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OPTIMIZATION OF PROCESS PARAMETERS USING TAGUCHI METHOD OF EN8 GRADE MATERIAL MACHINED IN CNC 3 AXIS PLASMA CUTTING

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***Abstract*— In the last forty years there is tremendous research in machining and development in technology, with increase in competition in market and to attain high accuracy nowadays the non conventional machining has become life line of industries. One of the most important non conventional machining methods is plasma cutting machining. In that CNC plasma cutting they prefer high accuracy, finishing, ability of machining of any hard materials and to produce intricate shape increases its demand in market. In order to attain target and optimum results, Taguchi method is preferred. The workpiece of carbon steel (EN8) material has been used for experiment purpose. The optimum value has been determined with the help of main effect plot. Taguchi equation for MRR and surface roughness (Ra) has been developed with the help of mini tab 15 software. Result has been compared to tested value.**

***Keywords*—CNC Plasma Cutting Machine, Taguchi Method, Signal to Noise ratio, Surface Roughness.**

I. INTRODUCTION

This paper is the Analysis of process parameter of plasma arc cutting using Taguchi method. The focus of this paper is to obtain an optimum condition to obtain maximum MRR and minimum surface roughness (Ra).Advanced materials exhibit very excellent technical properties. However the high cost of both raw materials and processing limit their use. Alternatively advanced machining such as plasma arc cutting is normally used.

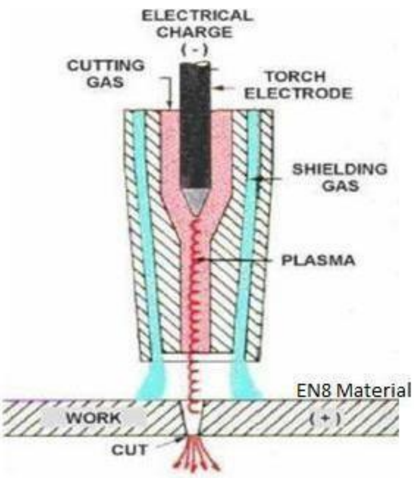

Fig 1.1 Principle of the Plasma Cutting

Advanced material such as nickel base alloys, titanium alloys and carbon steel can be used as the work piece in this type of cutting. The feasibility and effectiveness needs to be proven by experiment and by using Taguchi method of the process parameter to obtain the best factors combination (MRR and Surface roughness).

II. DESIGN OF EXPERIMENT

Design of experiments (DOE) is a powerful statistical technique introduced by R.A. Fisher in England in 1920s to study the effect of multiple variables simultaneously DOE can highly effective when:

a).Optimize product and process design , study the effect of multiple factor on process.

b).Study the influence of individual factors on the performance and determine which factor has more influence and which one has less. It can also find which factor should have higher tolerance should be relaxed.

Fig 2.1 Design of testing workpiece

Taguchi methods are most recent additions of tool kit design process for manufacturing engineers and quality assurance experts. In contrast to statistical process control which attempt to control the factor that adversely affect the quality of production. The significance of beginning quality assurance with an improved process or product design is not difficult to gauge. Taguchi method systematically reveals the complex cause and effective relationship between design parameter and performance .

III. ANALYSIS OF PROCESS PARAMETER BY TAGUCHI METHOD

EN8 is essentially a low carbon steel which contains chromium at 10% or more by weight. It is this addition of chromium that gives steel its unique stainless, corrosion resisting properties. The chromium content allows the formation of a tough, adherent, invisible, corrosion resisting chromium oxide film on the steel surface

GRADE	C%	Si %	Mn %	Ni %	Mo %	S%	P%	Cr %
EN-8	0.35	0.05	0.06	-	-	0.06	0.06	-
	0.45	0.35	1.00	-	-	-	-	-

Table 3.1 Composition ranges for (EN-8) grade material

Grade	Tensile Strength N/mm2	Yield stress 0.2%proof (N/mm2)	Elongation (% in per min)	Rock wellB HRB max	Brinell (HB) max
EN8	700 to 850	465	16		201 to 255

Table 3.2 Mechanical properties of EN8 grade material

Material Removal Rate:-

The material removal rate, MRR, can be defined as the volume of material removed divided by the machining time. Material Removal Rate (MRR) is defined by Standard L16 Array with (2*4):-Column number 1 2 4 & 8 of L16 (2**15) Array is used for this experiment:-

