	543	335	670
25"	10	352	403	223	887	0.711	0.172	0.250	0.625	0.677	25"	10	952	403	233	887
25"	532	325	543	935	570	0.939	0.077	0.643	0.127	0.502	26"	592	925	543	985	570
27"	953	105	441	954	951	0.210	0.530	0.724	0.133	0.231	27"	953	905	441	964	951
28"	203	341	114	288.	133	0.176	0.203	0.341	0.114	0.233	28"	203	341	114	238	133
29"	580	327	837	333	457	0.132	0.953	0.905	0.441	0.964	29"	530	327	367	333	457
30"	635	713	540	13	213	0.961	0.033	0.252	0.730	0.241	30"	685	713	540	13	213

7. Conclusion

On the basis of the experimental results, the calculated MRR, SR and the Graphs the following conclusions are drawn for the effective machining of Al/Al_2O_3 composite by the spark erosion EDM process:

For maximum MRR, the current intensity is most significant. Gap control voltage also affects the MRR. For better surface finish, the current intensity is most significant. Pulse on Time is also significant. Mathematical relation for MRR and SR based on machining parameter was developed by using regression analysis.

This Taguchi method-based approach for searching out significant EDM parameters during the machining of Al/Al_2O_3 provides efficient guideline for manufacturing engineers.

The GA is implemented for finding best combination of parameters. After 100 iterations the best combination is as follows

Parameters

Current = 3.616 amp
T ON = 6.884µs
T OFF = 6.122 µs
Voltage = 1.38 volt
Flushing Pressure = 11.05kg/cm^2

Responses

MRR = 0.140093 gms/min

Surface Roughness (Ra) = 6.689573 µm

With this combination of parameters, confirmatory experiment was conducted and the results found to be close with the simulated results.

 © SME

References

1. *Joze Valemtincic, Kusen D, Smrkolj S, Oki Blatnink and Mihael Junkar (2007), "Machining parameters selection for varying surface in EDM", Int. J. Materials and product Technology, Vol. 29, 1/2/3/4.*

2. *Rozenek M, Kozak J, Dabrswski L and Lubkowski K (2001), "EDM Characteristics of MMCs", Journal of Materials Processing Technology, Vol. 109, 367-370.*

3. *Koenraad Bonny, Patric de Baets, Jozef Vleugels, Salehi A, Omer Van derBiest, Bert Lauwers and Wenqing Liu, (2008), "EDM machinability and frictional behaviour of ZrO_2-WC composites",International Journal of Advanced Manufacturing Technology, Vol. 41(11),1085-1093.*

4. *Su J C, Kao J Y and Tarng Y S (2004), "Optimization of the electrical discharge machining process using a GA-based neural network", International Journal of Advanced Manufacturing Technology, Vol.24, 81-90.*

5. *Shajan kariahose and Shunmugam M S (2005), "Multi-objective optimization of WEDM process by GA", Journal of Materials Processing Technology, Vol. 170, 133-141.*

6. *Mu-Tian yan, Chi-Cheng Fang (2008), "Application of genetic algorithm-based fuzzy logic control in EDM machine", Journal of Material Processing Technology, Vol. 205, 128-137.*

7. *Asthana R (1998), "Processing effect on the properties of cast of metal matrix composites" University of Wisconsil-Stout, Menomonie WI 54751, 213-255.*

8. *Lindroos V K and Talvitie M J (1995), "Recent advances in metal matrix composites" Journal of Material Processing Technology, Vol. 53, 273-284.*

9. *Bhaskar reddy C, Diwakar reddy V and Eswara reddy C (2012), "Experimental Investigations On Mrr And Surface Roughness Of EN 19 & SS 420 Steels In Wire Edm Using Taguchi Method" International Journal Of Engineering Science And Technology, Vol. 4 (11), 4603-4614.*

10. *Harsimran Singh and Harmesh Kumar (2015), "Review On Wire Electrical Discharge Machining (WEDM) Of Aluminum Matrix Composites" International Journal of Mechanical and Production Engineering, Vol. 3 (10).*

11. *Nataraj M and Ramesh P (2016), "Investigation on Machining Characteristics of Al 6061 Hybrid Metal Matrix Composite Using Electrical Discharge Machining", Middle-East Journal of Scientific Research, Vol. 24 (6), 1932-1940.*

 © SME