OPTIMIZATION OF PROCESS PARAMETERS OF CO2 LASER CUTTING PROCESS ON SS304

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Abstract: Laser cutting is mostly a thermal process in which a focused laser beam is used to melt material in a localized area. A co-axial gas jet is used to eject the molten material from the cut and leave a clean edge. A continuous cut is produced by moving the laser beam or work piece and leave a clean edge. A particular characteristic of a laser cut is the formation of striations on the cut edge. These striations play an important part in laser cutting as they effectively control the edge roughness. Laser Beam Machining is widely used manufacturing technique utilized to perform cutting, engraving and welding operations on a wide variety of materials ranging from metals to plastics. In the present work an attempt has been made to study the effect of process parameters such as feed rate, input power and gas pressure of 3 levels of each parameter on the quality of the machined surface using laser beam on stainless steel. The quality of cut is assessed in terms of response parameters such as upper kerf width, lower kerfs width, heat affected zone and surface roughness. Design of experiments is implemented by using a full factorial design. The effect of the process parameters on response have been shown by means of main effect plots developed using ANOVA analysis. After Design of Experiment (DOE) by using full factorial method, the analysis will be carry by the Analysis Of Variance (ANOVA) method and optimization will be carry Response surface methodology.
KeyWords: ANOVA, Surface roughness, DOE, HAZ, SS304, Full factorial design, GRA.etc.

I. INTRODUCTION

Laser cutting is a thermal cutting process in which a cut kerf (slot) is formed by the heating action of a focused traversing laser beam of power density on the order of 104 W/mm2 in combination with the melt shearing action of a stream of inert or active assist gas. The focused laser beam melts the material throughout the material thickness and a pressurized gas jet, acting coaxially with the laser beam, blows away the molten material from the cut kerf.

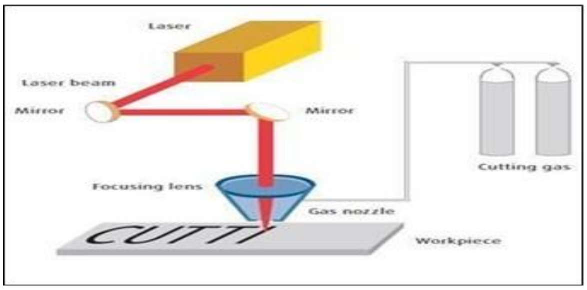

Figure1.1 Laser Cutting Process

II. METHODOLOGY

2.1 Experimental Setup

From the literature survey of past researchers it is shown-that the material selection in manufacturing process is most important thing as per process availability and customer's requirement. There is number of material used in modern industry but steel have corrosion resistive property and high strength, so it is widely use in modern industry. The material used to carry out experiment is SS304. In order to achieve the goal of this experimental work the cutting test were carried out in a MAZAK HYPER GEAR 510 laser cutting machine at Martiaen engineering company, Unjha.

Figure: 2.1 Mazak hyper gear 510

2.2 Full factorial design

Design of experiment: We have used factorial design, and used full factorial design. For a full factorial design, if the numbers of levels are same then the possible design N is

$N = L^m$ $N=3^3$ $N=27$

Where L = number of levels for each factor, and m= number of factors.

Table 2.2-Parameter and their Levels

Process parameter	Process designation	Level 1	Level 2	Level 3
Input Power (watt)	A	1300	1500	1700
Feed (mm/min)	B	2000	2100	2200
Gas pressure (bar)	C	0.5	0.6	0.7

III. RESULTS OF DOE–FULL FACTORIAL METHOD

Obtain results are shown in table 3.1.

