

INVESTIGATION OF THE EFFECT OF PROCESS PARAMETER ON SURFACE ROUGHNESS AND KERF TAPER DURING CO₂ LASER CUTTING PROCESS USING GREY RELATIONAL ANALYSIS (GRA)

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Abstract— This paper deals with the investigation of the effect of CO₂ laser cutting of Aluminium alloy 6351. The process parameters considered were laser power, speed and pressure and the responses were roughness and kerf taper. Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it was found that optimal parameter levels are laser speed at level 3 (4.5 m/min), power at level 1(0.8 kw) and pressure at level 2(0.15 bar).

Keywords— CO₂ laser, GRA, laser power, speed, gas pressure, roughness and kerf taper.

I. INTRODUCTION

This paper deals with the investigation of the effect of CO₂ laser cutting of Aluminium alloy 6351. The process parameters considered were laser power, speed and pressure and the responses were roughness and kerf taper. Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it was found that optimal parameter levels are laser speed at level 3 (4.5 m/min), power at level 1(0.8 kw) and pressure at level 2(0.15 bar).

II. DESIGN OF EXPERIMENTS

Box Behenkn design with 17 experiments was planned. According to box-behnken with three parameters and three levels are considered.

TABLE I
PARAMETERS AND ITS LEVELS

Parameters and its level	Level 1	Level 2	Level 3
Power	0.32	0.33	0.34
Speed	0.20	0.21	0.22
Pressure	0.70	0.80	0.90

The parameters to be examined and the levels of each parameter are sorted out. The box-behnken used is presented below.

TABLE II
BOX BEHENKN DESIGN

Expt.No	Power kw	Speed m/min	Pressure Bar
1	3.3	2.2	0.7
2	3.3	2	0.9
3	3.3	2.1	0.8
4	3.4	2.1	0.9
5	3.2	2.1	0.7
6	3.3	2.1	0.8

7	3.3	2.1	0.8
Expt.No	Power kw	Speed m/min	Pressure Bar
8	3.4	2	0.8
9	3.2	2.2	0.8
10	3.2	2.1	0.9
11	3.3	2.2	0.9
12	3.3	2.1	0.8
13	3.3	2	0.7
14	3.4	2.2	0.8
15	3.2	2	0.8
16	3.3	2.1	0.8
17	3.4	2.1	0.7

III. MACHINING OPERATIONS

The machine used for this machining was LCG3015. Aluminium plate of 350X300X2 mm is divided into 17, 50X20 cross section. The profile shown in figure is then created in the AutoCAD and then saved in to the directory of the laser machine which is used for machining.

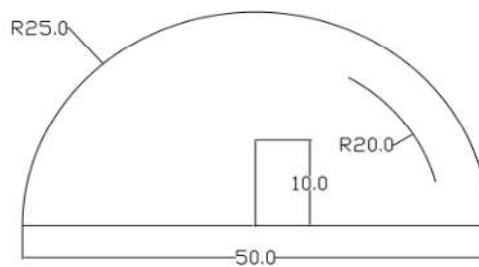


Figure 1 Profile for cutting

IV. RESULTS AND DISCUSSION

The below response was measured with the help of the surface roughness tester and tool makers microscope.

TABLE III
RESPONSES

Expt.No.	Kerf Taper Degrees	Roughness micrometer
1	0.573	3.855
2	0.753	4.503
3	0.831	4.094
4	1.341	4.362
5	0.764	3.697
6	0.761	4.127
7	0.736	4.144
8	1.328	3.978
9	0.778	4.095
10	0.772	4.435
11	0.581	4.652
12	0.868	4.145
13	0.774	3.746
14	1.340	3.989
15	0.757	4.045

16	0.766	4.125
17	1.336	3.649

A. GREY RELATIONAL ANALYSIS

The grey system theory has been applied successfully in many scientific fields, such as finance, engineering and even social sciences. Grey relational analysis (GRA) is derived from grey system theory and is proven to be an efficient statistic tool for the analysis of experimental results and system optimization. Although GRA is not a method for experimental design, it can be easily combined with one of the available experimental design methods to form a powerful experimental analysis tool.

TABLE IV
GREY GRADE AND RANK

Expt. No.	Grey Grade	Rank
1	0.360	17
2	0.583	6
3	0.451	9
4	0.817	1
5	0.372	16
6	0.443	11
7	0.442	12
8	0.696	3
9	0.440	13
10	0.550	7
11	0.668	4
12	0.472	8
13	0.380	15
14	0.713	2
15	0.424	14
16	0.444	10
17	0.659	5

Table 4 shows the grey grade and the corresponding rank.

