Plasma Arc Cutting Response to IS 2062 (E250) Material

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Abstract

In this present scenario of industrialization, a fabrication shop play vital role for any manufacturing industry. The initial step involved in any fabrication shop are based on cutting of plate and obtain high surface finish to attain high accuracy now a day non-conventional machining are become life line of many industry. In this work of Plasma Arc Cutting (PAC) show the effect Speed (mm/Sec.), Current (A), Stand of Distance (mm) on IS 2062 (E250) Steel Material. In this Experiment we have done Experiment by using Taguchi design methods and ANOVA analysis for MRR and Surface roughness by performing cuts of different run sets of L9 orthogonal Array.

Keywords: Plasma arc Cutting, Taguchi Method, ANOVA Method, GRA

I. INTRODUCTION

The plasma arc cutting process is shown in Fig.1 the basic principle is that the arc formed between the electrode and the work piece is constricted by a fine bore, copper nozzle. This increases the temperature and velocity of the plasma discharging from the nozzle. The temperature of the plasma is in excess of 20 000°C and the velocity can approach the speed of sound. When used for cutting, the plasma gas flow is raised so that the deeply penetrating plasma jet cuts through the material and molten material is removed in the efflux plasma.

Fig. 1: CNC Plasma M/C

Fig. 2: Cutting plate

II. EXPERIMENT

The Taguchi method has been used, in which the experiments are done as per standard Orthogonal Arrays (OA) while the optimum level of input process parameters (control factors) are decided on the basis of analysis of the experimental results. Based on the review of the literature, the selected input parameters to be investigated were four namely the stand of distance, cutting speed, current, and voltage. The MRR and surface roughness has been selected as output parameter. This led to the use of an L9 orthogonal array. The Levels of each parameter are listed below.

Table – 1
Process parameters with level values

Parameter	*Unit*	*Level 1*	*Level 2*	*Level 3*
Stand of distance	*mm*	*3*	*4*	*5*
Cutting speed	*mm/min*	*600*	*700*	*800*
Arc voltage	*Volt*	*130*	*140*	*150*
Arc current	*Ampere*	*40*	*42.5*	*45*

According to L9, four parameters with three levels are considered. The parameters to be examined and the levels of each parameter are sorted out.

Table – 2
Result of MRR and Surface Roughness

Exp. no	*Process parameter*				*Response parameter*	
	Stand of distance (mm)	*cutting speed (mm/min)*	*Arc voltage (volt)*	*Arc current (ampere)*	*MRR (gms/sec)*	*Surface roughness (μm)*
1.	*3*	*600*	*130*	*40*	*0.7115*	*1.4135*
2.	*3*	*700*	*140*	*42.5*	*0.5228*	*2.337*
3.	*3*	*800*	*150*	*45*	*0.7272*	*2.4752*
4.	*4*	*600*	*140*	*45*	*0.4381*	*1.464*
5.	*4*	*700*	*150*	*40*	*0.3846*	*1.8162*
6.	*4*	*800*	*130*	*42.5*	*0.7638*	*2.006*
7.	*5*	*600*	*150*	*42.5*	*0.5590*	*1.6735*
8.	*5*	*700*	*130*	*45*	*0.6690*	*1.91078*
9.	*5*	*800*	*140*	*40*	*0.5035*	*2.5042*
Total					*5.2799*	*17.6005*

A. ANOVA (Analysis of Variance)

The analysis of variance (ANOVA) is the statistical treatment generally applied to the results of the experiments to determine the percentage contribution of each factors. Study of ANOVA table for a given analysis helps to decide which of the factors need control and which do not. By understanding the source and magnitude of variance, robust operating condition can be predicted.

Table - 3
ANOVA calculation table for MRR

Source of variation	*Degree of freedom*	*Factor Sum of square*	*Variance(mean square)*	*Percentage contribution*
Factor-A stand of distance	*2*	*0.02384*	*0.01192*	*16.09%*
Factor-B speed	*2*	*0.03046*	*0.01523*	*20.56%*
Factor-c voltage	*2*	*0.08132*	*0.04066*	*54.89%*
Factor-D current	*2*	*0.01287*	*0.006433*	*8.46%*
Total	*8*	*0.1485*	*0.07424*	*100%*

From the above ANOVA analysis it has been conclude that, for material removal rate percentage contribution of cutting speed 20.33 %, arc current 8.7 %, stand of distance 16.09 %, voltage 54.88 %.

