6.1 Normalization of Experimental results

The normalization of experimental results of MRR and SR. Each value is normalized in the range of 0to 1.

$$X_i(M)=\frac{Y_i(M)-\min Y_i(M)}{\max Y_i(M)-\min Y(M)} \longrightarrow (1)$$

$$X_i(M)=\frac{\max Y_i(M)-Y_i(M)}{\max Y_i(M)-\min Y_i(M)} \longrightarrow (2)$$

Where,

$X_i(M)$ = value after normalizing data/Grey relational generation value.

Min $Y_i(M)$ = smallest value of $Y_i(M)$ for M^{th} response.

Max $Y_i(M)$ = largest value of $Y_i(M)$ for M^{th} response.

Table: Normalized data for MRR and SR

Run No.	Normalized Values	
	Material removal rate(MRR)	Surface Roughness(SR)
1	0	1
2	0.0138	0.9158
3	0.2468	0.7519
4	0.0280	0.4711
5	0.5520	0.5023
6	0.3809	0.4867
7	0.6976	0.2215
8	0.4692	0.2462
9	1	0

6.2 Grey Relation Coefficient

The calculation of grey relational coefficient values for MRR and SR.The following grey relation coefficient can be used to calculate MRR and SR.

$$\varepsilon_i(M)=\frac{\Delta_{min}+\varphi\Delta_{max}}{\Delta_{oi}(M)+\varphi\Delta_{max}} \longrightarrow (3)$$

Where Δ_{0i}=quality loss function= $\Delta_{oi}(M)$ = [X oi (M)- Xi (M)], Δ_{min} and Δ_{max} are the minimum and maximum values of the differences of Δ_{0i}. Values of Ψ lie between 0 to1. The considerable value of Ψ is0.5

Table: Grey relational coefficient for MRR and SR

Run No.	Grey Relational Coefficient values	
	MRR	SR
1	0.3333	1
2	0.3364	0.8558
3	0.3989	0.6683
4	0.3396	0.4859
5	0.5274	0.5011
6	0.4467	0.4934
7	0.6231	0.3910
8	0.4850	0.3539
9	1	0.3333

6.3 Grey relational grade and order

By averaging the gray relative coefficients akin to the performance characteristics, the gray relative grade is calculated. By exploitation the gray relative grade, the multi objective responses ar regenerate into single response.

$$\text{Grey relational garde } (\gamma_i)=\frac{1}{n}\sum_{M=1}^{n}\varepsilon_i(M) \longrightarrow (4)$$

Where n=number of responses, $\varepsilon_i(M)$ = Grey relational coefficient.

Table: Grey relational grade and order

Exp No.	Grade	Order
1	0.6667	2
2	0.5961	3
3	0.5336	4
4	0.4126	9
5	0.5142	5
6	0.4700	7
7	0.5070	6
8	0.4194	8
9	**0.6767**	**1**

6.4 Response table for SR

The average of each process parameters(Means and S/N ratio) for each response at each level. In response tables, ranks square measure allotted for method parameters supported the delta values. The delta value is that the distinction of highest and lowest average values of every method parameter. The rank indicates the importance of every issue on the response. The ranks and delta values shows that Pulse on time have high result on MRR and SR and is followed by Discharge current and duty cycle.

Table: Response table for grey relational grade(means)

Level	Discharge Current (D)	Pulse on time(E)	Duty cycle (F)
1	0.5988	0.5288	0.5187
2	0.4656	0.5099	0.5585
3	0.5310	0.5568	0.5183
Delta	0.1332	0.0469	0.0402
Rank	1	2	3

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Table: Response table for grey relational grade(S/N ratios)

Level	Discharge Current (D)	Pulse on time(E)	Duty cycle (F)
1	-4.490	-5.704	-5.876
2	-6.675	-5.939	-5.235
3	-5.656	-5.178	-5.711
Delta	2.185	0.761	0.641
Rank	1	2	3

6.5 Analysis of multi objective optimization:

ANOVA table was obtained by execute the Analysis of variance (ANOVA) in Minitab17 tool. This analysis is distributed for a significance level of α=0.05, i.e. for a confidence level of 95%. Sources with a P-value but zero.05 were thought-about to own a statistically vital contribution to the performance measures. and therefore the higher F-ratio shows additional result and additional contribution of input parameter on grade. The magnitude relation between the mean sq. factors to the mean sq. errors is named F-ratio.

