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Study of Process Parameter of LBM for Machining SS-304

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Abstract - *This paper investigates the laser beam machining of SS-304. In this research work, the effects of three parameters, namely, gas pressure, laser power and cutting speed were studied upon taper and Surface roughness. The objective was to study the effect of input parameter individually on the final outcome. Response surface methodology was used to design the experiments and the performance characteristics in LBM operation were studied. The experimental result indicate that laser power is the most significant factor. At high values of laser power, taper and surface roughness were found high.*

Key Words: LBM, RSM, SS-304

1. INTRODUCTION

Modern machining methods are made to process materials that are difficult to process when using conventional machining methods. One of the modern machining methods is laser beam machining (LBM). Lasers can be used for welding, cladding, marking, surface treatment, drilling, and cutting among other manufacturing processes. It is used in the automobile, shipbuilding, aerospace, steel, electronics, and medical industries for precision machining of complex parts. Drilling and cutting with lasers is advantageous in that there is little to no wear on the cutting tool as there is no contact to cause damage. LBM uses the light energy from a laser device for the material removal by vaporization and ablation. The light laser beam is pulsed so that the released energy results in an impulse against the work surface with the melted material evacuating the surface at a high velocity that produces a combination of evaporation and melting.

Researchers worked in area of laser beam machining to investigate effect of process parameters. Rajaram et al. (2003) studied the combined effects of laser power and cutting speed on kerf width, surface roughness, striation and size of HAZ of 4130 steel. It was observed that the laser power had a major effect on the kerf width and size of HAZ, while the cutting speed had a major role in determining the surface roughness and striation frequency [1]. Kurt et al. (2009) have employed the ANOVA and regression analysis to assess the effect of the process parameters (gas pressure, cutting speed and laser power) on the dimensional accuracy and surface roughness for engineering plastics. They reported that the relationship can be used to optimize the process to get the optimum surface quality and roughness values [2]. Bekir Sami Yilbas et al. (2017) carried out analysis to find out influence of laser output power and laser cutting speed on the kerf width size. The kerf width size variation increases with increasing laser output power. However, this behavior reverses with increasing laser cutting speed [3]. Arun Kumar Pandey and Avanish Kumar Dubey (2012) carried out simultaneously optimization of kerf taper and surface roughness in the laser cutting of Titanium alloy sheet. The parametric study shows that higher values of cutting speed and moderate gas pressure will be more suitable for machining [4]. Huehnlein et al. (2010) has attempted DOE approach for the optimization of laser cutting of thin Al2O3 ceramic layers. They mentioned that DOE allows to separate the most important influencing factors on the targeted cutting process, to clarify their interaction, to reduce the overall amount of parameter sets that need to be examined and to identify the optimized parameter regions [5].

2. EXPERIMENTAL SET-UP

During this study, series of experiments on the SS-304 were conducted to examine the effect of input machining parameters, such as gas pressure, laser power and cutting speed on taper and surface roughness. In this experimental work, nozzle diameter (0.2 mm) and stand-off distance (0.5 mm) were kept constant throughout the experimentation. All the experiments were performed on LBM of Prime Power made DOMINO CP 4000 Machining set up is shown in figure 1.

Fig -1: Laser Beam Machining Set-up

Machining parameters and their level chosen for this study are presented in Table 1.

Table 1: Machining parameters and their levels

Parameters	Units	Levels		
		-1	0	1
Gas Pressure	Bar	12	13	14
Laser Power	Watt	2500	3000	3500
Cutting Speed	Mm/min	1500	1700	1900

Experiments were carried out in single block. Surface roughness was measured Taylor Hobson surtronic 3 series surface roughness tester and kerf width was measured using profile projector. Total 24 experiments were conducted out of which 20 are as per DOE and 4 for confirmation purpose. Work piece cut after the machining are shown in Fig 2.