Table - 4
ANOVA calculation table for surface roughness

Source of variation	*Degree of freedom (f)*	*Factor Sum of square*	*Variance(mean square)*	*Percentage contribution*
Factor-A stand of distance	*2*	*0.1863*	*0.09315*	*13.74%*
Factor-B speed	*2*	*0.9855*	*0.49275*	*73.24%*
Factor-c voltage	*2*	*0.1612*	*0.08060*	*11.89%*
Factor-D current	*2*	*0.0153*	*0.00765*	*1.13%*
Total	*8*	*1.355*	*0.67415*	*100%*

From the above ANOVA analysis it has been conclude that, 1) for surface roughness percentage contribution of cutting speed 74.24 %, arc current 1.13%,stand of distance 13.74%, voltage 10.89 %.

B. GRA (Grey Relation Analysis)

The grey relational analysis (GRA) is one of the powerful and efficient soft-tool to analyse various processes having multiple performance characteristics Grey relational Analysis (GRA) method is used to solve the problems of the systems that are complex and multivariate.

The basic process steps for multi-response optimization are given below:

- Normalization of experimental results for all performance characteristics.
- Calculation of grey relational coefficient (GRC).
- Calculation of grey relational grade (GRG) using weighing factor for performance characteristics.
- Analysis of experimental results using GRG.
- Selection of optimal levels of process parameters.
- Conducting confirmation experiment to verify optimal process parameter settings.

In this experiment, require minimum surface roughness and maximum MRR. After performing the step of GRA we get following data.

Table - 5
Calculation table for grey relation analysis

Exp. No.	*Data Pre-Normalization*		*Deviation Sequence*		*Grey Relation Coefficients*		*Grey Relational Grade*	*Rank order*
	SR	*MRR*	*SR*	*MRR*	*SR*	*MRR*		
1	*1.0000*	*0.8619*	*0.0000*	*0.1381*	*1.0000*	*0.7836*	*0.8918*	*1*
2	*0.1533*	*0.3645*	*0.8466*	*0.6355*	*0.3713*	*0.4403*	*0.4058*	*8*
3	*0.0265*	*0.9035*	*0.9734*	*0.0965*	*0.3394*	*0.8382*	*0.5888*	*5*
4	*0.9537*	*0.1410*	*0.0463*	*0.8590*	*0.9154*	*0.3679*	*0.6416*	*3*
5	*0.6308*	*0.0000*	*0.3693*	*1.0000*	*0.5752*	*0.3333*	*0.4543*	*7*
6	*0.4569*	*1.0000*	*0.5432*	*0.0000*	*0.4793*	*1.0000*	*0.7397*	*2*
7	*0.7616*	*0.4598*	*0.2384*	*0.5402*	*0.6772*	*0.4807*	*0.5789*	*6*
8	*0.5441*	*0.7500*	*0.4559*	*0.2500*	*0.5231*	*0.6667*	*0.5949*	*4*
9	*0.0000*	*0.3137*	*1.0000*	*0.6860*	*0.3333*	*0.4216*	*0.3775*	*9*

From above table, it has been found that the 1st experiment has the highest grey relation grade followed by 6th and 4th experiment. Thus the 1st experiment gives the best the best multi performance among the nine experiment.

Table - 6
Average grey relation grade by factor level.

Parameters	*Average grey relation grade*		
	Level 1	*Level 2*	*Level 3*
Stand of distance	*0.6287**	*0.6119*	*0.5171*
Speed	*0.7041**	*0.4850*	*0.5687*
Voltage	*0.7421**	*0.4749*	*0.5407*
Current	*0.5745*	*0.5748*	*0.6084**

Table shows average grey relational grade by factor level. From this table, one has concluded optimum parameter levels which are denoted by "*".From this table it is concluded that the optimum parameter level for stand of distance, Cutting Speed, voltage, Current, is 3mm, 60m/min, 130V, 45A respectively.

Now, from optimum parameter selection, it has been said that the 1st experiment gives the best multi-performance characteristic.

