Parametric Investigation and Optimization of Co2 Laser Cutting Process Used For Cutting Hardox-500 Materials

Parth Patel[1] H.G.Rana[2]
[1]PG Student M.E. Production [2]Assistant Professor, Department of Mechanical Engineering
[1, 2] L.D.R.P.-IRT, Gandhinagar, Gujarat, India

Abstract--- To improve and optimize the responses of a Laser Beam machining process, the various input machining control parameters are to be set at an optimal value. As such one has to adopt experimental methods, which are cumbersome, time consuming, costly and at times not feasible. During such situations, optimization technique like Taguchi can be used as it provides a cost effective method for solution of such complex problems. Unlike traditional optimization techniques, Taguchi is robust and performs well in optimization problems. Considering these advantages of Taguchi, optimization of Co2 Laser beam machining process is done using this technique. In this research work, the desired responses are kerf width and surface roughness and Perpendicularity of cut are calculated. The process control parameters considered are Gas pressure, Cutting Speed, pulse frequency and power.

I. INTRODUCTION

Due to wear problem, industries faces high losses due to the material and maintenance cost. To overcome the wear problem many industries are using advance materials. Mostly in industries the wear resistive materials are used. HARDOX-500 is one of that wear resistive materials which are often used in industries. It is a hard material, Which has high number of hardness value. Due to that precise cutting of this material is done by the special cutting method. Here, we selected Co2 LASER Cutting Method for cutting of HARDOX-500 over various cutting methods. Now, quality of cut of material can differ due to the various parameters affecting it, like power, cutting speed, frequency and gas pressure. By varying this parameters we can achieve required quality of cut. Now, conducting experiment on cutting of HARDOX-500 by varying parameters and considering output as kerf width, surface roughness and perpendicularity of cut, we are going to optimize the parameters for optimum conditions.

II. EXPERIMENTAL PROCEDURE AND OPERATION PARAMETER

A. Material

The base material used in this study was Hardox 500 sheet 10mm thick is an abrasion resistant steel with a nominal hardness of 500 HBW. Typical applications are components and structures subject to wear. Chemical composition of material as showen in Table 1.

C	Si	Mn	P	S	Cr	Ni	Mo	B
0.3	0.7	1.6	0.02	0.01	1.5	1.5	0.6	0.005

Table 1

B. Machine Specification

- Company- Proteck Pvt.Ltd
- Model - Pro Laser CL2030
- Controller- Rexroth
- Work Area- 1.5m*3m
- Max Power- 2000 watts
- Max Pressure- 15 bar
- Nozzle Diameter- 0.02mm

C. Parameters

1) Input Parameters

- Pressure:- 0.5bar , 0.6bar and 0.7bar
- Power:- 1300watts , 1800 watts and 2000 watts
- Cutting Speed:- 300 mm/min , 600 mm/min and 900 mm/min

2) Output Parameters

- Kerf Width
- Surface Roughness
- Perpendicularity

D. Taguchi Methodology based experiment

No.	Power	Cutting Speed	Pressure
	watt	mm/min	bar
1	1300	300	0.5
2		600	0.6
3		900	0.7
4	1800	300	0.6
5		600	0.7
6		900	0.5
7	2000	300	0.7
8		600	0.5
9		900	0.6

Table 2

This experiment is based on the Taguchi methodology. So for 3 parameters and to get 3-level of accuracy L9 Array, and according to that above experiment Table 2 is prepared. Here for each and every set of parameters we measured Kerf width, Perpendicularity and Roughness.

1) Kerf Width Measurement

The Kerf width of work piece is measured with help of the tools maker microscope. Each and every work piece is measured and readings are taken which are shown in Table 3.

No.	Power	Cutting Speed	Pressure	Kerf Width
	watt	mm/min	bar	mm
1	1300	300	0.5	0.48
2		600	0.6	0.07
3		900	0.7	0.076
4	1800	300	0.6	0.527
5		600	0.7	0.058
6		900	0.5	0.03
7	2000	300	0.7	0.495
8		600	0.5	0.03
9		900	0.6	0.05

Table 3

2) *Surface Roughness Measurement*

Surface Roughness of all work piece is measured by the profilometer named as SJ-201. Each work piece is checked by the profilometer and take readings shown in Table 4.

No.	Power	Cutting Speed	Pressure	Roughness
	watt	mm/min	bar	micron
1	1300	300	0.5	36.1
2		600	0.6	4.956
3		900	0.7	4.526
4	1800	300	0.6	38.2
5		600	0.7	2.47
6		900	0.5	7.828
7	2000	300	0.7	31.2
8		600	0.5	4.831
9		900	0.6	3.021

Table 4

3) *Perpendicularity Measurement*

Perpendicularity of cut is measured with the help of tools maker microscope. by measuring difference between two edge from different surfaces. Reading are shown in Table 5.

