RESEARCH PAPER | Engineering | Volume : 5 | Issue : 3 | March 2015 | ISSN - 2249-555X

Prediction of Process Parameters of Co_2 Laser Cutting Machine for Aluminium 5052 Alloy Using ANN

KEYWORDS: Laser Beam Machining (LBM), Quality parameters, Artificial neural network method (ANN), Aluminium5052 Alloy, GMDH shell regression

Pankajbhai R. Prajapati
PG student, Department of Mechanical Engg., Sankalchand Patel College of Engineering, Visnagar, Gujarat, India.

Prof. Vikram A. Patel
Asst. Professor, Department of Mechanical Engg., Sankalchand Patel College of Engineering, Visnagar, Gujarat, India

ABSTRACT *Machining process efficiency can be improved by optimization the control parameters. This requires identifying and determining the value of critical process control parameters that lead to desired response ensuring a lower cost of manufacturing. A CO_2 Laser can produce a coherent, convergent and monochromatic beam of electromagnetic radiation. Laser machining is thermal energy based non contact type advance machining. The objective of the research work is to study the effect of CO_2 Laser cutting parameters (Laser power, Gas pressure, Cutting speed, Laser frequency, Nozzle tip distance) on the cut quality parameters (surface roughness, kerf width, Heat affected zone) at the problem associated with cutting of Aluminium5052 Alloy. The L_27 orthogonal array has been used for performing the experiments. An artificial neural network (ANN) method to optimize response parameters.*

I. INTRODUCTION

LASER stands for "Light Amplification by Stimulated Emission of Radiation". Laser cutting offers a high precision, CNC control method of cutting plastic, metallic and thin ceramic components. There are two types of industrial laser cutting. (1) Laser cutting (2) Nd: YAG Laser cutting. The Laser cutting wavelength 10.6 µm and Nd: YAG laser cutting wavelength 1.06 µm. The Laser cutting materials would involve a motion control system to follow a CNC or G-code of the pattern to be cut on to the material.

1.1 Application of Laser cutting.

(1) Cutting of die boards.
(2) Straight and profile cutting of metallic and non metallic sheets.
(3) Cutting of polymers and polymer matrix composites.
(4) Cutting of diamonds.
(5) Cutting of aerospace materials such as titanium and Aluminium based alloys.

1.2 Properties of Laser beam.

(1) Monochromaticity

A laser can be constructed to operate in only one longitudinal mode to give better Monochromaticity.

(2) Beam coherence

The wavelength of the laser light is in phase in space and time.

(3) Brightness or Radiance

Brightness or Radiance is defined as the amount of power emitted per unit area per unit solid angle.

1.3 Advantages of Laser cutting.

- Most of the laser cutting processes is CNC controlled giving accurate control over the dimensions of cut and faster cutting speeds.
- Laser cutting is a fast process.
- Fine and precise cut dimensions.
- Better quality of cuts.

II. Literature Reviews

G. L. Goshwami [1998] applied Response surface methodology for optimization of Heat Affected Zone (HAZ) during process parameters (cutting speed, pulse energy, gas pressure) on multiple performance F. Memola [2001] have worked polymeric plastics (PE, PP,PC) and measured Surface Roughness results to compare Kulenovik [2011] worked experimental analysis to find different type of steel 1.4828 thickness steel and process parameters (assist gas, cutting speed, gas pressure, focus position) to apply and observed HAZ and Kerfwidth value to compare and find effective Amit Sharma [2011] applied Taguchi methodology to study the effect of machining parameters on the kerf width and kerf Ruben phipon and B. B. Pradhan [2012] have worked Genetic algorithm methodology applied process parameters (gas pressure, pulse width, pulse frequency, cutting speed) on the surface roughness. Zirconium oxide using a design of experiment Pradip kumar [2012] have presented an optimization study of laser cutting mild steel using a design of experiment approach. They have used ANOVA analysis to identify all interactions between the laser cutting parameters (gas pressure, cutting speed, laser power) are consider as their. Madic Milos [2013] have applied Taguchi methodology to optimize multiple quality parameters (surface roughness and F. Lambiase [2013] applied ANN methodology to study the effect of machining parameters on the hardness. The experiment worked out Bohlerk 340 steel material used and process parameters applied cutting speed and laser Kaushal Pratap Singh [2014] have applied Response surface methodology to optimize HAZ. The experiment conducted process parameters (gas pressure, cutting speed and laser power) on PMMA (Polymethylmethacrylate) Vipul shah [2014] have worked out stainless steel to apply different process parameters (gas pressure, cutting speed and laser power) to experimental analysis surface roughness and

III. Experimental Setup

AMADA FONT-3015, Laser machine with 2.0 kW in continuous mode is used for experiment work. The size of work piece was 500 mm X 300 mm and 20 X 20 mm slot cut down from the plate for response parameters measurement. Surface roughness measured using portable pro-

Volume : 5 | Issue : 3 | March 2015 | ISSN - 2249-555X

filometer of Mitutoya, Kerf width measured using vernier caliper of Mitutoya and HAZ measured high magnification microscope.