III. RESULT AND DISCUSSION

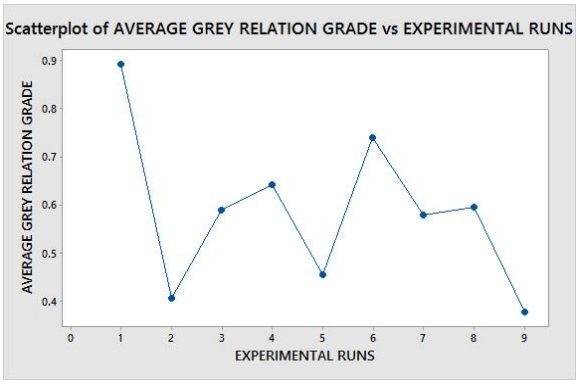

Fig. 3: Response GRG vs. Experimental Run

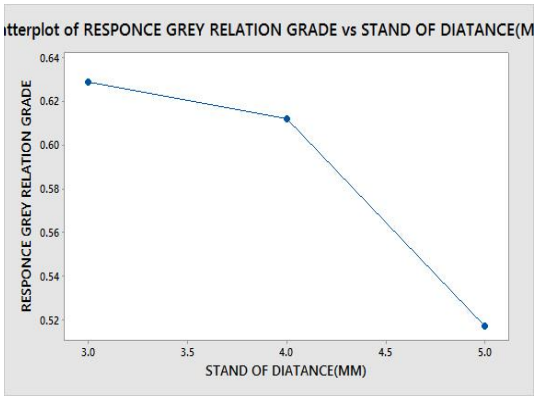

Fig. 4: Response GRG vs. Stand of Distance

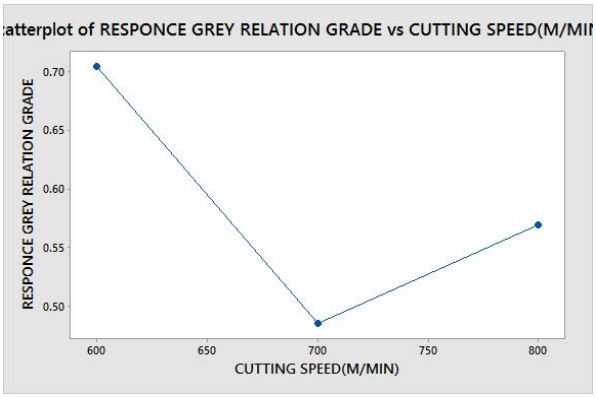

Fig. 5: Response GRG vs. Cutting Speed

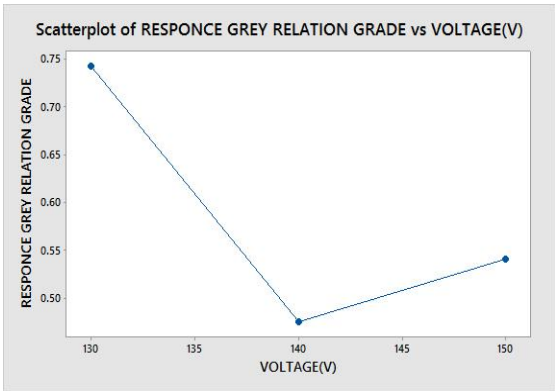

Fig. 6: Response GRG vs. voltage

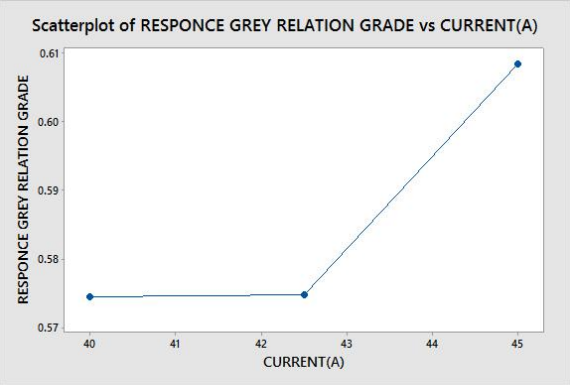

Fig. 7: Response GRG vs. current

- From fig.3 experimental run 1 has highest grey relation grey thus the 1st experiment give the best multi performance characteristic of PAC process among the 9 experimental run.
- From this fig.4 3mm stand of distance has highest response grey relation grade compare to 4 and 5 mm stand of distance so 3mm is optimum parameter level from 3 level of stand of distance.
- From this fig.5 600 mm/min cutting speed has highest response grey relation grade compare to 700 and 800 mm/min cutting speed so 600 mm/min is optimum parameter level from 3 level of cutting speed
- From this fig.6 130 V has highest response grey relation grade compare to 140 and 150V so 130 V is optimum parameter level from 3 level of voltage.
- From this fig.7 45 Amp current has highest response grey relation grade compare to 40 and 42.5 Amp current so 45 amp is optimum parameter level from 3 level of current.

IV. CONCLUSION

- From ANOVA analysis it has been conclude that, the most affecting parameter for MRR and surface roughness is voltage and speed respectively.
- From Grey relation analysis it has been found that the optimum value of stand of distance, speed, voltage and current is 3 mm, 60 mm/min, 130 V, 45 Amp Respectively.
- After deciding the optimum value of each parameter it has been say that the 1st run give the best multi-performance characteristic so the 1st run is best.

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