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Parametric Analysis of EN8 (AISI 1040) Alloy steel on Plasma Arc Cutting

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Abstract: There are many cutting process available in the market. But, the plasma arc cutting process is one of the most effective process for the cutting of the material. In this research paper, study about the effect of selected plasma cutting parameters such as air pressure, current flow rate, cutting speed and arc gap etc. used and cutting of EN8 (AISI 1040) material. The experiment was done on the 8mm thick plate. In this experiment, the main focus on select the best parameter combination for cutting using material removal rate (MRR), surface roughness (SR) and kerf width (KW).

Keywords: EN8 (AISI 1040), Air pressure, Cutting speed, Arc gap, MRR, SR, KW, Taguchi design.

1. INTRODUCTION

Plasma is bright radiating light energy and hot radiating thermal energy. Plasma is treated as the 4th aggregate state of mater. Some examples of plasma are stars, static electricity, lightning, neon lights, fluorescent bulbs and plasma televisions. Plasma arc cutting is a thermal non-traditional cutting process. Plasma arc cutting process operates on direct current, straight polarity having electrode negative with a constricted transferred arc as shown in Figure 1. [1]

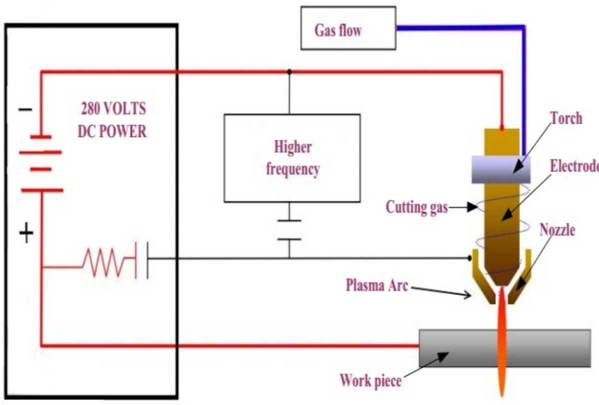

Figure 1: Schematic diagram of plasma arc cutting process

In industries. Plasma arc cutting process is most preferable for better accuracy of cutting, high production rate and good quality of cutting. There are many parameters affected on the cutting process of any material such as Air pressure, cutting pressure, selection of primary and secondary cutting gas, current flow rate, cutting speed and arc gap etc. in this research, using these plasma parameter measure the material removal rate (MRR), surface roughness (SR) and kerf width (KW). Reference [1] gives the detail information about plasma cutting process of material an Fig. 1 shows schematic diagram of plasma cutting process. In this research, medium strength steel EN8 (AISI 1040) selected which is suitable for shafts, stressed pins, studs, keys, general purpose axles and gears etc. [2]

2. EXPERIMENTAL PROCEDURE AND PARAMETERS

2.1 Material:

In this study, the EN8 (AISI 1040) medium strength steel of 8mm thick material selected whose chemical composition listed in table 1.

Fe	C	Mn	Si	S	P
94.30-96.50	0.36-0.44	0.60-1.00	0.10-0.40	>0.050	>0.050

Table 1: Chemical composition of EN8 (AISI 1040)

2.2 Taguchi method based experiments:

These experiments were performed with a 35 N/cm^2 (3.5 bar) of cutting gas pressure, to remove the instability and damage created by the high pressure of the cutting. In this research, the specified selected parameter were used with specified range of cutting process. Table 2 which shows the selected parameter for the cutting process of EN8 material. In this process, the list of fixed parameter shown in Table 3. The full factorial method was used to generate the L16 array and best combination of cutting parameter affecting on the response parameter. The L16 orthogonal array table created using taguchi full factorial method shown in table 4. [5] [6]

Parameter	Sign	Level 1	Level 2	Level 3	Level 4
Air Pressure (N/cm^2)	A	30	40	45	55
Current flow rate (Amp.)	B	50	70	90	110
Cutting speed (mm/min)	C	550	650	750	850
Arc gap (mm)	D	3	4	5	5.5