3.1 Material specification

The aluminium 5052 Alloy is highest strength of more common non heat-treatable grades. This grade has particularly good resistance to marine atmosphere and salt water corrosion.

Chemical	Si	Fe	Cu	Mn	Mg	Lead	Zn	Ti	Al
% Composition	0.089	0.250	0.006	0.005	0.004	0.001	0.004	0.001	99.610

Table1. Material composition of Aluminium5052 Alloy.

3.2 Control parameters and Range selection

The experimental trial setup developed by using Minitab 17 software to performed orthogonal array. The Experiment is conducted by varying five parameters and their values are given in the table 2.

Symbol	Factor	Level 1	Level 2	Level 3
A	Laser power (w)	1600	1800	2000
B	Gas pressure (bar)	0.5	0.6	0.7
C	Cutting speed (mm/min)	1500	1750	2000
D	Laser frequency (Hz)	600	800	1000
E	Nozzle tip distance (mm)	0.6	0.8	1.0

Table 2. Process parameters and their levels

IV. Results and Discussion

The application of artificial intelligence is more in all the fields of engineering. An ANN is neural network consists of an interconnected group of artificial neurons. It has been developed as generation of mathematical models of human cognition or neural biology. A model can be constructed very easily based on the given input and the output is trained to accurately predict the process dynamics.

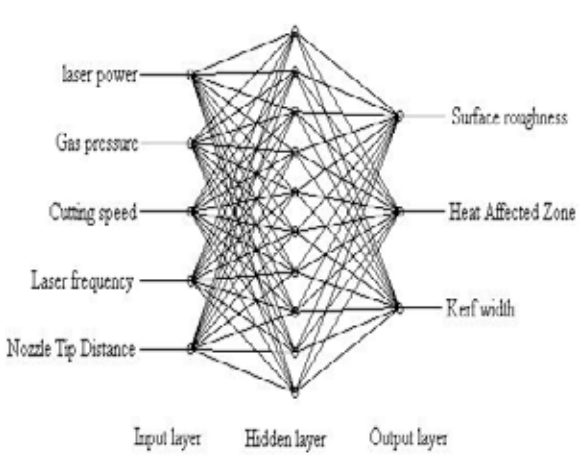

Fig. 1 Artificial Neural Network

A feed-forward structure with input, output, hidden layers and nonlinear sigmoid functions are used in this type of network. ANN have important role in the field of linear and nonlinear problems in engineering. The ANN optimization process to used MATLAB software to find predicted response parameters. The GMDH shell regression software to find predicted response parameters.

Table 3. Experimental observation OA

Exp.	A	B	C	D	E	SR	KW	HAZ
1	1600	0.5	1500	600	0.6	5.93	0.36	10.698
2	1600	0.5	1500	600	0.8	4.814	0.3	10.125
3	1600	0.5	1500	600	1	3.122	0.38	11.025
4	1600	0.6	1750	800	0.6	3.12	0.35	10.365
5	1600	0.6	1750	800	0.8	5.059	0.40	10.458
6	1600	0.6	1750	800	1	4.173	0.39	10.569
7	1600	0.7	2000	1000	0.6	4.71	0.42	10.235
8	1600	0.7	2000	1000	0.8	5.349	0.40	10.265
9	1600	0.7	2000	1000	1	4.099	0.36	10.547
10	1800	0.5	1750	1000	0.6	5.19	0.33	10.625
11	1800	0.5	1750	1000	0.8	4.293	0.40	10.235
12	1800	0.5	1750	1000	1	5.12	0.45	10.658
13	1800	0.6	2000	600	0.6	5.07	0.42	10.365
14	1800	0.6	2000	600	0.8	5.34	0.32	10.658
15	1800	0.6	2000	600	1	4.255	0.37	10.698
16	1800	0.7	1500	800	0.6	6.98	0.38	10.658
17	1800	0.7	1500	800	0.8	4.82	0.35	10.625
18	1800	0.7	1500	800	1	3.909	0.40	10.965
19	2000	0.5	2000	800	0.6	4.619	0.32	10.652
20	2000	0.5	2000	800	0.8	6.311	0.33	10.682
21	2000	0.5	2000	800	1	4.012	0.38	10.591
22	2000	0.6	1500	1000	0.6	7.03	0.30	10.365
23	2000	0.6	1500	1000	0.8	5.247	0.31	10.208
24	2000	0.6	1500	1000	1	4.675	0.37	10.356
25	2000	0.7	1750	600	0.6	5.573	0.36	10.364
26	2000	0.7	1750	600	0.8	4.753	0.38	10.652
27	2000	0.7	1750	600	1	6.287	0.31	10.359

The MATLAB software to find ANN based optimized prediction output parameters. Also the GMDH shell software to find regression based predicted output parameters.