Fig -2: Workpiece cut by LBM

Table 2: Experimental Design Matrix of Coded and actual Values

Expt. No.	**Coded variables**			**Actual variables**		
	Gas pressure	**Laser power**	**Cutting speed**	**Gas pressure**	**Laser power**	**Cutting speed**
1	1	-1	-1	14	2500	1500
2	1	1	1	14	3500	1900
3	0	0	0	13	3000	1700
4	-1	-1	1	12	2500	1900
5	-1	1	-1	12	3500	1500
6	0	0	0	13	3000	1700
7	0	0	0	13	3000	1700
8	-1	-1	-1	12	2500	1500
9	0	0	0	13	3000	1700
10	1	1	-1	14	3500	1500
11	-1	1	1	12	3500	1900
12	1	-1	1	14	2500	1900
13	0	0	-1	13	3000	1500
14	0	0	1	13	3000	1900
15	0	1	0	13	3500	1700
16	0	0	0	13	3000	1700
17	1	0	0	14	3000	1700
18	-1	0	0	12	3000	1700
19	0	0	0	13	3000	1700
20	0	-1	0	13	2500	1700

3. RESULT AND DISCUSSION

The analysis was made using the popular software specifically used for design of experiment applications known as MINITAB. In present study, it is desirable to minimize both the response parameters. Experimental results are listed in table no 3.

Table 3: Experimental results

Expt. No.	Gas pressure	Laser power	Cutting speed	Taper	Surface roughness
	(bar)	(Watt)	(mm/min)	(^{0})	(µm)
1	14	2500	1500	0.298	2.43
2	14	3500	1900	0.494	3.51
3	13	3000	1700	0.352	2.53
4	12	2500	1900	0.343	2.51
5	12	3500	1500	0.359	2.89
6	13	3000	1700	0.352	2.53
7	13	3000	1700	0.352	2.53
8	12	2500	1500	0.339	2.45
9	13	3000	1700	0.352	2.53
10	14	3500	1500	0.381	3.11
11	12	3500	1900	0.404	3.18
12	14	2500	1900	0.341	2.49
13	13	3000	1500	0.334	2.45
14	13	3000	1900	0.381	2.58
15	13	3500	1700	0.396	3.16
16	13	3000	1700	0.352	2.53
17	14	3000	1700	0.359	2.54
18	12	3000	1700	0.356	2.48
19	13	3000	1700	0.352	2.53
20	13	2500	1700	0.325	2.45

A. Analysis of Taper

The main effect plot for taper is shown in Fig 3. It shows that the taper is directly proportional to the laser power and cutting speed. Taper decreases with increase in gas pressure initially and then start to increase.

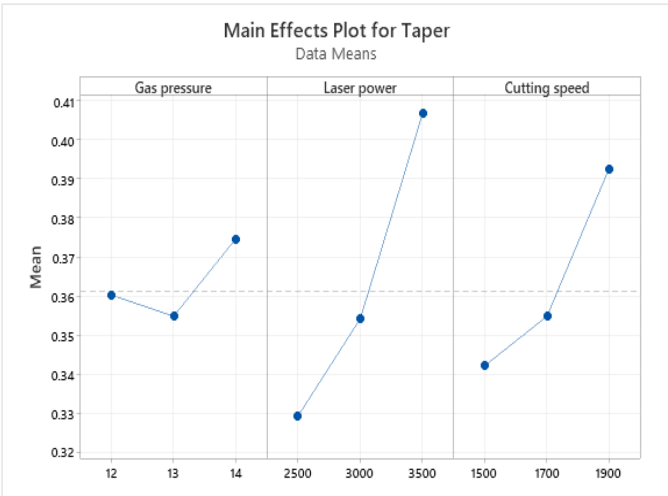

Fig. 3. Main effect plot for Taper

The pareto chart for taper is shown in Fig 4. It shows that the laser power is most significant factor followed by cutting speed and gas pressure,

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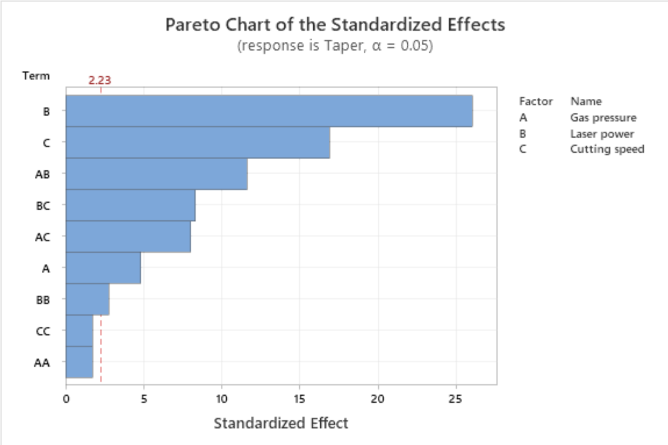

Fig. 4. Pareto chart for Taper

Then, regression equation 1 is performed based on the results by the design of experiment. Here, the taper act as dependent variable, which has three independent variables. Residual plot for taper is shown in figure 5.

