Experimental investigation of process parameters and optimization in EDM using taguchi method and grey relational analysis

Ritesh Kumar Hui, Assistant Professor,Aryan Institute of Engineering &Technology, Odisha,kumarritesh333@gmail.com
Chandrabhanu Malla,PhD Research scholar, KIIT University,
Odisha, chandrabhanu.malla@gmail.com

ABSTRACT-Among the thermal mode of machining, electrical discharge machining (spark erosion machining) is mainly a method for the manufacturing of a multitude[1] of ever changing geometries very often produced as unit job or in small batches.The basic concept of Electrcal Discharge Machining (EDM) process is creating out of metals affected by the sudden stoppage of the electron beam[3] by the solid metal surfaces of the anode.The portion of the anode facing the direct electrical pulse reaches the boiling point.Even in case of medium long pulse the rate of temperature increases in tens of millions of degree per second which means dealing with an explosion process.In the present work, a combined optimization approach is used for the estimation of maximum metal removal rate(MRR) [5]and minimum tool wear rate(TWR), surface roughness(SR) and overcut(OC) of produced in electrical discharge machining. The important input parameters current (I), pulse on time (T_{on}), pulse off time (T_{off}) and voltage (V) are considered. Twenty five experiments has been performed on AISI D2 steel as work piece and copper(Cu) as tool materials. The optimum setting of the machining parameters has been evaluated from the grey relational grade. With the help of Analysis of variance the percentage contribution of the input parameters has been found out. The optimal set of parameters are current (50A), voltage (27V) , pulse on time (300µs),pulse off (10µs).

Keywords: Electro discharge machining (EDM), AISI D2 steel, Copper, Taguchi Analysis,Grey relational analysis (GRA) .

INTRODUCTION

The process of electric discharge machining also known as electro-erosion or spark machining involves controlled erosion of electrically conducting materials by an interrupted, repetitive electric spark,discharge between the tool(cathode) and work(anode) separated by a dielectric fluid medium.

The process is used mainly for the manufacture of tools made of carbide and other hard materials and having complicated profiles such as dies used for molding, forging, extrusion, wire drawing etc in as hard condition.

Principle of EDM

The workpiece and electrode are separated by a gap, called spark gap(0.005 to 0.05mm) and a suitable dielectric slury,which is non-conductor of electricity, is forced through this gap at a pressure of about 2kgf/cm^2.When a proper voltage[4] is applied the dielectric breaks down and electrons are emitted from cathode and the gap is ionized.Avalanche of electrons takes place with collection of more electrons in the gap,consequently the resistance drops causing electric spark to jump between the workpiece and the tool.Each electric discharge causes a focused stream of electrons to move with a very high velocity from the cathode towards anode and their collision with the work results in the generation of compression shock waves on high spots of workpiece[12] closest to the tool which consequently developes local rise in temperature the tune of 10000^{0}C sufficient enough to melt a part of the workpiece metal. Gap control in EDM is affected through a servo system which correctly locates the tool in relation to the workpiece surface, maintains a constant gap throughout the operation,sences the changes in the gap and corrects them immediately.A short-circuit across the gap causes the servo to reverse the motion of the tool until the correct gap is established.Servo system may be electrical or hydraulic type.Eletro hydraulic servo control is preferred.

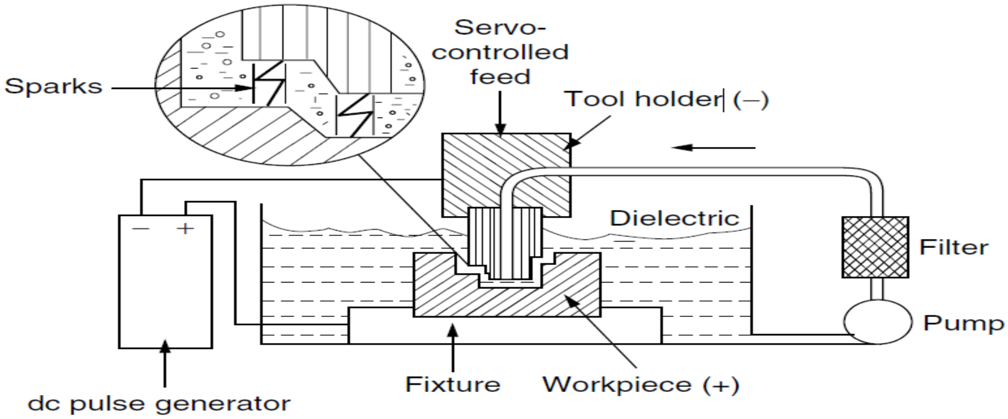


Fig.1.1 Set up of Electric Discharge Machining

Important parameters of EDM

(a) Spark on time (pulse time or T_{on}): The duration of time (µs) the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on time. The energy is really controlled by the peak current and the length of on time.

(b)Spark off time (pause time or $T_{off)}$ The duration of time (µs) between the sparks (that is to say, on time). This time allows the molten material to solidify and to be wash out from the arc gap. This parameter has to effect the speed and the stability of the cut. Thus, if the off time is too short, it will cause spark to be unstable.

(c) Arc gap (or gap): The arc gap is the distance between the electrode and work piece during the process of EDM. It may called as spark gap. Spark gap can be maintained by servo system.

(d) Discharge current (current**):** Discharge current is directly proportional to material removal rate.

(e) Duty cycle (τ): It is the percentage of the on time relative to the total cycle time. This parameter is calculated by dividing the on time to the total cycle time.

$$\tau = \frac{Ton}{Ton + Toff}$$

(f) Voltage (V): It is a potential that can be measured in volt, it is also effect the material removal rate and allowed to per cycle.

(g) Diameter of the electrode (D): It is the electrode of copper with diameter 11 mm in this experiment.

(h) Over cut**:** It is the clearance per side of the electrode and the work piece after the machining operation.

Objective of the present work

From the literature review it is concluded that many researchers have done experiment with different workpieces and tools in EDM. In those experiments they have evaluated the value of performance parameters taken into consideration of different values of process parameters. The objective of the present work is an attempt for experimental investigation of process parameters and optimisation of the performance parameters in EDM with the help of Grey relational analysis method for AISI D2 steel.The machining parameters taken into consideration are discharge current,voltage,pulse on time,pulse off time.The performance parameters which are taken into consideration MRR,TWR,SR and OC.Five level of process parameters are taken into consideration while doing the experimental work.And one of the measure feature of the experiment is that here the machining time is constant.By keeping the machining time constant the over cut can be measuresd.

Experimental work

In this chapter we are going to discuss about the experimental work which is consist about formation of the L-25 orthogonal array based on Taguchi design, orthogonal array is reduces the total on of experiment, in this experiment total 18 run. And Experimental set up, selection of work piece, tool design, and taking all the value and calculation of MRR, TWR, and OC.

