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MULTI OBJECTIVE OPTIMIZATION OF CO_2 LASERCUTTING PROCESS ON STAINLESS STEEL 316L USING GREY RELATIONAL ANALYSIS TECHNIQUE

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Abstract

The aim of this paper was to investigate the effect of various laser cutting parameters like laser power, cutting speed and gas pressure during CO_2 laser cutting of stainless steel 316L materials on roughness and kerf taper.Box behnken design involves three parameter at three levels were considered and the results were analyzed using Analysis of variance [ANOVA] method, which shows that the spindle speed influences roughness and kerf taper.Grey Relational Analysis [GRA] was applied to obtain grey relational grade which was analyzed to find the optimal parameters from the grey relational analysis the optimal parameters has been found power at level 1 (0.8 kw), speed at level 3 (4.5 m/min) and pressure at level 2 (0.15 bar).

1. Introduction

LASER has become an important tool in modern manufacturing. Laser machining is a non-contact process and the attractive characteristics of laser machining include narrow low thermal distortion, generates no mechanical stress on the work piece like conventional machining process, high precision, high machining rate, ecologically clean technology and superior surface finish. The basic principle involves generation of high intensity beam of infrared light. This beam is focused onto the surface of work piece which the material and establishes localized melt throughout the depth of the sheet. The molten metal is ejected from the area by pressurized gas and this localized area of material removal across the material generates a cut.

2. Literature Review

Laser cutting process research mainly focus on the good quality of cut which depends on the parameters like laser power, thermal properties, thickness, assist gas type and pressure, cutting speed. Surface roughness is one of the effective and key parameter in representing the surface quality. Ghany&Newishy (2005) found that compared with oxygen, nitrogen gas produces smooth and brighter surface. Arun Kumar Pandey&Avanish Kumar Dubey (2012) observed that low frequency, high cutting speed and moderate assist gas pressure results in good surface finish. Riveiro (2010) found that good quality can be obtained by high cutting speed and high laser power. Stournaras (2009) found that cutting speed & laser are the important parameter on the cutting quality. Thawari (2005) observed that surface roughness decreases with high frequency, high speed, low power and low gas pressure. Rajaram (2003) in their study concluded that high powers and lower feed rates gave good surface roughness.

Madic (2013) observed that the high cutting speed, low gas pressure and intermediate laser power results in minimum surface roughness. Sundar (2009) concluded that surface roughness decreases with low gas pressure and high cutting speed.

3. Methodology

RSM is a group of mathematical and statistical techniques, often employed in engineering studies with regard to model problems, whose underlying structure is unknown and also optimize the desired output of these problems. The term Response Surface is employed to describe the surface that represents the output of a process when input parameter values vary within specified ranges. This method is of great importance specifically for machining problems, as it can be seen from the considerable amount of scientific works employing this method in the literature.

Table 1 Input parameter levels

Levels and parameters	Level 1	Level 2	Level 3
Power (kW)	0.80	0.90	1.00
Speed (m/min)	4.30	4.40	4.50
Pressure (bar)	0.05	0.15	0.25

Box-behnken three parameters with three levels are considered. The parameters to be examined and the levels of each parameter are sorted out.

4. Results and discussion

The below response was measured with the help of tool makers microscope and roughness tester and the following the graphs were obtained from design expert software.

Table 2 Response Values for the experiment

Expt. No.	Power KW	Speed m/min	Pressure Bar	Kerf Taper	Roughness Micro meter
1	1	4.4	0.05	1.018	2.119
2	0.8	4.4	0.25	1.117	2.163
3	0.9	4.4	0.15	1.168	2.185
4	0.9	4.5	0.25	1.419	2.327
5	0.9	4.3	0.05	1.132	2.157
6	0.9	4.4	0.15	1.121	2.163
7	0.9	4.4	0.15	1.117	2.163
8	0.8	4.5	0.15	1.416	2.317
9	1	4.3	0.15	1.133	2.165
10	0.9	4.3	0.25	1.132	2.160

11	1	4.4	0.25	1.016	2.121
12	0.9	4.4	0.15	1.095	2.151
13	0.8	4.4	0.05	1.132	2.167
14	1	4.5	0.15	1.419	2.321
15	0.8	4.3	0.15	1.138	2.158
16	0.9	4.4	0.15	1.127	2.166
17	0.9	4.5	0.05	1.418	2.323