Table 2: Input parameter for cutting process

Fixed parameter	Set value
Material	EN8 (AISI 1040)
Cutting pressure	$35N/cm^2$ (3.5 bar)
Cutting gas	O_2
Shielding gas	Air

Table 3: Fixed parameter for cutting process

2.3 Material Removal Rate (MRR):

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:

$$\mathbf{MRR} = \frac{WRW}{T} \text{ [gm/min]}$$

Where,

WRW: Work piece Removal Weight (gm)

T: cutting time (min)

2.4 Surface Roughness measurement:

The surface roughness for all the cutting pieces measured using the profilometer or surface tester named as SJ-201P. Fig. 2 shows the measuring process of surface roughness. [4]

2.5 Specification of Mitutiyo surface tester SJ-201P:

Measurement range	350µm
Tip radius	5µm
Measuring force	4mN (0.4gf)
Detector drive range	21mm
Traversing speed	**Measurement:-** 0.25mm/sec, 0.5mm/sec **Return:-** 0.8mm/sec
Bottom configuration	V way
AC power supply	100V, 120V, 230V

Table 4: Specification of surface tester SJ-201P

2.6 Kerf Width (KW):

The kerf width of the cutting pieces was measured using the vernier caliper. Fig. 3 and 4 shows the measuring process of kerf width.

Exp. No	Air pressure (N/cm^2)	Current flow rate (A)	Cutting speed (mm/min)	Arc gap (mm)
1	30	50	550	3
2	30	70	650	4
3	30	90	750	5
4	30	110	850	5.5
5	40	50	650	5
6	40	70	550	5.5
7	40	90	850	3
8	40	110	750	4
9	45	50	750	5.5
10	45	70	850	5
11	45	90	550	4
12	45	110	650	3
13	55	50	850	4
14	55	70	750	3
15	55	90	650	5.5
16	55	110	550	5

Table 5: L16 orthogonal array for experimental setup

Figure 2: Measuring of surface roughness

Figure3: cutting piece measured by outer jaw of vernier caliper

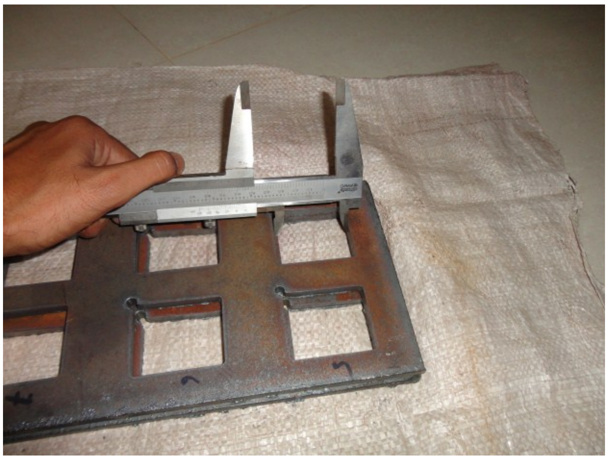

Figure 4: Hole measured by outer jaw of vernier caliper

Exp. no	Air pressure	Current flow rate	Cutting Speed	Arc gap	MRR (gm/min)	SR (μm)	KW (mm)
1	30	50	550	3	132.526	2.89	3.48
2	30	70	650	4	119.402	2.55	4.01
3	30	90	750	5	105.461	2.33	3.25
4	30	110	850	5.5	199.095	2.17	3.31
5	40	50	650	5	103.004	2.72	2.5
6	40	70	550	5.5	125.412	2.47	2.54
7	40	90	850	3	112.994	2.27	3.26
8	40	110	750	4	110.403	3.08	3.23
9	45	50	750	5.5	118.143	2.26	2.93
10	45	70	850	5	138.309	1.89	3.07
11	45	90	550	4	135.593	2.49	3.14
12	45	110	650	3	129.292	3.18	3.09
13	55	50	850	4	104.683	1.84	2.94
14	55	70	750	3	117.839	2.33	3.09
15	55	90	650	5.5	123.188	2.46	3.25
16	55	110	550	5	131.687	3.23	3.13