Experimental set up

Specification Of the Die sink EDM Used For Machining Process

Description	Details
Manufactured by	Electronica
Model name	EMS-5535/PS 50
Specification	(X-300*Y-200*Z-200)MM
Price	.8 Million
Year	1995

Die-Sink EDM

Selection of workpiece

For this particular research work AISI D2 steel has been considered as the workpiece because this material has good machining quality with copper tool as here in this paper copper has considered as electrode

Material specification

Chemical composition of AISI D2 Steel.

- C :- 1.50%
- Si :- 0.30%
- Cr :- 12%
- Mo:- 0.80%
- V :- 0.90%

Mechanical properties of AISI D2 Steel at room temperature

0.2% Offset yield strength	1532MPa
Tensile strength	1736MPa
Hardness (HRC)	57

Process parameters

- Current (I_p)
- Voltage (V)
- Pulse on time(T_{on})
- Pulse off time(T_{off})

Performance parameters

- Metal Removal Rate (MMR)
- Tool Wear Rate (TWR)
- Surface Roughness (SR)
- Over Cut (OC)

Taguchi design of experiment in minitab 16:-

MINITAB provides both static and dynamic response experiments in a static response experiment; the quality characteristic of interest has a fixed level. The goal of robust experimentation is to find an optimal combination of control factor settings that achieve robustness against (insensitivity to) noise factors. MINITAB calculates response tables and generates main effects and interaction plots for:-

- Signal-to-noise ratios (S/N ratios) vs. the control factors.

- Means (static design) vs. the control factors.

A Taguchi design or an orthogonal array the method is designing the experimental procedure using different types of design like, two, three, four, five, and mixed level. In the study, a four factor mixed level setup is chosen with a total of eighteen numbers of experiments to be conducted and hence the OA L25 was chosen. This design would enable the two factor interactions to be evaluated. As a few more factors are to be added for further study with the same type of material, it was decided to utilize the L25 setup, which in turn would reduce the number of experiments at the later stage. In addition, the comparison of the results would be simpler.

Machining Parameters and Their Level

Level of Control Parameters	Control Parameters			
	Current I	Voltage V	Pulse On TON	Pulse Off TOFF
1	20	20	50	8
2	30	25	100	9
3	40	27	150	10
4	50	28	200	11
5	35	26	300	12

Taguchi L25 Design Creation in Mini Tab

Expt.No	Current	voltage	T_{ON}	T_{OFF}
1	20	20	50	8
2	20	25	100	9
3	20	27	150	10
4	20	28	200	11
5	20	26	300	12
6	30	20	100	10
7	30	25	150	11
8	30	27	200	12
9	30	28	300	8
10	30	26	50	9
11	40	20	150	12
12	40	25	200	8
13	40	27	300	9
14	40	28	50	10
15	40	26	100	11
16	50	20	200	9
17	50	25	300	10
18	50	27	50	11
19	50	28	100	12
20	50	26	150	8
21	35	20	300	11
22	35	25	50	12
23	35	27	100	8
24	35	28	150	9
25	35	26	200	10

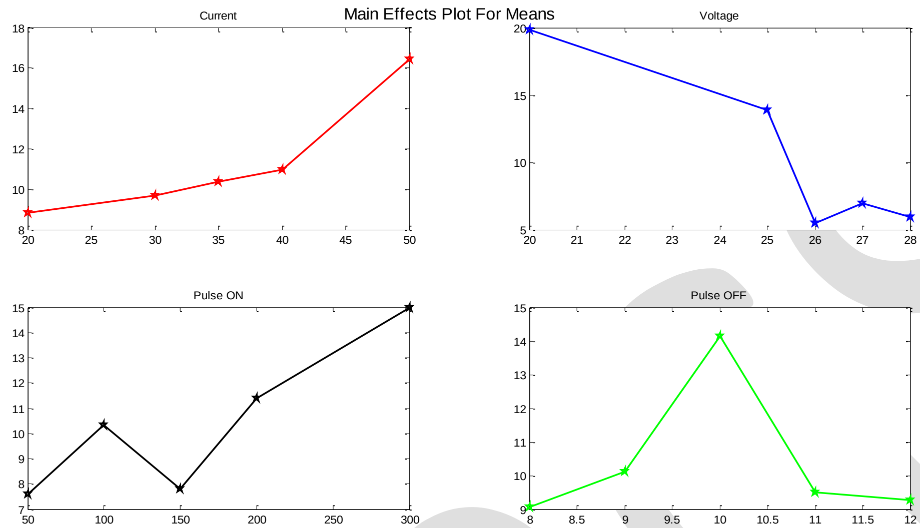
Experimental investigation:-

Calculation of MRR, TWR, SR, OC

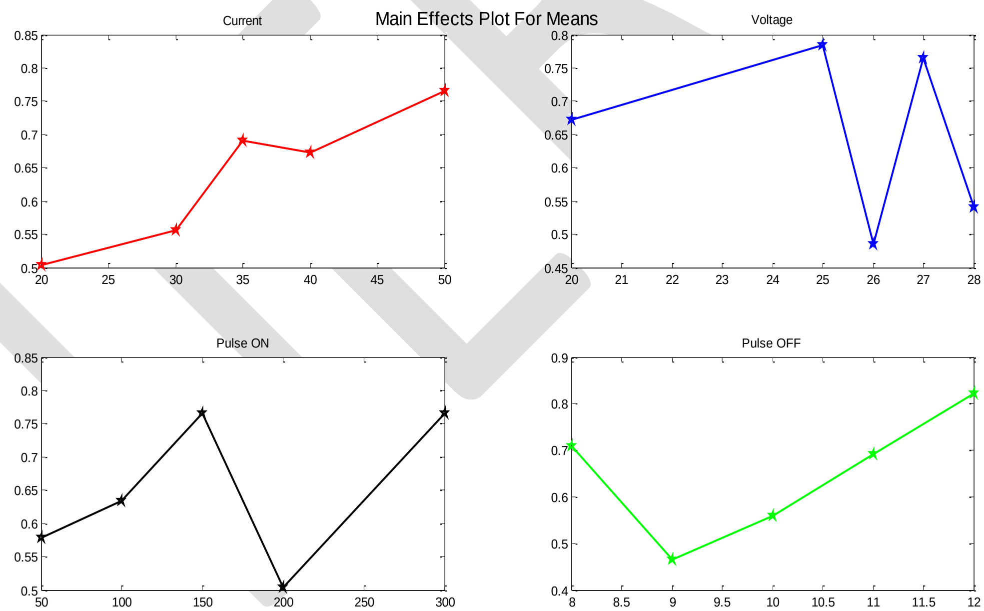
Exp.No.	Current	Voltage	Pulse ON	Pulse OFF	MRR	TWR	SR	OC
1	20	20	50	8	12.651	.560	2.758	.120
2	20	25	100	9	9.430	.373	5.325	.110
3	20	27	150	10	6.329	.747	9.127	0
4	20	28	200	11	6.329	.186	8.191	0
5	20	26	300	12	9.493	.653	7.129	.100
6	30	20	100	10	24.261	.560	10.197	.180
7	30	25	150	11	7.383	.842	7.197	.030
8	30	27	200	12	7.383	.747	6.234	.040
9	30	28	300	8	6.329	.653	9.231	.050
10	30	26	50	9	3.164	.280	8.919	.030
11	40	20	150	12	13.712	.934	7.231	.070
12	40	25	200	8	12.651	.934	8.951	.100
13	40	27	300	9	6.329	.653	9.321	.130
14	40	28	50	10	5.274	.280	5.613	.070
15	40	26	100	11	4.219	.560	5.239	.090
16	50	20	200	9	27.426	.373	12.235	.130
17	50	25	300	10	31.647	.934	12.913	.190
18	50	27	50	11	8.438	.934	9.132	.020
19	50	28	100	12	7.383	.934	7.197	.100
20	50	26	150	8	7.383	.653	6.239	.030
21	35	20	300	11	21.097	.934	11.239	.130
22	35	25	50	12	8.438	.842	7.197	.030
23	35	27	100	8	6.329	.747	9.231	.070

