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FUZZY LOGIC BASED MODELING OF CO_2 LASER CUTTING FOR STAINLESS STEEL SHEET

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ABSTRACT

CO_2 laser cutting is most popular technologies in modern sheet metal processing industries. Thus the technologies have been developed expert system using fuzzy logic model to predict the CO2 laser cutting process parameter on 2.5mm thickness stainless steel sheet. The fuzzy logic model developed in MATLAB using the mamdani techniques. A set of 25 training data used to format of input parameters of laser power, Cutting speed, Gas pressure and focal position and responses are top kerf width, bottom kerf width and kerf deviation. The relationship between fuzzy logic model and experimental value is good correlation. Based on the results the proposed fuzzy model is to predict the top kerf width, bottom kerf width and kerf deviation on stainless steel sheet.

Keywords: AISI 316L, curved profile, fuzzy logic, kerf width

1. INTRODUCTION

The stainless steel sheets are widely used in automobile industries. AISI 316L is playing vital role in automobile industries. The AISI 316L sheet with laser cutting is a difficult task due to different profile cutting. Consequently kerf quality plays the most significant role in determining the productivity and the quality of a product produced with AISI 316L. So this work takes AISI 316L stainless steel as a work piece material for CO_2 laser cutting. With regard, to the laser power, cutting speed gas pressure and focal position are considered as a predominant principal parameter in laser cutting.CO_2 Laser cutting of Stainless sheet metals has a most important research area for marking out the best quality of cut[1]. the quality of laser cuts are mainly depends upon the to varying the process parameters such as laser power, gas pressure, cutting speed, focal position and sheet metal thickness. [2,3] have been investigating about the outcome of laser cutting parameters on kerf dimension and surface quality of cut by used Responce surface methodology. Most of the researchers to varying the only one parameter at a time approach to study the effect of process parameters on responses [4]. However, this approach consumes more time and money in favor of a large number of experimental runs since only one parameter is varied in each experimental run, and then keeps other parameters as constant. As well as in this method the interaction effects process parameters are not considered. Design of experiments (DOE) commonly used in experimental approach [6].

The modelling studies to way of to predict the CO_2 laser cutting process parameters and cutting of different profiles. A mathematical model is systematic approach of the numerical equations input parameters and to the responses. Few researchers are concentrate of modelling and optimization of laser cutting systems of Fuzzy logic approach [7]. So that work tries to attempt that fuzzy logic approach of CO_2 laser cutting systems.

2. METHODOLOGY

The CO_2 Laser cutting process considered in this work AISI 316L Stainless steel sheet for curved cut profile is discussed following section.

A. Experimental procedure

All the cuts work were carried out on AMADA make CO_2 Laser cutting machine as shown in figure.1. The work piece considered for this work is stainless steel AISI 304 sheet size was 500 X 500 X 2.5 mm each specimen to cut curved profile radius of 20mm as shown in figure 2. Cutting operation carried out on work piece with straight profile the work piece [8]. The input parameters considered are power, cutting speed and gas pressure. The considered parameters ranges are the laser power in between (2000watts, 3000watts and 4000watts), Cutting Speed levels are within (3500mm/min, 4500 mm/min and 5500mm/min) and Gas pressure was (0.7Mpa, 0.8 Mpa and 0.9Mpa) [9]. Three identical cuts are for each condition.

B. Measurement of responses

To measure the kerf width for straight and curved profile by indirect measurement using Tool makers microscope with 10X magnification factor, for each cut a total of three kerf width were taken in terms of average kerf width of the measured value taken as the result.