TABLE 5
GREY RELATIONAL ANALYSIS RANK

Parameters	Main effect	Rank	Optimum level
	Max - Min		
Power	0.275	1	0.547
Speed	0.028	3	0.528
Pressure	0.212	2	0.533

From table 5 it is observed that Power influences roughness and kerf taper much followed by Assist gas pressure and speed.

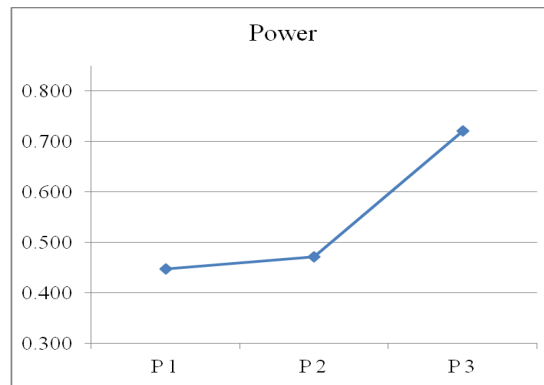


Figure 2 GRA vs POWER

Figure 2 shows the effect of laser power on grey relational grade. It shows that when laser power increases from 0.721 to 0.447 kW then grey relational grade is decreases. In figure 4.9 at laser power 0.721 kW grey relational grade is higher, so 0.721 kw is optimum parameter level from three levels of laser power.

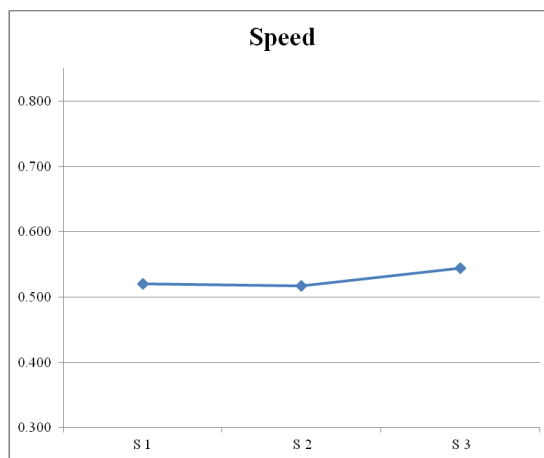


Figure 3 GRA vs Speed

Figure 3 shows the effect of cutting speed on grey relational grade. It shows that when cutting speed increases from 5.45 to 5.21 m/min then grey relational grade is decreases. But, if cutting speed increases from 5.45 to 5.21 m/min then grey relational grade is decreases. In figure 4.10 at 5.45 m/min cutting speed, the grey relational grade is higher, so 5.45 m/min is optimum parameter level from three levels of cutting speed.

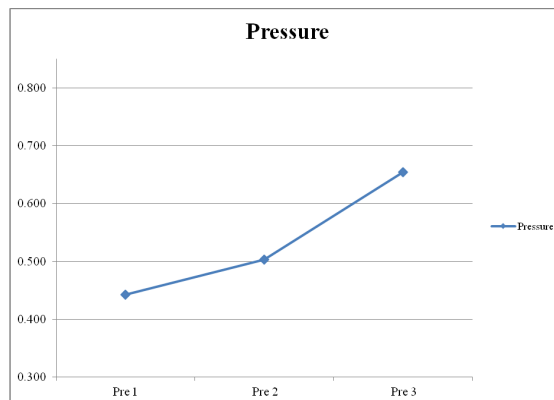


Figure 4 GRA vs Pressure

Figure 4 shows the effect of gas pressure on grey relational grade. It shows that with increase in gas pressure from 6.54 to 4.43 bar, there is also increase in the value of grey relational grade. In figure 4.43 at 6.54 bar gas pressure, grey relational grade is higher, so 4.4 bar is optimum parameter level from three levels of gas pressure.

V. CONCLUSIONS

. The paper presented here is an overview of work carried out in laser cutting process. The relationship between the various values of input parameters like laser power, cutting speed and assist gas pressure and their effect on roughness and kerf width were studied for CO₂ Laser cutting of aluminium 6351 plate of 2mm thickness.

The following conclusions from RSM were

- Kerf taper increases and decreases with increases in power and gas pressure were increases with increases in speed.
- Roughness increases and decreases with increases in power and gas pressure were decreases and increases with increases in speed.

Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it was found that optimal parameter levels are laser speed at level 3 (5.45 m/min), power at level 1 (4.47 kw) and pressure at level 2 (5.03 bar).

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