24	35	28	150	9	4.219	.653	8.951	.060
25	35	26	200	10	3.164	.280	6.391	.090

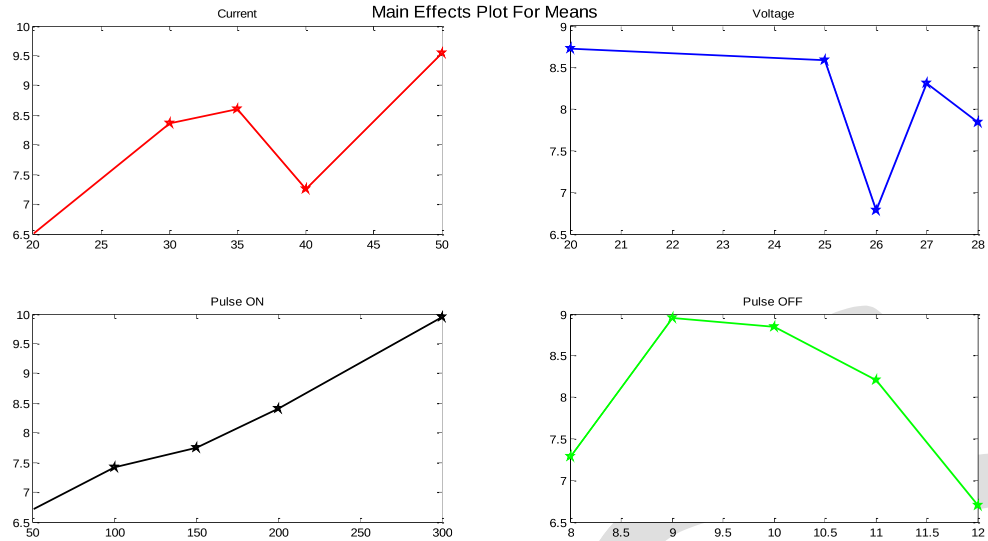
Effect of process parameters on performance parameters



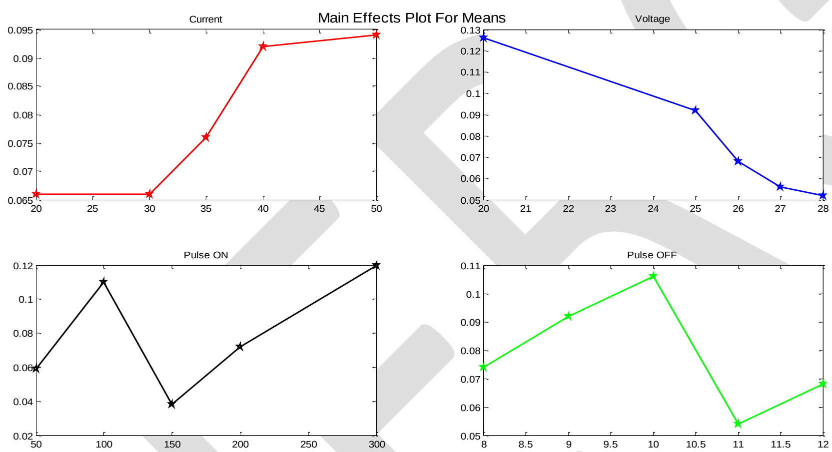
Effect of Process Parameters on MRR



Effect of Process Parameters on TWR



Effect of Process Parameters on SR



Effect of Process Parameters on OC

Optimization method

The experiment was conducted based on varying the process parameters which affect the machining process to obtain the required quality characteristics. Quality characteristics are those response values or output values expected out of the experiments. The most commonly used quality characteristics are:

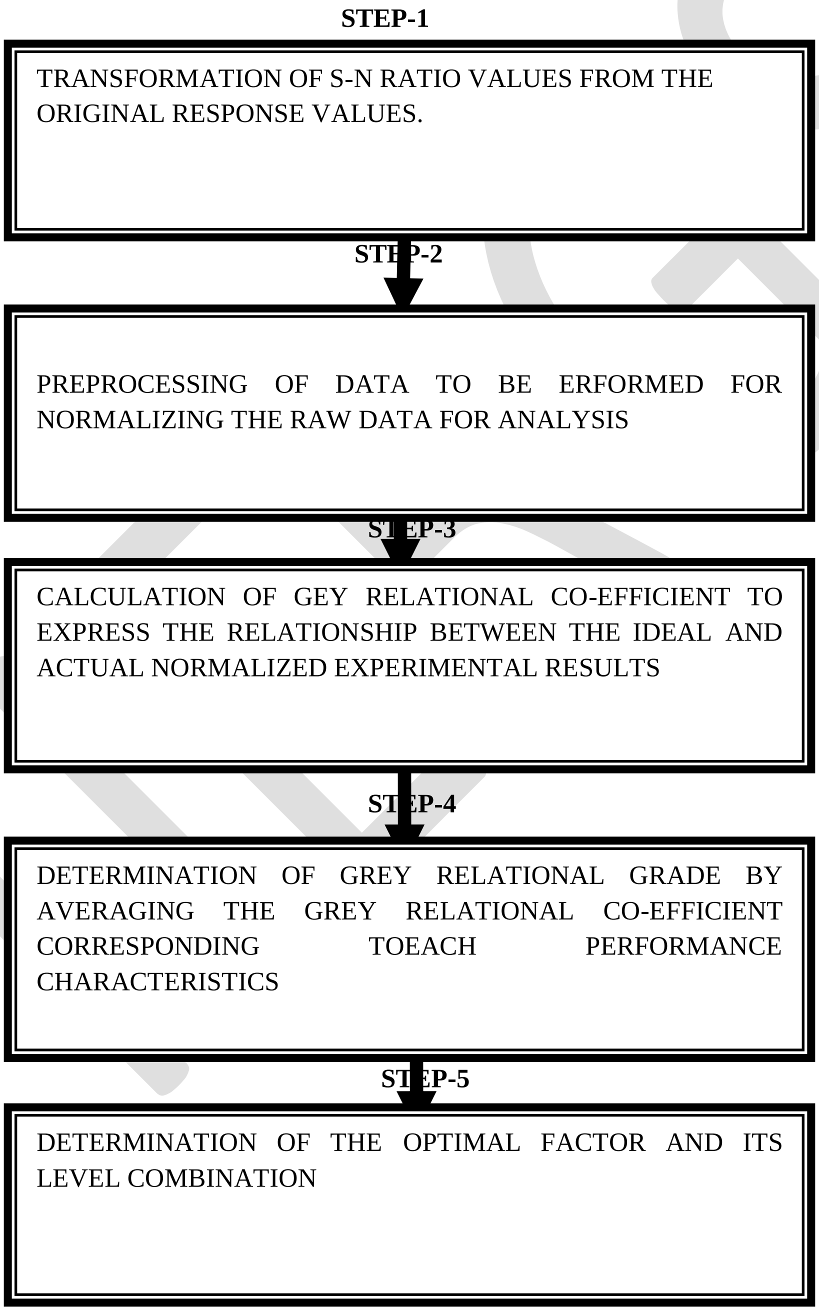
(1) Larger the better
(2) Smaller the better
(3) Nominal the better