C. Fuzzy logic based model

The aim of this work is to develop the suitable fuzzy logic model [10], in experimentally to predicting the laser cutting parameter on quality of kerf width for stainless steel sheet. In

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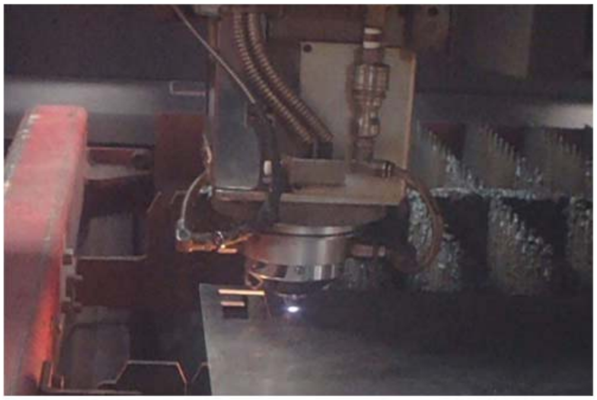

Figure-1. AMADA CO_2 laser cutting machine.

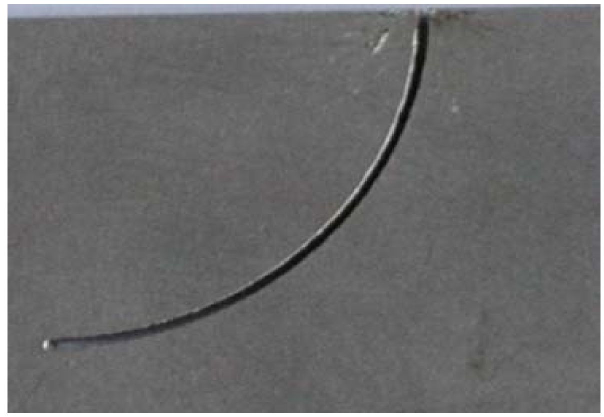

Figure-2. Curved cut profile.

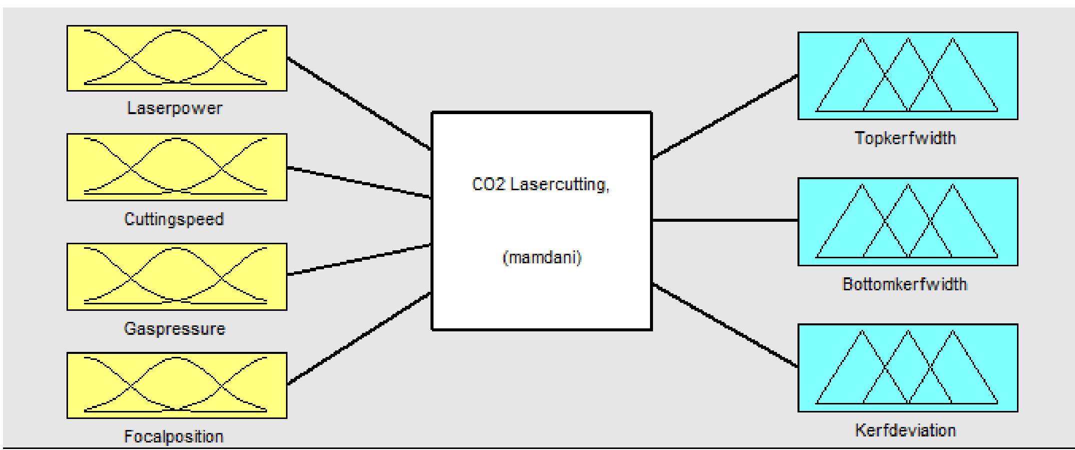

Figure-3. Input/output Fuzzy model.