No.	Power	Cutting Speed	Pressure	Perpedicularity
	watt	mm/min	bar	radian
1	1300	300	0.5	1.65
2		600	0.6	0.7
3		900	0.7	0.57
4	1800	300	0.6	2.1
5		600	0.7	0.75
6		900	0.5	0.9
7	2000	300	0.7	2.35
8		600	0.5	0.86
9		900	0.6	1.1

Table 5

III. RESULT AND DISCUSSION

To get the desired output for kerf width , surface roughness and perpendicularity according to input parameters we have to understand effect of each and every input parameters on output parameters.

A. *Effect On Kerf Width*

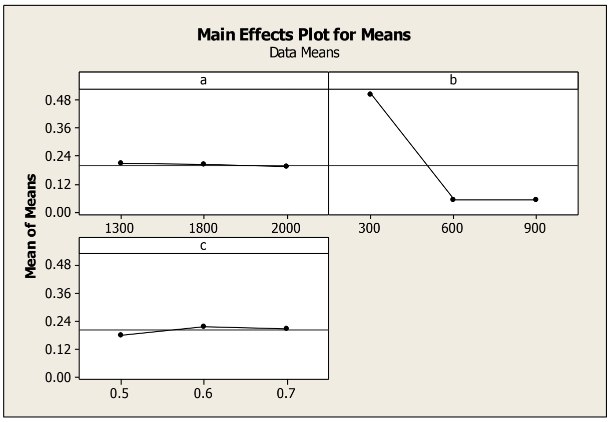

Fig. 1: Effect on kerf width

The main effect of different input parameter on the output parameter kerf width. As we can see in graph there is a minor effect occurs to kerf width due to the different power values. It is gradually decreases as increase in power. Accordingly the graph pressure has also minor effect on kerf width. Kerf width increases as pressure increase than after certain value it starts to decrease again as pressure increases. At low cutting speed width is higher , but as the speed increases width decreases.

B. *Effect on Roughness*

Graph shows that perpendicularity is increased as the value of power is increased. As the cutting speed increases perpendicularity of cut is decreased first but after certain level it starts to increase again. According to graph as the pressure increases the perpendicularity increases and after certain level it starts to decrease.

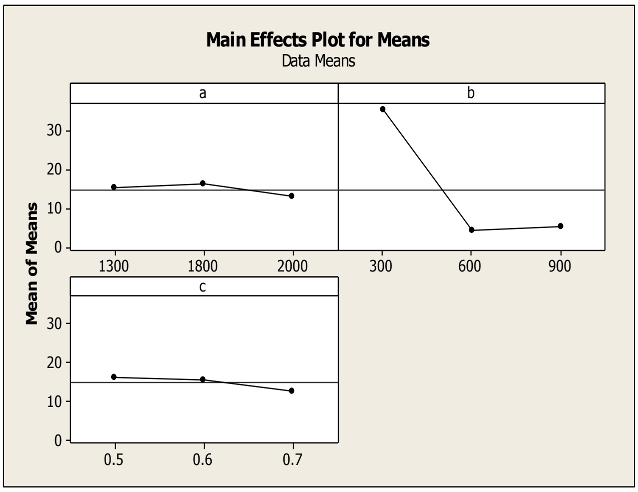

Fig. 2: Effect on Roughness

IV. CONCLUSIONS

- Hardox-500 can be cut by many methods but to obtain high accuracy and precision, laser cutting is most convenient.
- By using Taguchi Method we can reduce many no. of experiments. In our case, by using L9 Array we just have to perform 9 experiments for each material.
- For Hardox-500 we get the best result for kerf width at 18kw, 900 min/min and 0.5 bar.
- For Hardox-500 we get the best result for roughness at 18kw, 600 min/min and 0.7 bar.
- For Hardox-500 we get the best result for perpendicularity at 13kw, 900 min/min and 0.7 bar.
- Kerf Width is increase, Roughness decreases and Perpendicularity increases as Pressure increases.
- Kerf Width is decreases, Roughness decreases and Perpendicularity increases as Power increases.
- Kerf Width is decreases, Roughness decreases and Perpendicularity decreases as Cutting Speed increases.

REFERENCES

[1] www.ssab.com
[2] www.hardox.com
[3] controls.engin.umich.edu
[4] KalpakjianS,SchmidSR.Manufacturingengineeringandtechnology.Delhi: Addison WesleyPrivateLimited;2000.
[5] Dubey AK ,Yadava V. Multi-objective optimization of laser beam cutting process. OptLaserTechnol2008;40:562–70.
[6] SchuockerD.Lasercutting.MaterManufProcesses1989;4(3):311–30.

[7] J. Powell, CO2 Laser Cutting, 2nd Edition, Springer-Verlag Berlin Heidelberg, New York, (1998).
[8] S. L. Chen, The effects of gas composition on the CO2 laser cutting of mild steel, J. Material Process Technology, Vol. 73, 1998, pp. 147–159.