As the objective is to obtain the high material removal rate, low tool wear rate ,low over cut and smaller value of surface roughness. So it is concerned with connected with larger value of MRR, smaller value of tool wear, low value of over cut and smaller value of surface roughness. Hence the required quality characteristics for high MRR is larger the better, which states that the output must be as large as possible and for tool wear, over cut and surface roughness is smaller the better which states that the output must be as low as possible.

Grey relational analysis

In Grey Relational Analysis the multiple performance characteristics have been investigated with Grey Relational approach.In this approach the multiple performance characteristics can be converted into single grey relational grade. In the grey relational analysis, the grey relational grade is used to show the relationship among the sequences. If the two sequences are identical, then the value of grey relational grade is equal to 1. The grey relational grade also indicates the degree of influence that the comparability sequence could exert over the reference sequence. Therefore, if a particular comparability sequence is more important than the other comparability sequences to the reference, then the grey relational grade for that comparability sequence and reference sequence will be higher than other grey relational grades.

Steps for optimization using grey relational analysis



Formula used in each step in gra

Step-1:

Type 1: $S/N_{HB} = -10\log_{10}[(\frac{1}{n})(\sum \frac{1}{Y_{ij}^{2}})]$

Type-2: $S/N_{LB} = -10\log_{10}[\sum \frac{Y_{ij}^{2}}{n}]$

Where Y_{ij} is the value of the response
'j' in the i^{th} experiment condition , with i=1,2,3....n; J=1,2,....k

Step-2:

$$Z_{ij} = \frac{y_{ij} - \min(y_{ij}, i=1,2,...n)}{\max(y_{ij}, i=1,2,...n) - \min(y_{ij}, i=1,2,...n)}$$ for higher the better criteria

$$Z_{ij} = \frac{\max(y_{ij}, i=1,2,...n) - y_{ij}}{\max(y_{ij}, i=1,2,...n) - \min(y_{ij}, i=1,2,...n)}$$ for lower the better criteria

Step-3:

$$\xi_i(k) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{0i}(k) + \zeta\Delta_{\max}}$$

Where $\Delta_{oi}(k)$ is the deviation sequence of the reference sequence and compatibility sequence

$$\Delta_{0i}(k) = \| y_0(k) - y_i(k) \|$$

$$\Delta_{\min} = \min_{\forall j \in i} \min_{\forall k} \| y_0(k) - y_j(k) \|$$

$$\Delta_{\max} = \max_{\forall j \in i} \max_{\forall k} \| y_0(k) - y_j(k) \|$$

y_0 (k) denotes the sequence and y_j(k) denotes the comparability sequence . ζ is distinguishing or identified coefficients. The value of ζ is the smaller and distinguished ability is the larger. ζ =0.5 is generally used.

Step-4:

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n}\xi_i(k)$$

Where γ_i is the gray relational grade for the j[th] experiment and k is the number of performance characteristics

RESULTS AND DISCUSSION

Tabulation representation of step-1 for optimization using grey relational analysis

Expt.No.	Response values				S/N Ratio			
	MRR	TWR	SR	OC	MRR	TWR	SR	OC
1	12.651	.560	2.758	.120	22.042	5.036	-8.811	18.416
2	9.430	.373	5.325	.110	22.219	11.576	-11.51	22.182
3	6.329	.747	9.127	0	20.790	7.304	-14.43	44.710
4	6.329	.186	8.191	0	22.047	20.630	-12.24	0
5	9.493	.653	7.129	.100	26.580	10.691	-10.07	26.989
6	24.261	.560	10.197	.180	35.480	12.817	-12.38	22.676
7	7.383	.842	7.197	.030	25.812	9.944	-8.692	38.908
8	7.383	.747	6.234	.040	26.391	11.564	-6.988	36.989
9	6.329	.653	9.231	.050	25.569	13.244	-9.762	35.563
10	3.164	.280	8.919	.030	20.004	21.050	-9.006	40.457
11	13.712	.934	7.231	.070	33.155	11.006	-6.770	33.511
12	12.651	.934	8.951	.100	32.834	11.384	-8.245	30.791
13	6.329	.653	9.321	.130	27.166	14.841	-8.249	28.860
14	5.274	.280	5.613	.070	25.904	22.518	-3.522	34.559
15	4.219	.560	5.239	.090	24.265	16.797	-2.624	32.676
16	27.426	.373	12.235	.130	40.804	20.607	-9.710	29.762
17	31.647	.934	12.913	.190	42.311	12.897	-9.916	26.729
18	8.438	.934	9.132	.020	31.077	13.143	-6.658	46.532
19	7.383	.934	7.197	.100	30.152	13.380	-4.358	32.787
20	7.383	.653	6.239	.030	30.374	16.710	-2.891	43.467

21	21.097	.934	11.239	.130	39.703	13.815	-7.792	30.943
22	8.438	.842	7.197	.030	31.949	14.917	-3.718	43.881
23	6.329	.747	9.231	.070	29.643	16.180	-5.687	36.715
24	4.219	.653	8.951	.060	26.300	17.503	-5.235	38.239
25	3.164	.280	6.391	.090	23.984	25.036	-2.131	34.894

In the above table S/N ratios are calculated for the different response values found for every performance parameter from the experiment.