Volume : 5 | Issue : 3 | March 2015 | ISSN - 2249-555X

Exp. No.	6	11	17	22	27
Exp. SR(μm)	4.173	4.293	4.820	7.030	6.287
ANN SR(μm)	4.172	4.249	4.818	7.048	6.401
GMDH shell SR(μm)	4.148	4.599	5.096	6.120	4.929
Exp. KW(mm)	0.39	0.40	0.35	0.30	0.31
ANN KW(mm)	0.38	0.40	0.35	0.29	0.30
GMDH shell KW(mm)	0.38	0.35	0.37	0.35	0.39
Exp. HAZ(μm)	10.569	10.235	10.625	10.365	10.359
ANN HAZ(μm)	10.569	10.222	10.624	10.206	10.304
GMDH shell HAZ(μm)	10.614	10.436	10.511	10.333	10.697

Table 4 Comparison predicted output parameters

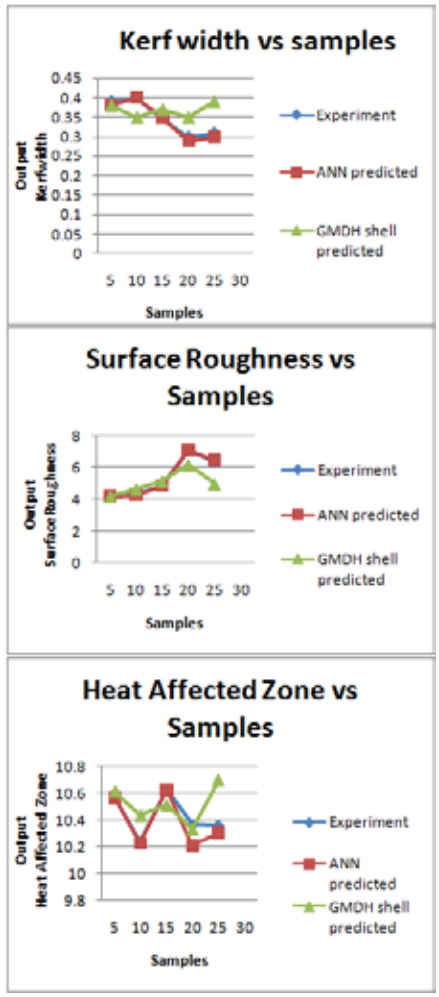

Fig. 2 Graph for Matching of desired and predicted values of KW (graph 1), SR (graph 2) and HAZ (graph 3).

V. Conclusion

Comparison of Experimental result, ANN predicted result and GMDH shell regression based predicted result it is found that they are very close and error is very less. The maximum error is 0.159 ANN is powerful technique for prediction of process parameters giving very accurate result. Experimental results are agreeable with ANN predicted result.

REFERENCE [1] Jose Mathew and G. L. Goshwami "Parametric studies on pulsed Nd: YAG laser cutting of carbon fiber reinforced plastic composites." Journal of Materials processing technology 15 September. 1998.] | [2] F. Caiazzo G.Daurelio, F. Memola "Laser cutting of different polymeric plastics (PE, PP and PC) by a CO2 laser beam." Journal of Materials Processing Technology. | [3] Cekic, Kulenovic "Quality of machined surface during CO2 laser cutting of alloy steels."International DAAAM Symposium, Volume22, 2011. | [4] Amit Sharma "Optimization of kerf quality using robust design of experiments during Nd: YAG laser cutting of thin Aluminum Alloy sheet for straight profile." | MIT International Journal of Mechanical Engineering Vol.1, No.1, Jan 2011,pp 1-8. | [5] Ruben Phipon, B. B. Pradhan "Control parameters optimization of laser beam machining using Genetic Algorithm." International Journal Of Computational Engineering Research (ijceronline.com) Vol. 2 Issue. 5 September 2012. | [6] Vipul K Shah, Hardik Patel "OPTIMIZATION OF INPUT PARAMETERS ON SURFACE ROUGHNESS DURING LASER CUTTING - A REVIEW" International Journal for Technological Research in Engineering Volume 1, Issue 5, January – 2014. | [7] Kaushal Pratap Singh, Susheel Kumar Upadhyay "An Analysis the Effect of Process Parameters on Heat Affected Zone in Laser Cutting Using Response Surface Methodology." International Journal of Emerging Technology and Advanced Engineering Volume 4, Issue 2, February 2014 | [8] Pathik Patel, Piyush Gohil, and Shilpesh Rajpurohit "Laser Machining of polymer Matrix Composites: scope, limitation and application."IJETT-Volume4 Issue6-June 2013. | [9] F. Lambiase, A. Paoletti "Prediction of laser hardening by means of neural network." Procedia CIRP12 (2013) 181-186. | [10] Cindy Goppold, Karsten Zenger "Experimental analysis for improvement of process efficiency and cut edge quality of fusion cutting with 1 μm laser radiation." Procedia by 8th international conference on photonic technologies LANE 2014. |