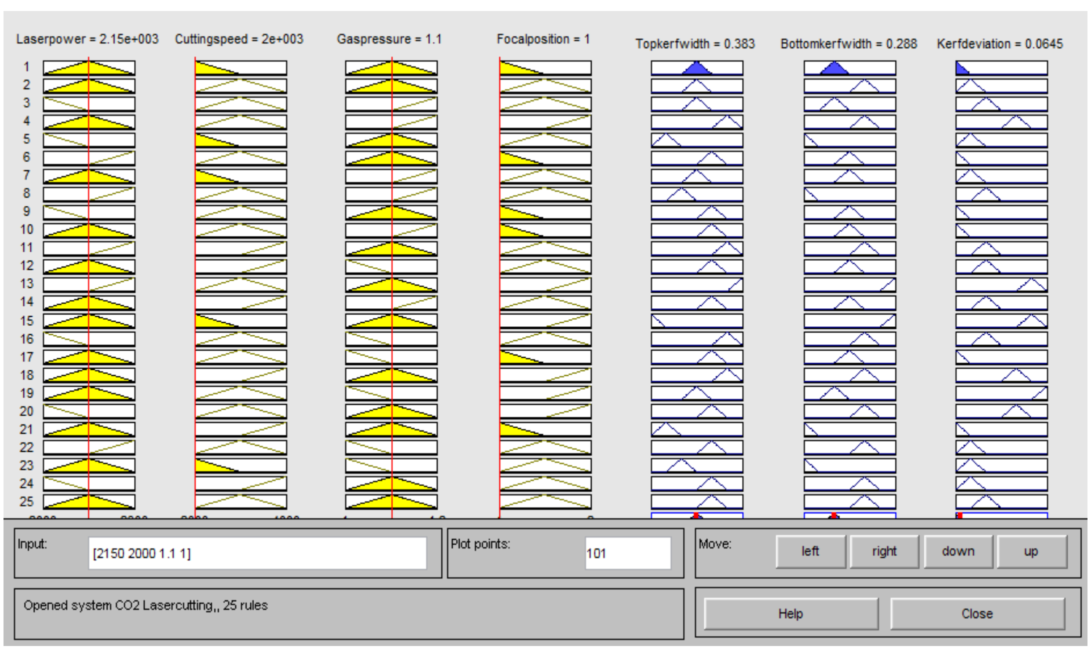

Figure-4. Fuzzy rule editor.

the developed fuzzy model three input parameters laser power, cutting speed, gas pressure and focal position are considered. The block diagram of input/output fuzzy logic model (mamdani) developed are shown in figure 3. The fuzzy logic aims at the systematically generating fuzzy rules from given input/output data.

3. RESULT AND DISCUSSIONS

A. Methodology and Implementation

Fuzzy inference system implemented in fuzzy logic toolbox of MATLAB version R2007b mamdani fuzzy expert system was used in this work [11]. Because of generally widely used algorithm, the input/output linguistics variables of the present study are set fuzzy intervals.

The fuzzy membership function values are between 0 and 1. In order to design a proper fuzzy model, Trapezoidal and triangular membership functions are commonly used in this work, the Gaussian membership functions are applied for both input and output variables. The membership functions of the fuzzy sets and contained in the data base. The rule base unit contains a series fuzzy rules are describe the relationships between the input and output variables. These rules are basically represented in the form of IF–THEN conditional statements. The present work made by to set 27 rules and training data figure 4 shows the IF–THEN rules in rule editor [12].

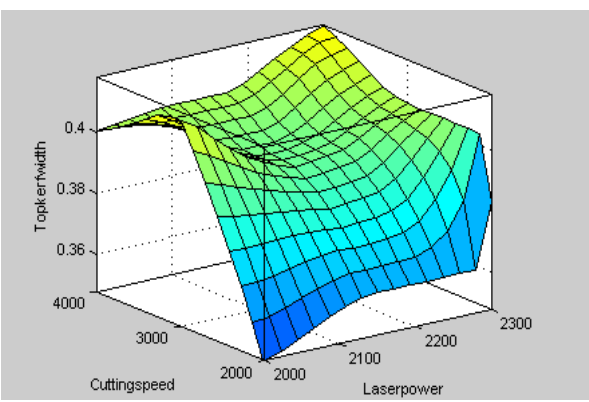

Figure-5. Effect of laser power and cutting speed on top kerf width.

The Figure-5 represents the effect of laser power and cutting speed on AISI 316L stainless steel 2.5 mm thickness sheet as work piece materials. Initially the machining top kerf width is very low (range from 0.35 to 0.37 mm) at the laser power is 2000-2300 watts while the cutting speed is range from 2000- 3000 mm/min. During top kerf width is gradually increased with respect to increase the laser power and cutting speed. The top kerf width is maximum (0.39-0.42 mm) at the high level of laser power 2300 watts while high level of cutting speed.