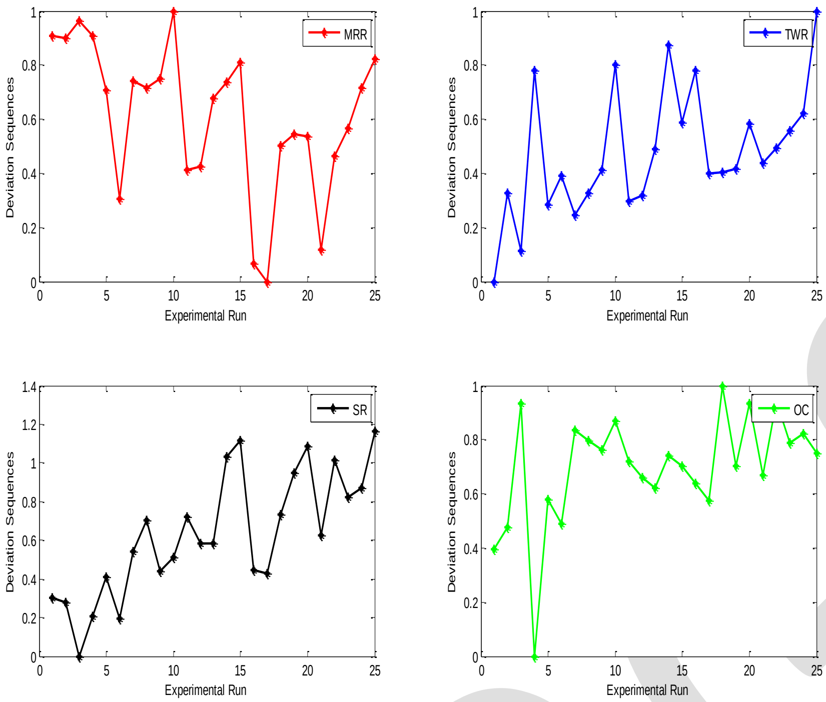
Tabulation and graphical representation of step-2 for optimization using grey relational analysis

Expt.No.	Current	Voltage	Pulse ON	Pulse OFF	Normalized S/N Ratio			
					MRR	TWR	SR	OC
1	20	20	50	8	0.0913	1.000	0.8611	0.6042
2	20	25	100	9	0.0992	0.6730	0.8850	0.5232
3	20	27	150	10	0.0352	0.8860	1.1611	0.0648
4	20	28	200	11	0.0915	0.2208	0.9540	1.0000
5	20	23	300	12	0.2947	0.7172	0.7490	0.4199
6	30	20	100	10	0.6937	0.6109	0.9679	0.5126
7	30	25	150	11	0.2603	0.7546	0.6191	0.1638
8	30	27	200	12	0.2863	0.6736	0.4583	0.2050
9	30	28	300	08	0.2494	0.5896	0.7201	0.2357
10	30	26	50	09	0.0000	0.1993	0.6488	0.1305
11	40	20	150	12	0.5895	0.7015	0.4378	0.2798
12	40	25	200	08	0.5751	0.6826	0.5770	0.3382
13	40	27	300	09	0.3210	0.5097	0.5773	0.3797
14	40	28	50	10	0.2644	0.1259	0.1310	0.2573
15	40	26	100	11	0.1910	0.4119	0.0465	0.2977
16	50	20	200	11	0.9324	0.2214	0.7152	0.3603
17	50	25	300	10	1.000	0.6080	0.7347	0.4255
18	50	27	50	11	0.4963	0.5946	0.4272	0.0000
19	50	28	100	12	0.4549	0.5828	0.2101	0.2953
20	50	26	150	08	0.4648	0.4163	0.0717	0.0658
21	35	20	300	11	0.8830	0.5610	0.5342	0.3350
22	35	25	50	12	0.5354	0.5059	0.1497	0.0569
23	35	27	100	08	0.4321	0.4443	0.3355	0.2109
24	35	28	150	09	0.2823	0.3766	0.2929	0.1782
25	35	26	200	10	0.1784	0.0000	0.0000	0.2501

Tabulation and graphical representation of step-3 for optimization using grey relational analysis

Expt.No.	Current	Voltage	Pulse ON	Pulse OFF	Deviation Sequence			
					MRR	TWR	SR	OC
1	20	20	50	8	0.9087	0.0000	0.3000	0.3958
2	20	25	100	9	0.9008	0.3270	0.2761	0.4768

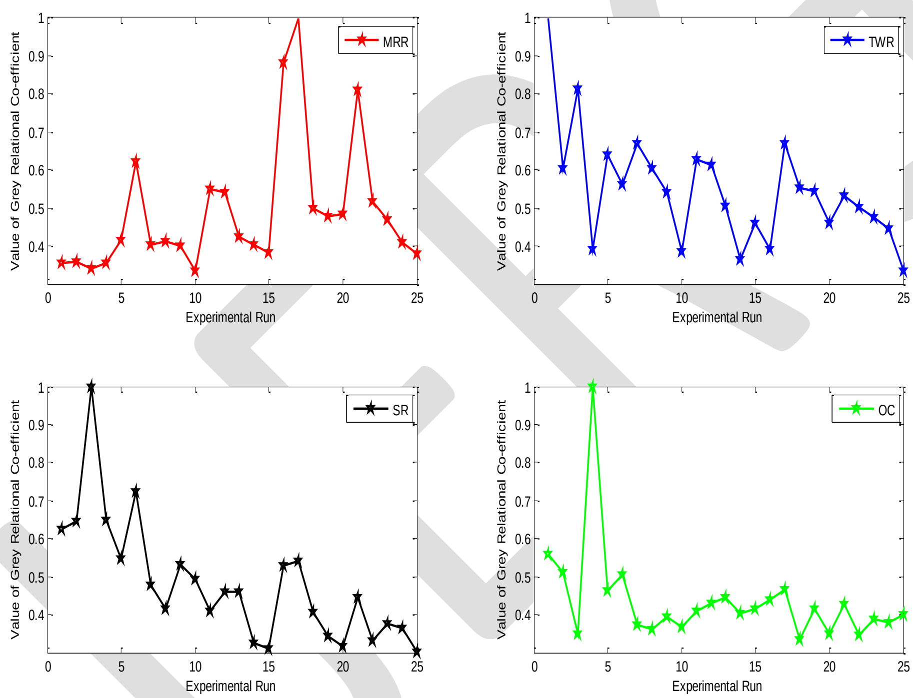
3	20	27	150	10	0.9648	0.1140	0.0000	0.9352
4	20	28	200	11	0.9085	0.7792	0.2710	0.0000
5	20	23	300	12	0.7053	0.2828	0.4121	0.5801
6	30	20	100	10	0.3063	0.3891	0.1932	0.4874
7	30	25	150	11	0.7394	0.2454	0.5421	0.8362
8	30	27	200	12	0.7137	0.3264	0.7028	0.7950
9	30	28	300	08	0.7506	0.4104	0.4410	0.7643
10	30	26	50	09	1.0000	0.8007	0.5123	0.8695
11	40	20	150	12	0.4105	0.2985	0.7233	0.7202
12	40	25	200	08	0.4249	0.3174	0.5841	0.6618
13	40	27	300	09	0.6790	0.4930	0.5838	0.6203
14	40	28	50	10	0.7356	0.8741	1.0301	0.7427
15	40	26	100	11	0.8090	0.5881	1.1146	0.7023
16	50	20	200	11	0.0676	0.7786	0.4459	0.6397
17	50	25	300	10	0.0000	0.3916	0.4264	0.5745
18	50	27	50	11	0.5037	0.4054	0.7339	1.0000
19	50	28	100	12	0.5451	0.4172	0.9510	0.7047
20	50	26	150	08	0.5352	0.5837	1.0830	0.9342
21	35	20	300	11	0.1170	0.4390	0.6269	0.6680
22	35	25	50	12	0.4646	0.4941	1.0114	0.9431
23	35	27	100	08	0.5679	0.5557	0.8256	0.7891
24	35	28	150	09	0.7177	0.6234	0.8682	0.8218
25	35	26	200	10	0.8216	1.0000	1.1611	0.7499