Table 6: Results obtain from the experiment

3. DISCUSSION AND CONCLUSION

3.1 Discussion about MRR:

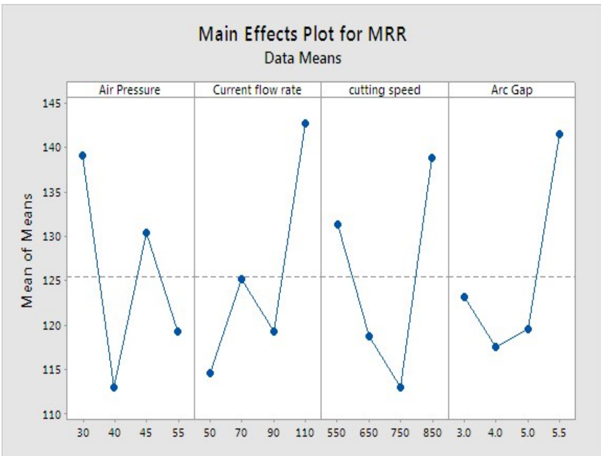

Figure 5: Main effect graph for MRR

In this research, the larger amount of MRR was most effective for the process. Fig. 5 shows that the higher MRR will meet at air pressure 30 N/cm^2, current flow rate 110 A, cutting speed 850 mm/min and arc gap 5.5 mm. The graph generate by the use of MINITAB 17 statistical software for MRR.

It has been conclude that the optimum combination of each process parameter for higher MRR is meeting at high cutting speed [C4], low air pressure [A1], high current flow rate [B4] and high arc gap [D4].

Exp. no	Air pressure	Current flow rate	Cutting speed	Arc gap	MRR
1	30	110	850	5.5	199.095
2	40	50	650	5	103.004

3.2 Discussion about SR:

Figure 6: Main effect for SR

In this research, the smaller amount of SR value was effective for the experiment. Fig. 6 shows that the higher MRR will meet at air pressure 45 N/cm^2, current flow rate 70 A, cutting speed 850 mm/min and arc gap 5.5 mm. The graph generate by the use of MINITAB 17 statistical software for MRR.

It has been conclude that the optimum combination of each process parameter for higher MRR is meeting at high cutting speed [C4], higher medium air pressure [A3], lower medium current flow rate [B2] and high arc gap [D4].

Exp. no	Air pressure	Current flow rate	Cutting speed	Arc gap	SR
1	50	110	550	5	3.23
2	55	50	850	4	1.84

3.3 Discussion about KW:

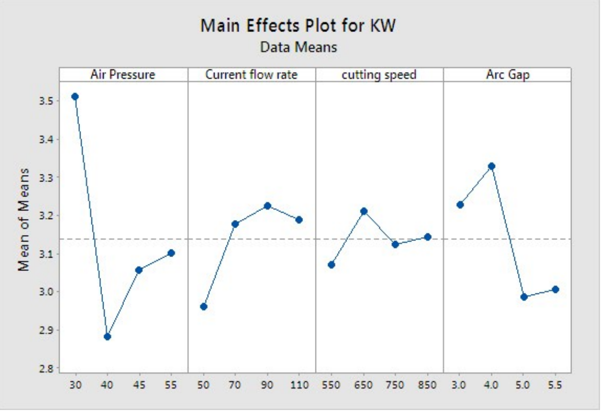

Figure 7: Main effect for KW

In this research, the smaller amount of KW value was effective for the experiment. Fig. 7 shows that the higher MRR will meet at air pressure 40 N/cm^2, current flow rate 50 A, cutting speed 550 mm/min and arc gap 5 mm. The graph generate by the use of MINITAB 17 statistical software for MRR.

It has been conclude that the optimum combination of each process parameter for higher MRR is meeting at low cutting speed [C1], lower medium air pressure [A2], low current flow rate [B1] and higher medium arc gap [D3].

Exp. no	Air pressure	Current flow rate	Cutting speed	Arc gap	SR
1	30	70	650	4	4.01
2	40	50	650	5	2.50

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