ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Parametric analysis of laser cutting of mild steel material

V. Senthilkumar[1*], G. Jayaprakash[2], M. Thilak[1]
[1]Department of Mechanical Engineering, TRP Engineering College, Tiruchirapalli, Tamil Nadu.
[2]Department of Mechanical Engineering, Saranathan College of Engineering, Tiruchirapalli, Tamil Nadu
***Corresponding author: E-Mail: trpvsk12@gmail.com**

ABSTRACT

Laser cutting process is a thermal based non-contact machining processes capable of generating complex cut profiles on almost all the engineering materials. This paper deals with the influence of laser power, speed, stand-off distance and assist gas pressure on the hardness and surface roughness. The selected orthogonal array was L16 for the four parameters arranged at four levels. From the analysis it was found that with the increase in power, speed, and standoff distance the surface roughness decreases and with the increase in power and at low standoff distance the hardness of the material increases.

KEY WORDS: Laser cutting, Power, Cutting Speed, Standoff distance, Surface roughness, Kerf.

1. INTRODUCTION

In modern technology LASER has become an important tool. 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. Kaushish (2010) classified laser as Gas Lasers (CO_2 and Argon Laser), Solid state lasers (Neodymium-doped yitrium garnet (Nd-YAG) laser and Neodymium-doped glass laser) and Liquid lasers (Nitrobenzene). Arun Kumar Pandey and Avanish Kumar Dubey (2010) stated that the solid state lasers like Nd, YAG and gas laser like CO_2 lasers are mostly used for cutting because of their high power and suitable properties needed for the cutting of the material.

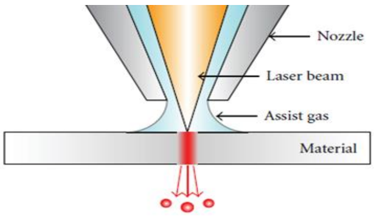

Figure.1. Schematic of conventional laser cutting process (Hitoshi Ozaki, 2012)

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.

2. METHODOLOGY

Design of Experiments: Based on the literature review the parameters selected for investigation were laser power, stand-off distance, cutting speed and gas pressure which were arranged at four levels to form L16 orthogonal array. The Levels of each parameter and the L16 orthogonal array are listed below

Table.1. Experiment parameters

Levels & parameter	Level 1	Level 2	Level 3	Level 4
Power (Watts)	1600	1750	2000	2250
Speed (mm/s)	2200	2500	2800	3100
Pressure (Bar)	0.3	0.4	0.5	0.6
SOD (mm)	0.7	0.9	1.1	1.3

Table.2. Taguchi L16 Orthogonal array DOE

Expt no.	Power	Speed	Pressure	Stand of distance
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	1	4	4	4
5	2	1	2	3
6	2	2	1	4
7	2	3	4	1
8	2	4	3	2
9	3	1	3	4
10	3	2	4	3
11	3	3	1	2
12	3	4	2	1
13	4	1	4	2
14	4	2	3	1
15	4	3	2	4
16	4	4	1	3

Machining Operations: 3mm thickness mild steel was cut using Truflow 4000 CO_2 laser cutting machine with the use of CO_2 assist gas.

Figure.2. Truflow 4000 CO_2 Laser cutting Machine

3. RESULTS AND DISCUSSION

Table.3. Response Values for the experiment

Expt. no	Roughness Microns	Hardness HRC	Expt. no	Roughness Microns	Hardness HRC
1	2.58	72	9	0.82	89
2	0.74	80	10	0.77	76
3	1.12	89	11	0.69	62
4	1.26	76	12	0.92	97
5	0.93	87	13	0.86	96
6	0.59	89	14	0.7	96
7	0.74	89	15	0.61	93
8	1.69	96	16	0.62	93

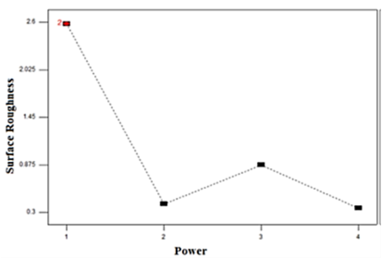

Figure.3. Surface Roughness Vs Power

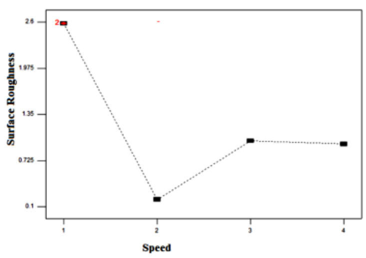

Figure.4. Surface Roughness Vs Speed

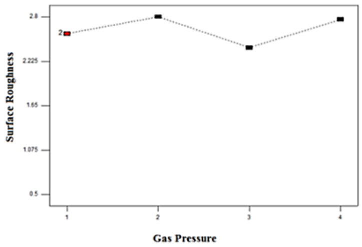

Figure.5. Surface Roughness Vs Gas Pressure

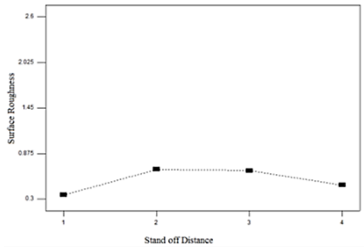

Figure.6. Surface Roughness Vs SOD

From the graph it is observed that surface roughness decreases with increase in cutting speed, power and stand-off distance and does not varies with Gas Pressure.