Calculation of gray relational co-efficient

Expt.No.	Current	Voltage	Pulse ON	Pulse OFF	MRR	TWR	SR	OC
1	20	20	50	8	0.3549	1.0000	0.6250	0.5581
2	20	25	100	9	0.3569	0.6045	0.6442	0.5118
3	20	27	150	10	0.3413	0.8143	1.0000	0.3483
4	20	28	200	11	0.3549	0.3908	0.6485	1.0000
5	20	23	300	12	0.4148	0.6387	0.5481	0.4629
6	30	20	100	10	0.6201	0.5623	0.7219	0.5063
7	30	25	150	11	0.4033	0.6707	0.4798	0.3741
8	30	27	200	12	0.4119	0.6050	0.4156	0.3861
9	30	28	300	08	0.3998	0.5409	0.5313	0.3954
10	30	26	50	09	0.3333	0.3844	0.4939	0.3650
11	40	20	150	12	0.5491	0.6261	0.4087	0.4097
12	40	25	200	08	0.5405	0.6119	0.4611	0.4303
13	40	27	300	09	0.4240	0.5048	0.4613	0.4463
14	40	28	50	10	0.4046	0.3638	0.3267	0.4023

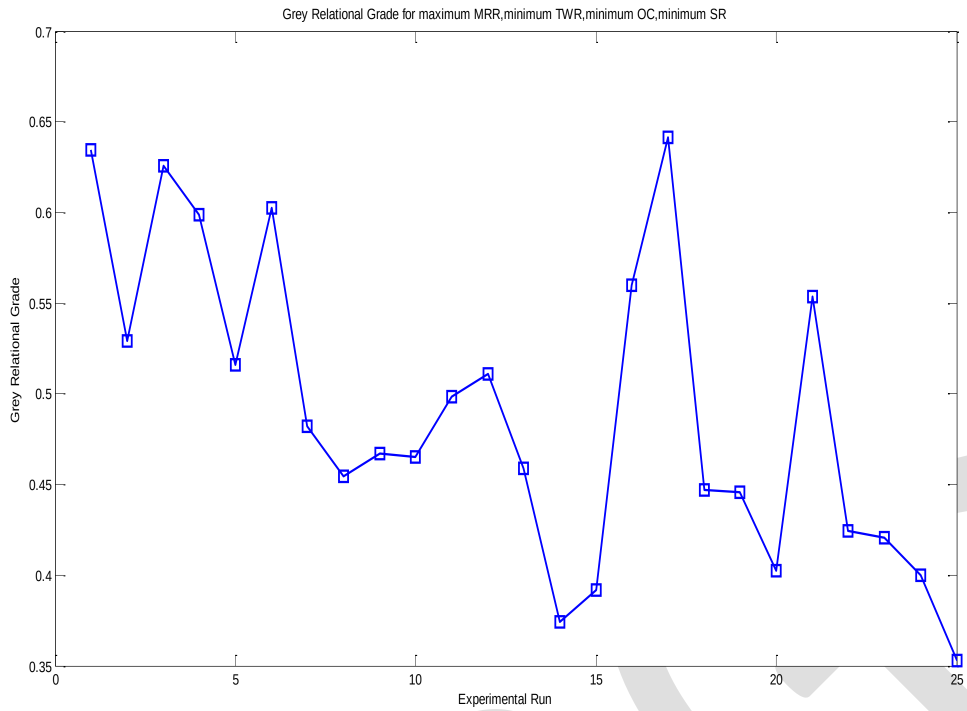
15	40	26	100	11	0.3819	0.4595	0.3096	0.4158
16	50	20	200	11	0.8809	0.3910	0.5288	0.4387
17	50	25	300	10	1.0000	0.5607	0.5397	0.4653
18	50	27	50	11	0.4981	0.5522	0.4052	0.3333
19	50	28	100	12	0.4784	0.5451	0.3445	0.4150
20	50	26	150	08	0.4829	0.4613	0.3157	0.3486
21	35	20	300	11	0.8103	0.5324	0.4436	0.4280
22	35	25	50	12	0.5183	0.5029	0.3308	0.3464
23	35	27	100	08	0.4682	0.4736	0.3771	0.3878
24	35	28	150	09	0.4106	0.4450	0.3654	0.3782
25	35	26	200	10	0.3783	0.3333	0.3010	0.4000



Tabulation and graphical representation of step-4 for optimization using grey relational analysis

Exp.No.	Current	Voltage	Pulse ON	Pulse OFF	Grey Relational Grade
1	1	1	1	1	.6345
2	1		2	2	.5293

3	1	3	3	3	.6259
4	1	4	4	4	.5985
5	1	5	5	5	.5161
6	2	1	2	3	.6026
7	2	2	3	4	.4819
8	2	3	4	5	.4546
9	2	4	5	1	.4668
10	2	5	1	2	.4654
11	3	1	3	5	.4984
12	3	2	4	1	.5109
13	3	3	5	2	.4591
14	3	4	1	3	.3743
15	3	5	2	4	.3917
16	4	1	4	2	.5598
17	4	2	5	3	**.6414**
18	4	3	1	4	.4471
19	4	4	2	5	.4457
20	4	5	3	1	.4021
21	5	1	5	4	.5535
22	5	2	1	5	.4246
23	5	3	2	1	.4206
24	5	4	3	2	.3998
25	5	5	4	3	.3530