4.1 Kerf Taper

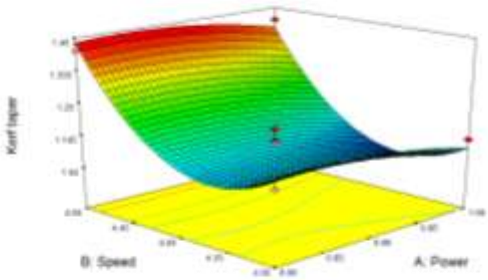

Figure 1 Power vs Speed

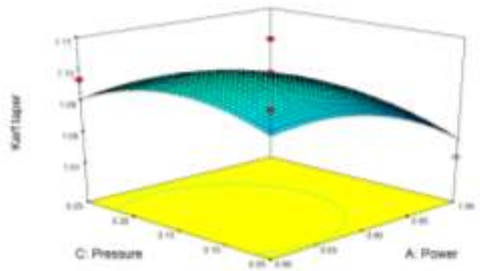

Figure 2 Power vs Pressure

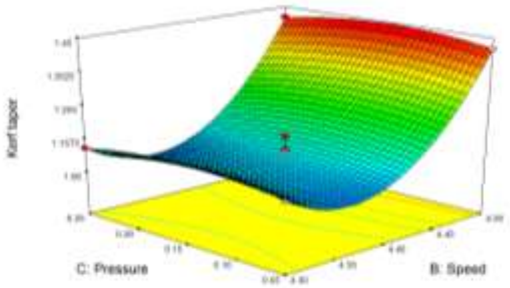

Figure 3 Pressure vs Speed

From ANOVA, the Model F-value of 27.84 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.Values of "Prob > F" less than 0.0500 indicate model terms are significant.In this case B, B^2 are significant model terms.

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4.2 Roughness

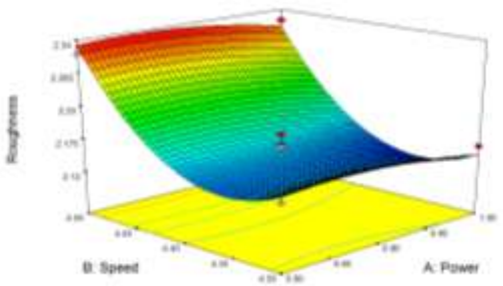

Figure 4 Power vs Speed

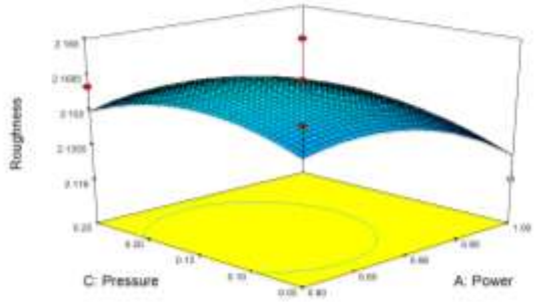

Figure 5 Power vs Pressure

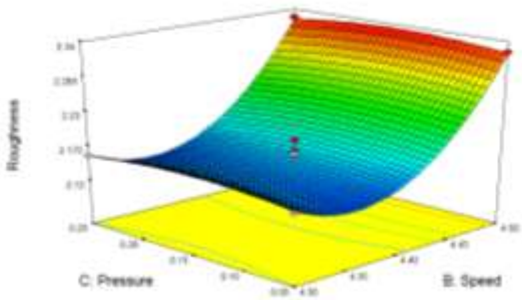

Figure 6 Pressure vs Speed

From ANOVA, the Model F-value of 34.50 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.Values of "Prob > F" less than 0.0500 indicate model terms are significant.In this case B, B^2 are significant model terms.

4.3 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. By grouping the relational grades for each factor and experimental level, grey relational grade graphs can easily be obtained and the correlations between the studied variables, as well as the optimum parameters for a process can be determined.

Table 3 Grey Relational Analysis rank

Parameters	Level 1	Level 2	Level 3	Main effect Max – Min	Rank	Optimum level
Power	0.571	0.543	0.517	0.054	2	0.544
Speed	0.460	0.402	0.944	0.542	1	0.602
Pressure	0.542	0.550	0.529	0.021	3	0.541

Grey Relational Analysis [GRA] was applied to obtain grey relational grade shown in table 3, which was analyzed to find the optimal parameters from the grey relational analysis the optimal parameters has been found power at level 1 (0.8 kw), speed at level 3 (4.5 m/min) and pressure at level 2 (0.15 bar).

5. Conclusion

The experiment presented here is an overview of work carried out in laser cutting process. 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).

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