Table 3.1–ExperimentalResults of Full factorial Method

Trail no.	Laser power (watt)	Gas pressure (bar)	Feed (mm/min)	Surface roughness (µm)	Material removal rate (g/sec)	Heat affected zone (µm)
1	1300	0.5	2000	3.59	1.0942	18.54
2	1300	0.6	2000	3.51	1.0960	18.39
3	1300	0.7	2000	2.96	1.1011	18.06
4	1300	0.5	2100	3.42	1.0983	18.48
5	1300	0.6	2100	3.39	1.1000	18.26
6	1300	0.7	2100	2.95	1.1011	18.13
7	1300	0.5	2200	3.41	1.1023	18.16
8	1300	0.6	2200	3.33	1.1023	18.09
9	1300	0.7	2200	3.27	1.1076	17.99
10	1500	0.5	2000	2.81	1.1546	25.39
11	1500	0.6	2000	2.71	1.1540	25.54
12	1500	0.7	2000	2.59	1.1559	25.39
13	1500	0.5	2100	2.81	1.1571	25.65
14	1500	0.6	2100	2.69	1.1591	25.34
15	1500	0.7	2100	2.57	1.1591	25.25
16	1500	0.5	2200	2.91	1.1616	26.01
17	1500	0.6	2200	2.73	1.1642	25.88
18	1500	0.7	2200	2.5	1.1655	25.61
19	1700	0.5	2000	3.52	1.2335	27.32
20	1700	0.6	2000	3.43	1.2379	27.15
21	1700	0.7	2000	3.39	1.2512	26.98
22	1700	0.5	2100	4.03	1.2430	27.27
23	1700	0.6	2100	3.62	1.2550	27.16
24	1700	0.7	2100	3.56	1.2671	27.03
25	1700	0.5	2200	4.13	1.2978	26.98
26	1700	0.6	2200	3.95	1.3075	26.88
27	1700	0.7	2200	3.9	1.3333	26.72

3.2 Analysis of Variance (ANOVA)

ANOVA was used to determine the significant parameters influencing surface roughness, Material removal rate and HAZ. Table3.2, 3.3 and 3.4 shows summery of ANOVA results for Surface roughness, Material removal rate and Heat affected zone. This analysis was level of significance as 5% and level of confidence as 95%.

Table3.2–ANOVA Results for **Surface roughness**

Source of Variation	DOF	Sum of Squares (SS)	Mean Square (MS)	Variance Ratio (F)	Percentage Contribution %C
Power	2	4.7729	2.3865	91.4368	80.48%
Gas pressure	2	0.4831	0.2415	9.2529	8.15%
Feed	2	0.1515	0.0758	2.9042	2.55%
Error	20	0.5226	0.0261		8.81%
Total	26	5.9301			100%
		S=0.16159		R-Sq =91.19%	

Table3.3–ANOVA Results for **Material removal rate**

Source of Variation	DOF	Sum of Squares (SS)	Mean Square (MS)	Variance Ratio (F)	Percentage Contribution %C
Power	2	0.133	0.06550	2.4116	93.00%
Gas pressure	2	0.00037	0.00018	0.0067	0.26%
Feed	2	0.0041	0.00205	0.0745	2.87%
Error	20	0.0055	0.00027		3.86%
Total	26	0.143			100%
		S=0.162990		R-Sq =96.29%	

Table3.4–ANOVA Results for **Surface roughness**

Source of Variation	DOF	Sum of Squares (SS)	Mean Square (MS)	Variance Ratio (F)	Percentage Contribution %C
Power	2	402.36	200.62	56025.52	99.72%
Gas pressure	2	401.25	0.195	5.4454	0.096%
Feed	2	0.39	0.005	0.1467	0.002%
Error	20	0.72	0.035		0.177%
Total	26				100%
		S=188956		R-Sq =99.82%	