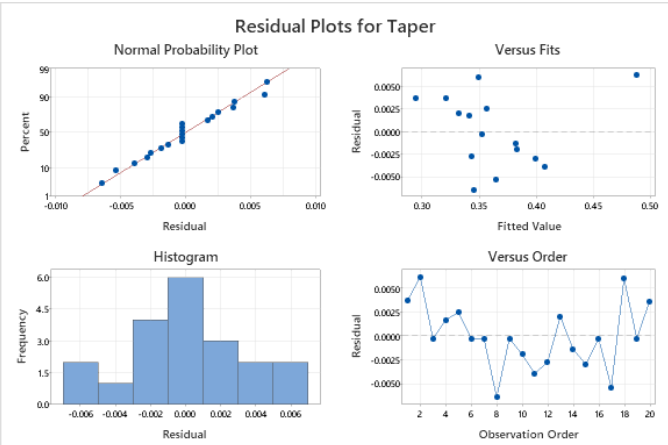

Fig. 5. Residual plot for Taper

$$\begin{aligned}\text{Taper} = {} & 4.977 - 0.3504 \text{ Gas pressure} - \\ & 0.000852 \text{ Laser power} - \\ & 0.001577 \text{ Cutting speed} \\ & + 0.00491 \text{ Gas pressure*Gas pressure} \\ & + 0.000000 \text{ Laser power*Laser power} \\ & + 0.000000 \text{ Cutting speed*Cutting speed} \\ & + 0.000039 \text{ Gas pressure*Laser power} \\ & + 0.000067 \text{ Gas pressure*Cutting speed} \\ & + 0.000000 \text{ Laser power*Cutting speed}\end{aligned} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

B. Analysis of surface roughness

The main effect plot for surface roughness is shown in Fig 6. It shows that the surface roughness is directly proportional to the laser power. Surface roughness decreases with increase in gas pressure and cutting speed initially and then start to increase.

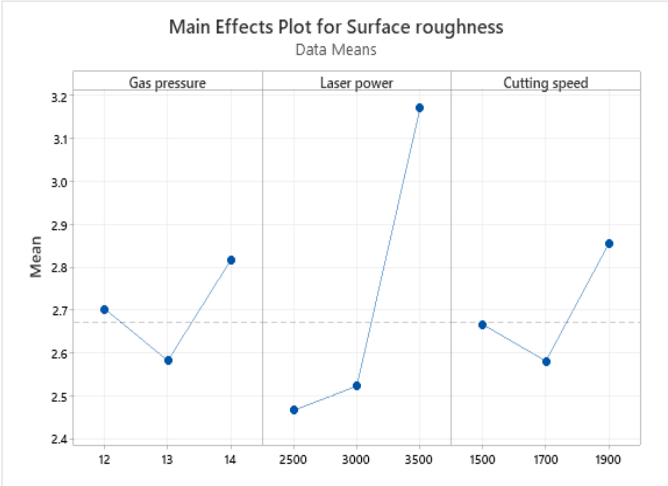

Fig. 6. Main effect plot for Ra

The pareto chart for surface roughness is shown in Fig 7. It shows that the laser power is most significant factor followed by cutting speed and gas pressure,