Hardness: In metallurgy hardness is defined as the ability of a material to resist plastic deformation.

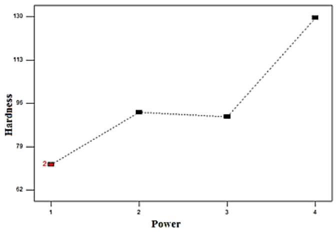

Figure.7. Hardness Vs Power

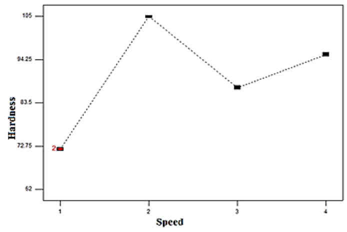

Figure.8. Hardness Vs Speed

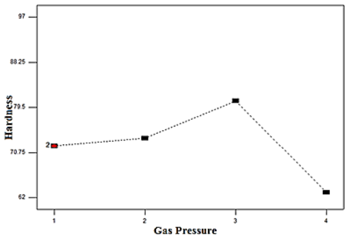

Figure.9. Hardness Vs Gas Pressure

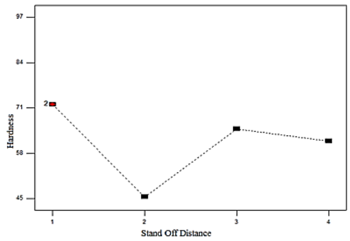

Figure.10. Hardness Vs Stand Off Distance

The hardness of a material increase if the power is increased and stand-off distance is lowered, But there is a decrease in hardness at high cutting speed and gas pressure.

4. CONCLUSION

From all the above discussions it can be concluded that surface roughness value decreases with increase in cutting speed, power and stand-off distance and has little effect with gas pressure and the stand-off distance. Meanwhile hardness of material increases with low stand-off distance and increase in power and the hardness decreases with increase in cutting speed and also in gas pressure.

REFERENCES

Arun Kumar Pandey, Avanish Kumar Dubey, Simultaneous optimization of multiple quality characteristics in laser cutting of titanium alloy sheet, Optics & Laser Technology, 44, 2012, 1858–1865.

Arun Kumar Pandey, Avanish Kumar Dubey, Taguchi based fuzzy logic optimization of multiple quality characteristics in laser cutting of Duralumin sheet, Optics and Lasers in Engineering, 50, 2012, 328–335.

Ghany KA, Newishy M, Cutting of 1.2 mm thick austenitic stainless steel sheet using pulsed and CW Nd, YAG laser, Journal of Materials Processing Technology, 168, 2005, 438–447.

Hitoshi Ozaki, Yosuke Koike, Hiroshi Kawakami, and Jippei Suzuki, Cutting Properties of Austenitic Stainless Steel by Using Laser Cutting Process without Assist Gas, Advances in Optical Technologies, 706-709, 2012, 2228-2233.

Kaushish JP**,** Manufacturing Processes**,** PHI Learning Pvt. Ltd, 2nd Edition, 781, 2010.

Milos Madic, Miroslav Radovanovic and Laurentiu Slatineanu, Surface Roughness Optimization In CO_2 Laser Cutting By Using Taguchi Method, U.P.B. Sci. Bull, Series D, 75 (1), 2013.

Rajaram N, CO_2 laser cut quality of 4130 steel, International Journal of Machine Tools and Manufacture, 43, 2003, 351–358.

Riveiro A, Quintero F, lusquinos F, Comesana R, Pou J, Parametric investigation of CO_2 laser cutting of 2024-T3 alloy, Journal of Materials Processing Technology, 210, 2010, 1138–1152.

Sivarao, Ammar, Anand T.J.S, Shukor, Stochastic Modeling and Optimization of Laser Machining by Response Surface Methodology, International Journal of Engineering & Technology, 10 (04), 13-21.

Stournaras A, Stavropoulos P, Salonitis K, Chryssolouris G, An investigation of quality in CO_2 laser cutting of aluminum, CIRP Journal of Manufacturing Science and Technology, 2, 2009, 61–69.

Sundar M, Nath A.K, Bandyopadhyay D.K, Chaudhuri S.P, Dey P.K, Misra D, Effect of process parameters on the cutting quality in lasox cutting of mild steel, International Journal of Advanced Manufacturing Technology, 40 (9-10), 2009, 865-874.

Thawari G, Influence of process parameters during pulsed Nd, YAG laser cutting of nickel-base superalloys, Journal of Materials Processing Technology, 170, 2015, 229–239.