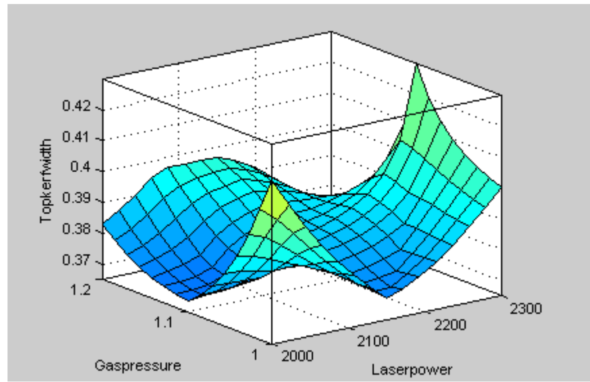

Figure-6. Effect of laser power and gas pressure on top kerf width.

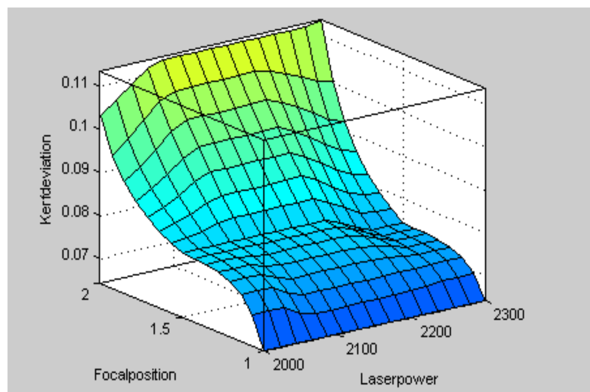

Figure-7. Effect of laser power and focal position on top kerf deviation.

From the Figure-6 low laser power and gas pressure the top kerf width are maximum, at low laser power and mid level of gas pressure to achieve minimum top kerf width.

The Figure-7 shows, at constant laser power of 2000 watts for increasing focal position kerf deviation increases. At constant focal position of 1 mm for increasing laser power the kerf deviation are decreases. At low laser power and focal position the kerf deviation are minimum.

From the Figure-8 mid level of laser power (2150 watts) and low focal position 1mm achieve minimum bottom kerf width are achieved.

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Table-1. Comparison between experimental value and fuzzy model value.

S. No	Top kerf width (mm)		Kerf deviation (mm)		Bottom kerf width (mm)	
	Experimental value	Fuzzy model value	Experimental value	Fuzzy model value	Experimental value	Fuzzy model value
1	0.3933	0.3831	0.0681	0.0717	0.2931	0.2889
2	0.3999	0.4092	0.0791	0.0769	0.3101	0.3019
3	0.3901	0.3839	0.0901	0.0926	0.2991	0.301
4	0.4133	0.4181	0.1102	0.1039	0.3121	0.3141
5	0.34001	0.3481	0.0811	0.0821	0.2501	0.2651
6	0.4001	0.4091	0.0821	0.0821	0.3021	0.3019
7	0.4066	0.401	0.07001	0.0717	0.3091	0.3051
8	0.3901	0.3831	0.0789	0.0926	0.3011	0.3011
9	0.3601	0.3652	0.0812	0.0926	0.2621	0.2651
10	0.4101	0.4182	0.091	0.0926	0.3201	0.3281
11	0.4133	0.4095	0.0882	0.0926	0.3212	0.3019
12	0.4033	0.402	0.0701	0.0821	0.3099	0.3011
13	0.4066	0.403	0.0685	0.0717	0.3101	0.3142
14	0.4234	0.4182	0.0861	0.0926	0.3211	0.3281
15	0.4101	0.4031	0.089	0.0821	0.3101	0.3141
16	0.4366	0.4312	0.1171	0.1261	0.3401	0.3371
17	0.4066	0.3838	0.0821	0.0926	0.3014	0.3013
18	0.3399	0.3366	0.1021	0.1031	0.3481	0.3379
19	0.4233	0.4189	0.0891	0.0821	0.3281	0.3281
20	0.4034	0.4021	0.0681	0.0645	0.3098	0.3012
21	0.4134	0.4185	0.1012	0.1031	0.3199	0.3149
22	0.4101	0.4092	0.0899	0.0926	0.3161	0.3019
23	0.3966	0.4012	0.1241	0.1216	0.2909	0.301
24	0.4166	0.4181	0.1131	0.1131	0.3199	0.3144
25	0.3567	0.3654	0.0691	0.0645	0.2691	0.2653