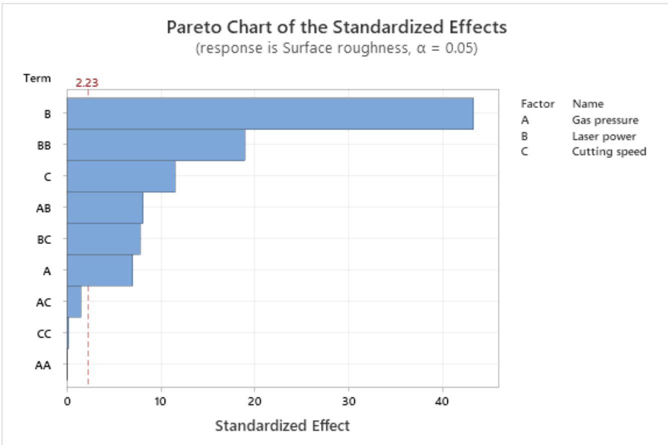

Fig. 7. Main effect plot for Ra

Then, regression equation 2 is performed based on the results by the design of experiment. Here, the surface roughness act as dependent variable, which has three independent variables. Residual plot for taper is shown in figure 8.

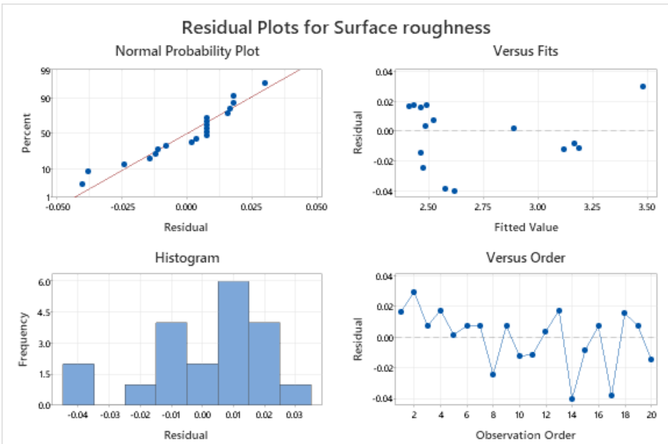

Fig. 8. Main effect plot for Ra

Ra= 20.38 - 0.467 Gas pressure - 0.009472 Laser power - 0.00287 Cutting speed
- 0.0014 Gas pressure*Gas pressure
+ 0.000001 Laser power*Laser power
+ 0.000000 Cutting speed*Cutting speed
+ 0.000148 Gas pressure*Laser power
+ 0.000069 Gas pressure*Cutting speed
+ 0.000001 Laser power*Cutting speed
……………………. (2)

3. CONCLUSIONS

The laser beam machining experiment were conducted on ss-304. The kerf width and surface roughness was evaluated. It is observed from the experimental result that kerf width increases drastically with increase in laser power. It was found that laser power is most significant factor followed by cutting speed and gas pressure.

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REFERENCES

1. N. Rajaram, J. Sheikh and S. H. Cheraghi, CO2 laser cut quality of 4130 steel, J. of Machine Tools and Manufacture, Vol. 43, 2003, pp. 351-358.
2. M. Kurt, Y. Kaynak, E. Bagei, H. Demirer and M. Kurt, “Dimensional analyses and surface quality of laser cutting process for engineering plastics” Inter. J. of Manuf. Technology, Vol. 41, 2009, pp. 259-267.
3. Bekir Sami Yilbas, Mian Mobeen Shaukat, Farhan Ashraf “Laser cutting of various materials: Kerf width size analysis and life cycle assessment of cutting process” Optics and Laser Technology 93 (2017) 67–73
4. Arun Kumar Pandey and Avanish Kumar Dubey “Simultaneous optimization of multiple quality characteristics in laser cutting of titanium alloy sheet” Optics & Laser Technology 44 (2012) 1858–1865.
5. K. Huehnlein, K. Tschirpke and R. Hellmann, Optimization of laser cutting processes using design of experiments, J. of Physics Procedia, Vol. 5, No. 2, 2010, pp. 243-252.
6. N. Rajaram, J. Sheikh-Ahmad, S.H. Cheraghi, CO2 laser cut quality of 4130 steel, Int. J. Machine Tools Manuf. 43 (2003) 351–358. J. Wang, W.C.K. Wong, CO2 laser cutting of metallic coated sheet steels, J. Mater. Process. Technol. 95 (1999) 164–168.
7. B.S. Yilbas, Effect of process parameters on the kerf width during the laser cutting process, in: Proceedings of the First MECH E Part B, J. Eng. Manuf. 215 (10) (2001) 1357–1365.