Runs	Gas Pressure	Current	Cutting Speed	Arc Gap
1	1	1	1	1
2	1	1	1	2
3	1	1	2	1
4	1	1	2	2
5	1	2	1	1
6	1	2	1	2
7	1	2	2	1
8	1	2	2	2
9	2	1	1	1
10	2	1	1	2
11	2	1	2	1
12	2	1	2	2
13	2	2	1	1
14	2	2	1	2
15	2	2	2	1
16	2	2	2	2

Table 3.3 Experimental Layout in Coded Factor Levels

Signal to Noise (S/N) Ratio:-

Noise factors are those that are either too hard or uneconomical to control even though they may cause unwanted variation in performance.

$$L(Y) = K (Y-T^2)........................ \quad (1)$$

MRR = WRW/T [g/min]

Where,

WRW: work piece removal weight (g)

T: cutting time(s)

WRW is the weight different between before and after work piece cutting. The volume different can be calculated when information regarding material density available. The relation between WRW and WRV is given as follow:

$WRV = WRW/\rho$

Where,

ρ: Work piece density (g/ mm3)

The density of the Nickel-Base Alloys is 8 g/cm3 or 0.008g/mm3.

3.Surface Roughness :-

$$R_a = \frac{1}{L}\int_0^L |Y(x)|dx$$

Exp No.	Pressure (Bar)	Current (A)	Speed (mm/min)	Arc Gap mm	MRR g/Sec	S/N ratio for MRR	SR Ra (µm)	S/N ratio for SR
1	5	50	1600	4	0.66	3.48	2.7	11.53
2	5	50	1600	4	0.66	*	3.2	*
3	5	50	1600	4	0.61	*	4.5	*
4	5	50	1600	4	0.72	*	4.1	*
5	5	50	1600	4	0.76	2.78	3.7	10.1
6	5	50	1600	4	0.72	*	3.5	*
7	5	50	1600	4	0.69	*	3.0	*
8	5	50	1600	4	0.71	*	3.7	*
9	10	60	2100	4	0.90	1.05	4.1	10.2
10	10	60	2100	4	0.85	*	4.2	*
11	10	60	2100	4	0.96	*	4.5	*
12	10	60	2100	4	0.81	*	4.9	*
13	10	60	2100	4	0.964	1.07	4.98	7.37
14	10	60	2100	4	0.880	*	3.45	*
15	10	60	2100	4	0.828	*	3.21	*
16	10	60	2100	4	0.855	*	4.78	*

Table 3.4 Calculation Sheet for MRR and Surface Roughness

Exp No.	Mass 1 (Before Cutting)	Mass 2 (After Cutting)	Mass Loss (g)	Time Taken (Sec)	MRR (g/Sec)	Surface roughness (µm)
1	27	24	3	4.51	0.6652	2.753
2	27	24	3	4.4	0.6696	3.245
3	27	24.3	2.7	4.4	0.6136	4.567
4	27	23.7	3.3	4.55	0.7252	4.125
5	27	23.7	3.3	4.32	0.7638	3.765

6	27	23.8	3.2	4.40	0.7272	3.567
7	27	23.9	3.1	4.44	0.6982	3.097
8	27	23.9	3.1	4.35	0.7126	3.786
9	27	23.9	3.1	3.43	0.9037	4.179
10	27	24	3	3.51	0.8547	4.235
11	27	23.7	3.3	3.43	0.9621	4.567
12	27	24.1	2.9	3.56	0.8146	4.907
13	27	23.7	3.3	3.42	0.9649	4.987
14	27	23.9	3.1	3.52	0.8806	3.456
15	27	24.1	2.9	3.50	0.8285	3.213
16	7	24.1	2.9	3.39	0.8554	4.789

Table 3.5 Experimental Layout and S/N ratios for MRR and Surface Roughness (Actual Factor Levels)

IV. RESULT AND DISCUSSION

This paper is to find out optimal condition of Plasma Arc Cutting Machine for maximizing MRR and minimizing Surface Roughness (Ra). For this 16 specimens of (EN8) were prepared which were easily and cheaply available in the scrap yard of Fabrication Division.

Table 5.1 Summary Table for Results.

MRR (g/sec)	Optimum value of A1B2C2D2 = 0.6494	Experimental result of A1B2C2D2= 0.7638	Percentage = 0.11%
Surface Roughness (µm)	Optimum value of A2B2C1D1 = 3.521	Experimental result of A2B2C1D1= 3.765	Percentage =0 .24%

From the above table we can conclude that there is 0.11% improvement in MRR and also surface roughness reduce with 0.24%.this finding indicates that the experiments in this study possess excellent repetitiveness and great potential for future reference.

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