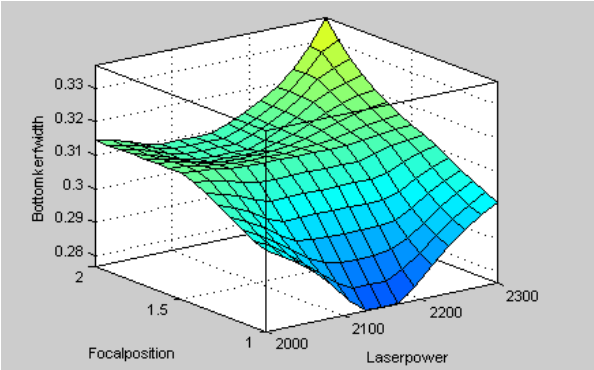

Figure-8. Effect of laser power and focal position on bottomkerf width.

B. Performance evaluation of developed models

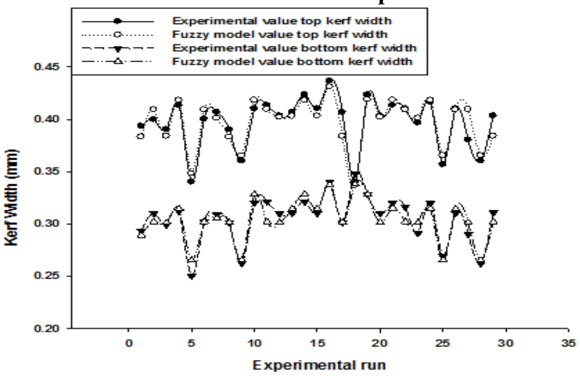

Figure-9. Comparison plots for experimental values and Fuzzy values of kerf width.

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The Table-1 shows that experimental value and fuzzy model values. Figure-9 shows that the Top kerf width and bottom kerf width fuzzy model values and Experimental values were

Compare on the basis of their prediction. The models were validated with 25 data sets of fuzzy rules based experimental data collection. The plots represent the experimental value nearer to the fuzzy models. The figure 10 is fuzzy model values and Experimental values models were compared on kerf deviations the experimental value nearer to the fuzzy logic based models.

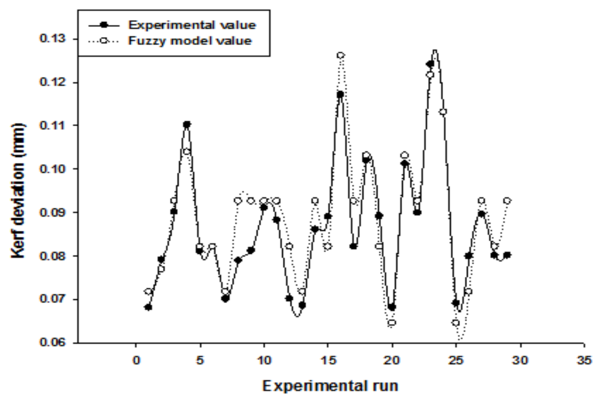

Figure-10. Comparison plots for experimental values and Fuzzy values of kerf deviation.

4. CONCLUSIONS

In this work mamdani fuzzy expert model have been developed to predict the top kerf width, bottom kerf width and kerf deviation as output parameters, for a co2 laser cutting parameters are laser power, gas pressure, cutting speed and focal position as input parameters. The model was trained and tested input and output experimental data are used fuzzy logic tool box of MATLAB. The predicted results for experimental values are nearer to the developed fuzzy models values. These models are satisfactory for the predictions of the top kerf width, bottom kerf width and kerf deviation in CO_2 laser cutting of thin AISI 316L stainless steel sheets. The proposed Fuzzy logic model is a suitable and practical technique that can be effectively used in the prediction of carbon dioxide (CO_2) laser cutting process.

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