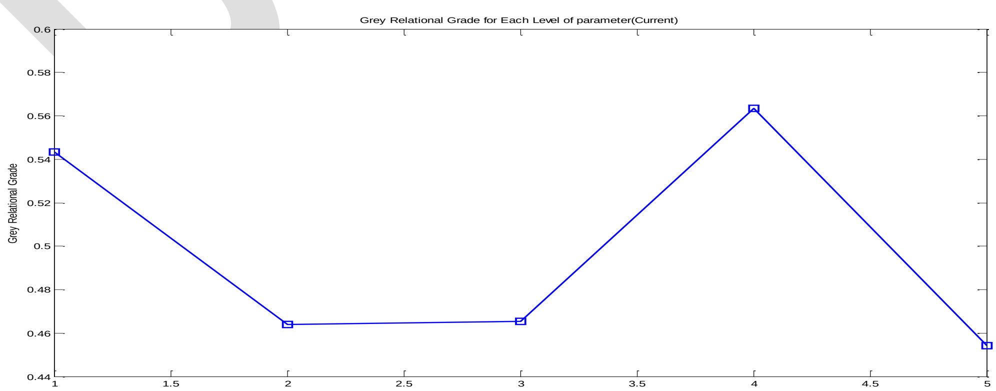


The above graph shows the value of gray relational grade for maximum MRR, minimum TWR, minimum SR, minimum OC against each experimental run.

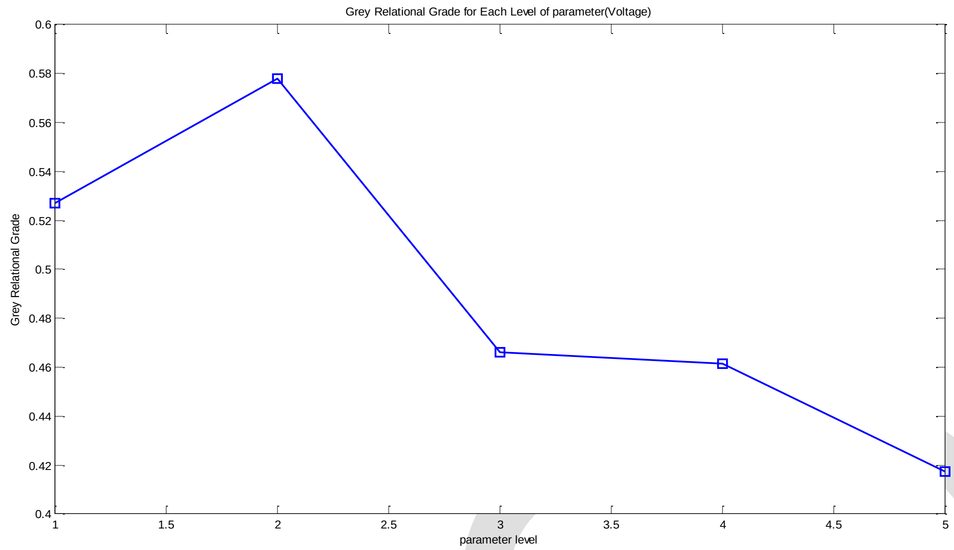
Tabulation and graphical representation of step-5 for optimization using grey relational analysis

Parameters	Level-1	Level-2	Level-3	Level-4	Level-5
Current	.5434	.4638	.4651	**.5634**	.4541
Voltage	.5269	**.5778**	.4603	.4616	.4173
Pulse ON	.4857	.4834	.4893	.4940	**.5468**
Pulse OFF	.4739	.5023	**.5391**	.4891	.5123

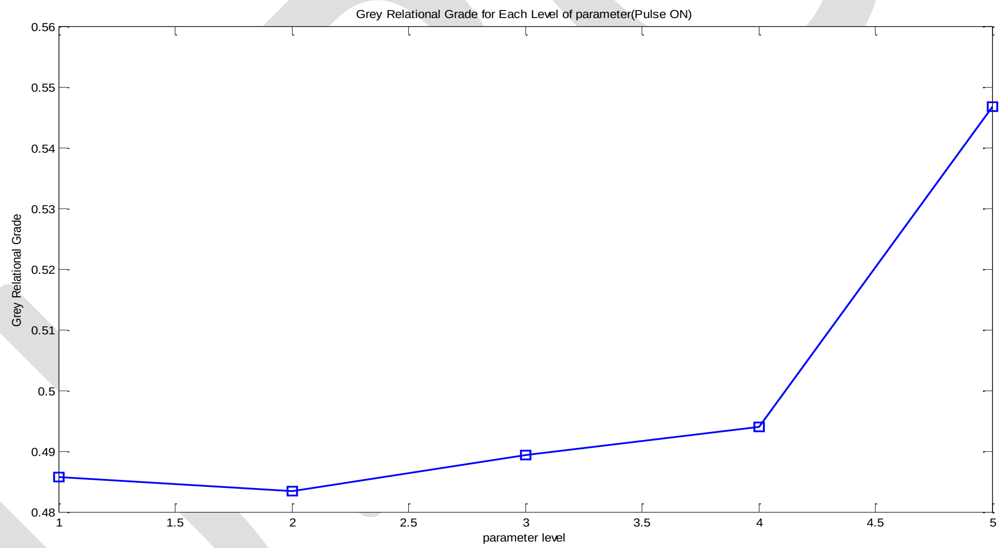
The above table shows the optical factor and its level of combination for the performance parameters.



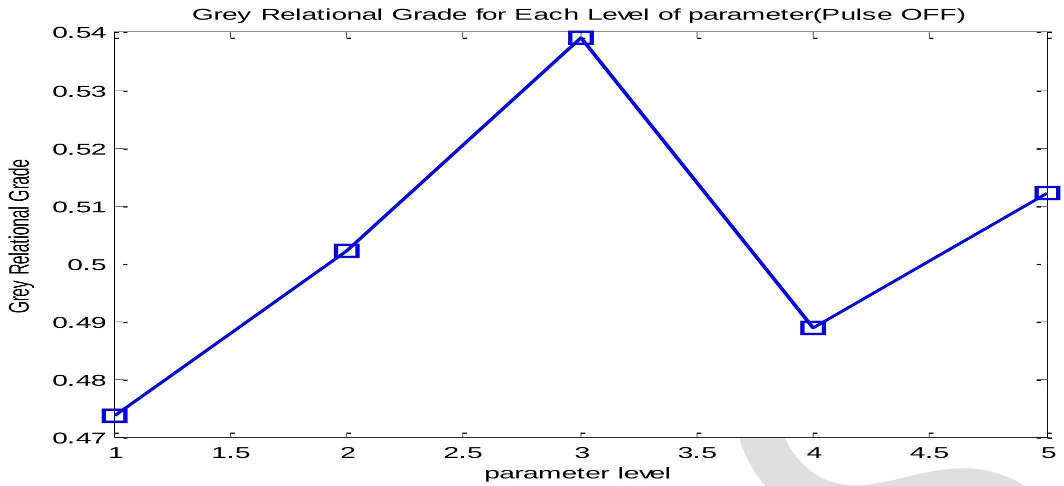
Representation of grey relational grade for each level of parameter (Current)