MAIN EFFECT PLOTS ANALYSIS

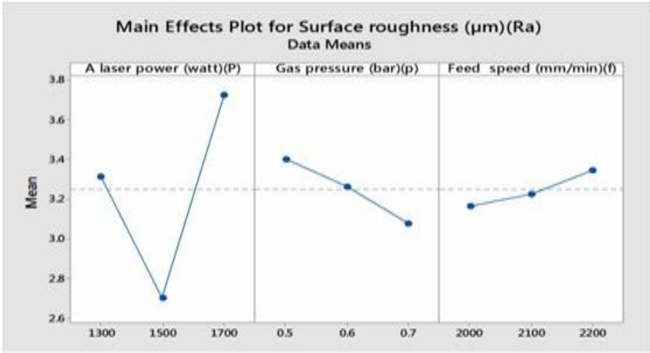

Fig. 3.1 main effect plot for surface roughness

According to the main effect plot the optimal conditions for minimum surface roughness are:

- Laser power at level 2 (1500 watt)
- Gas pressure at level 3 (0.7 bar)
- Feed rate at level 1 (2000 mm/ min)

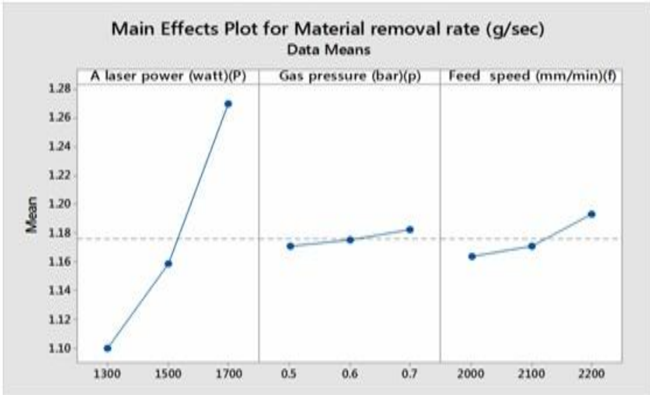

Fig. 3.2 main effect plot for material removal rate

According to this main effect plot, the optimal conditions for maximum material removal rate are:

- Laser power at level 3 (1700 watt)
- Gas pressure at level 3 (0.7 bar)
- Feed rate at level 3 (2200 mm/ min)

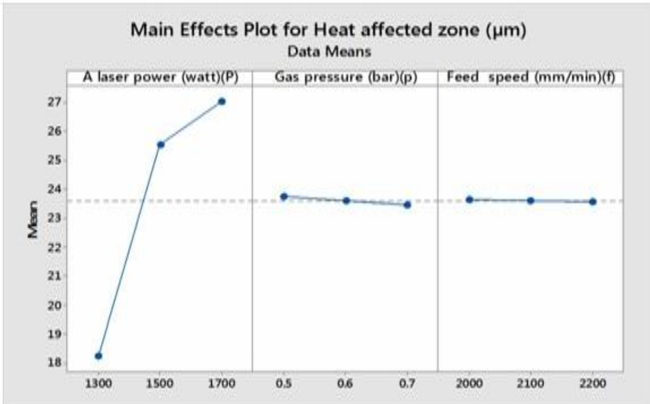

Fig. 3.3 shows the main effect plot for heat affected zone.

According to this main effect plot, the optimal conditions for minimum heat affected zone:

- Laser power at level 1 (1300 watt)
- Gas pressure at level 3 (0.7 bar)
- Feed rate at level 3 (2200 mm/ min)

IV. CONCLUSIONS

- Experimental results show that surface roughness decreases as power increases from 1300 to 1700 watt, as increases of gas pressure from 0.5 to 0.7 bar surface roughness is increase. The same thing happened for Feed, if fees is increase than surface roughness is decreases, the reason is that with increase in feed, the laser repetition is decrease so that surface becomes more rough as lower repetition of laser beam that is why with increasing feed, surface roughness decreases.
- Experimental results show that material removal rate is maximum at maximum power (1700 watt), maximum gas pressure (0.7 bar) and maximum feed (2200 mm/Sec.
- Now discuss on Heat affected zone, which is increase as power increases from 1300 to 1700 watt, as increases of gas pressure from 0.5 to 0.7 bar HAZ is decrease, if feed is increase than HAZ is decreases

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