Table: ANOVA for Grey relational grade

Source	DF	Adj. SS	Adj. MS	F-Value	P-Value	%Contribution
D	2	0.026616	0.013308	0.68	0.594	36.89
E	2	0.00336	0.001668	0.09	0.921	4.57
F	2	0.003198	0.001599	0.08	0.924	4.29
Error	2	0.038970	0.019485			54.03
Total	8	0.072120				

It is observed that Pulse on time has the higher percentage of contribution i.e. 36.89% on grade. And discharge current (4.57%), duty cycle (4.29%) has no significant effect on grade.

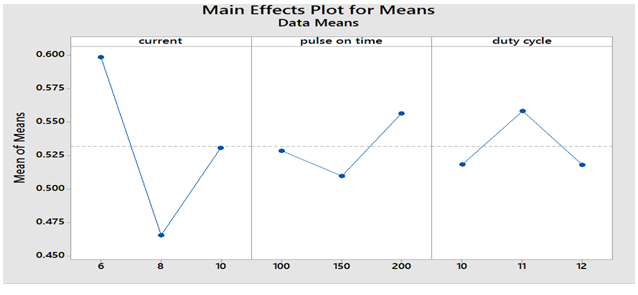

Figure: Main effect plot for Grey relational grade (Means)

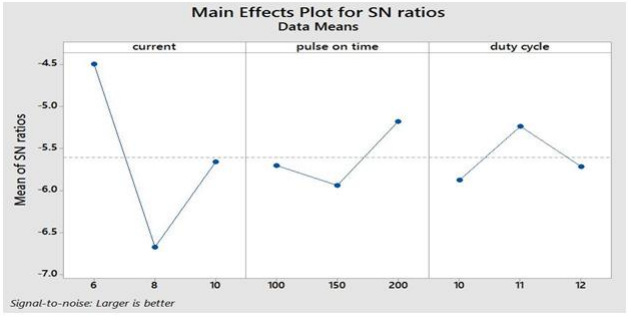

Figure: Main effect plot for Grey relational grade(S/N ratio)

As grade implies 'higher the better' kind response, it are often seen from the most impact plots five.3 that the third level of discharge current (D3), initial level of pulse on time (E1) and second level of duty cycle (F2) provides highest value of grade. The S/N quantitative relation plot (figure five.4) additionally suggests constant best condition i.e. D1E3F2 because the best optimal condition for getting most MRR and minimum SR in EDM method.

7. Conclusion

In the earlier chapters, the consequences of process parameters on process responses of the discharge machining (EDM) method are mentioned and additionally best setting of method parameters has been obtained for max MRR and minimum SR individually at the same time. The vital conclusions from this work square measure summarized as follows:

- The optimum set of method parameters ar known for achieving most MRR and minimum SR using Taguchi technique is as follows:
- The optimum setting of for achieving most MRR is D3 E3 F3 i.e. discharge current of ten Amp, pulse on time of two hundred μ sec and duty cycle of twelve the concerns.
- The optimum setting for achieving minimum SR is D1 E1 F1 i.e. discharge current of six Amp, pulse on time of a hundred μ sec and duty cycle of ten the concerns.
- Grey Taguchi optimization technique is utilized to getting most MRR and minimum SR at the same time. By conducting analysis of variance, it may be determined that Pulse on time is that the additional effecting parameter compared to discharge current and duty cycle.

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