Representation of grey relational grade for each level of parameter (Voltage)



Representation of grey relational grade for each level of parameter (Pulse ON)



Representation of grey relational grade for each level of parameter (Pulse OFF)

Tabulation for Result Of Analysis Of Variance Of MRR

Parameters	DOF	Sum of squares	Mean squares	F	P	Rank
Current	4	40.230	10.057	40.214	37.260%	1
Voltage	4	20.140	5.035	20.140	18.650%	3
Pulse on	4	28.360	7.090	28.036	26.2666%	2
Pulse off	4	17.240	4.310	17.240	15.96%	4
Error	8	2.000	.250			

Tabulation for Result Of Analysis Of Variance Of TWR

Parameters	DOF	Sum of squares	Mean squares	F	P	Rank
Current	4	2.831	.7077	23.82	47.26%	1
Voltage	4	1.329	.3322	10.818	23.18%	2
Pulse on	4	.651	.1627	5.3344	11.90%	3
Pulse off	4	.932	.183	3.315	15.55%	4
Error	8	.242	.0305			

Tabulation for Result Of Analysis Of Variance Of SR

Parameters	DOF	Sum of squares	Mean squares	F	P	Rank
Current	4	12.3154	3.0788	7.9596	19.09%	2
Voltage	4	8.5924	2.1481	5.5535	13.92%	3
Pulse on	4	40.3263	10.0815	26.0638	65.96%	1
Pulse off	4	7.7291	1.9322	4.9953	10.72%	4
Error	8	3.0946	.3838			

Tabulation for Result Of Analysis Of Variance Of OC

Parameters	DOF	Sum of squares	Mean squares	F	P	Rank
Current	4	.2091	.0522	10.6967	31.33%	2
Voltage	4	.3924	.0981	20.1024	53.16%	1

Pulse on	4	.0524	.0131	2.6844	8.09%	3
Pulse off	4	.0451	.0112	2.2950	7.11%	4
Error	8	.0390	.0048			

CONCLUSION

Taguchi signal –to- noise ratio (SNR) and grey relational analysis is applied in this work to improve the multi-response characteristics such as MRR (Material Removal Rate),TWR (Tool Wear Rate),SR (Surface Roughness),OC (Over Cut).The conclusions are as follows:

- The optimal parameters combination is determined as A4B2C5D3 i.e. current (50A), voltage (27V), pulse on time (300µs),pulse off (10µs).

- The work demonstrates the method of using Taguchi methods for optimizing the EDM parameters for multiple response characteristics.

REFERENCES:

[1] R. Venkata Rao, "*Advanced Modelling and Optimization of Manufacturing Process*", Springer, 2011.

[2]. S. Dhanabalan, K. Sivakumar, "*Optimization of EDM parameters with multiple performance characteristics for titanium grades*", European journal of scientific research, vol.68, 297-305, 2011

[3]. S.K. Saha,.and S.K. choudhary.,. "*Experimental investigation and emperical modelling of the dry electrical discharge machining*", International Journal of Machine tool and manufacture, Vol.49(3-4), 297-308, 2009.

[4] C.L. Lin, J1 Lin, T.C. Ko, "*Optimization of the EDM procedd based on the orthogonal array with fuzzy logic and grey relational analysis method*", International Journal of Advanced Manufacturing Process, Vol.19, 271-277, 2002.

[5] Z.C. Lin, C.Y. Ho, "*Analysis and application of gry relation and ANOVA in chemical mechanical polishing process parameters*", International Journal of Advanced Manufacturing technology, Vol .21, 10-14, 2003.

[6]. S.P. Lo, "*The application of grey system method in turning tool failure*", International Journal of Advanced Manufacturing technology, Vol.19, 564-572, 2002.

[7] C.K. Chang, "*Design optimization of cutting parameters for side milling operations*", International Journal of Advanced Manufacturing technology, Vol32(1/2), 18-26, 2007.

[8]. P. Krajinik, "*Optimization of TA6V alloy surface laser texturing using an experimental design approach*", Optics and Lasers in Engineering, 46(9), 671-678.

[9]. B.H. Yan, C.C. Wang, H.M. Chow, and Y.C. Lin, 2000. "*Dry machining of aluminium sillicon alloy usimg polished CVD diamond-coated cutting tools inserts*", Surface coating technology, Vol.200, 400-403, 2007.

[10]. N. Tosun, "*Feasibility study of rotary electrical discharge machining with ball burnishing for Al2O3/6061Al composite*", 2008, vol.23, 391–399.

[11]. J.L. Lin, "*Study of the effect of machining parameters on the machining characteristics in electrical discharge machining of tungsten carbide*", Journal of Materials Processing Technology, 115(3), 344-358.

[12]. C.J. Luis, "*A study of optimization of machining parameters for electrical discharge machining of boron carbide*", Materials and Manufacturing Processes, 19(6), 1041-1070.

[13]. C. Wang, And Y.C. Lin, 2009. "*Optimization of surface roughness in end milling using RSM*", International Journal of Refractory Metals and Hard Materials, 27(5), 872-882.

[14]. H.C. Tsai, B.H. Yan, and F.Y. Huang, 2003. "*EDM performance of Cr/Cu-based composite electrodes*", International Journal of Machine Tools and Manufacture, 43(3), 245-252.

[15]. S.S. Habib, (2009). "*Study of the parameters in electrical discharge machining through response surface methodology approach*", Applied Mathematical Modeling, 33(12), 4397-4407.

[16]. S. Raghuraman, "*Optimization of EDM parameters using Taguchi method and GRA for mild steel IS 2026*", International Journal ofInnovative Research In Science, Engineering And Technology, Vol2, Issue 7, July 2013..

[17]. Sreenivasulu Reddy. "*Application Of GRA For Surface Roughness And Roundness Error Of AL 6061 Alloy*", International journal of Lean Thinking, Vol3, Issue2, December 2012.

[18]. Eiji Suzuki, United States Patent 6, 396, 022 May 28, 2002

[19]. Lin and Tung-Han, United States Patent 6, 768, 077 Lin July 27, 2004.

[20]. M.S. Sohani, V.N. Gaitonde, B. Siddeswarappa, and A.S. Deshpande, 2009. "*Investigations into the effect of tool shapes with size factor consideration in sink electrical discharge machining (EDM) process*", International Journal of Advanced Manufacturing Technology, , 1-15.