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Optimization of Co2 Laser Cutting Parameter on Motor Cycle Frame Materials

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Abstract*: Two wheeler frame are very complicated to assemble in two wheeler manufacturing automobile industries, Because of difficult to cut the materials and profiles of the frame. So that the present works are studied CO2 laser cutting of austenite type stainless steel materials quality are investigated. In this present investigation, optimization is based on Response surface methodology approach with a grey relational analysis. Then the experimental runs have been planned using response surface methodology with three significant input parameters such as the assist gas pressure, the laser beam power, and the cutting speed. By considering responses such as bottom and top kerf width of the Austenite type AISI 304 is a stainless steel material in the curved profile. In this investigation ANOVA uses to investigate the performance characteristics due to the influence of the process parameters during the CO2 Laser cutting. The results obtained by this analysis clearly proves that the cutting speed and the laser beam power are the two major factors that desired performance characteristics and also optimum parameters are identified. The regression models are developed to be used RSM. The confirmation test was conducted to validate the results achieved by GRA approach. This work is to help the two wheeler manufacturing automobile industrialist for selecting parameters to attain desired outputs.

Index Terms*: Motorcycle Frame Material; RSM; GRA; ANOVA; two wheeler manufacturing.

I. INTRODUCTION

Now a days two wheeler frame assembly are very challenged because of to cutting the material are very difficult in CO_2 laser cutting technology are mainly used to fabrication of two wheeler manufacturing automobile industries. The mainly used in two wheeler frame materials are austenite type stainless steel sheet are widely used, the cutting of materials are very difficult because of cutting parameters are varied so that to optimize the cutting parameters are predominant for CO_2 laser cutting of austenite type steel sheets in this work [1]. The experimental work are Response Surface Methodology most used in to control the experimental run. The complicated and interrelationships among the performance characteristics can be solved by the grey relational analysis (GRA) [2]. Laser beam power and oxygen pressure mainly affected for steel and mild steel materials. And Taguchi method and ANN and to prediction of a CO_2 laser cutting experiment and implement the less number of experiment laser cutting process also combine the Taguchi and Response surface approach was developed the response models and to optimize the Nd:YAG laser cutting process for quality characteristics such as kerf width and materials removal rate[3]. The hybrid approach for Fuzzy and ANN has been developed the kerf width and Material removel rate models for Nd:YAG laser cutting also compared response surface models [4]. Then by using The GRA the CO_2 laser cutting process of st-37 steel was optimized based on the performance characteristics. The performance characteristics such as surface roughness, bottom and top kerf width [5]. To develop an expert system using fuzzy logic model to predict the effect of CO_2 laser cutting quality surface roughness, dross formation based on laser cutting parameter laser power, cutting speed and gas pressure on the incoloy alloy 800 at 1mm thickness [6]. The experimental design utilize the higher experimental run to want the cutting of materials it is higher expensive and waste of materials, many researchers to develop the empirical model only [7]. So that present work concentrate about to found the optimized values about the cutting of specific austenite stainless steel material for two wheeler frame material by using of GRA method [18-20].

II. EXPERIMENTAL PROCEDURE

The experiments are conducted for AMADA make CO2 Laser cutting machine as shown in figure.1 The work piece are considered for this work is AISI 304 austenite type Stainless steel 1.5 mm thickness sheet the cutting profiles are shown in Figure.2.

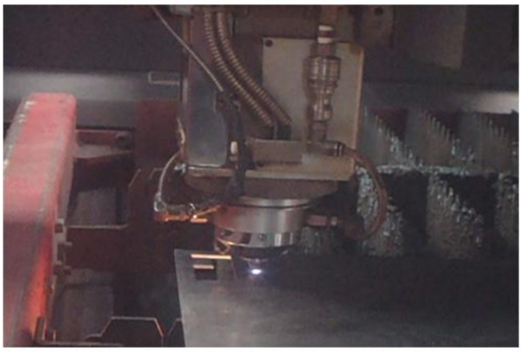

Figure .1. The CO2 laser cutting machine

And also significant parameters are considered for Laser beam power, gas pressure and cutting speed.

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For conducting the experiments the RSM Design was used and 29 experimental runs were carried out [8]. The ranges of input parameters are beam power (2500, 3500, 4500 Watts), Gas pressure (0.7, 0.8 0.9 Mpa) and Cutting Speed (4000, 5000, 6000 mm/min). The collected experimental data were given in table 1.

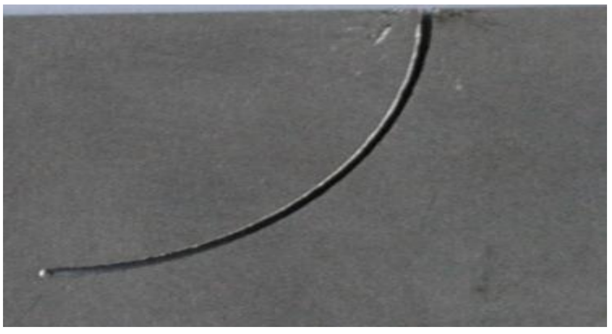

Figure. 2. The Profile of Cutting

Table. 1. The Experimental run

Sl. No	Kerf Width (mm)		Cutting Speed (mm/min)	Beam Power (Watts)	Gas pressure (Mpa)
	Bottom	Top			
1	0.2281	0.317	4000	2500	0.8
2	0.2361	0.330	6000	2500	0.8
3	0.2481	0.338	6000	4500	0.8
4	0.2581	0.347	5000	3500	0.8
5	0.2981	0.387	4000	3500	0.8
6	0.1861	0.241	5000	4500	0.8
7	0.2501	0.347	5000	3500	0.8
8	0.1891	0.249	6000	3500	0.8
9	0.2681	0.315	5000	3500	0.8
10	0.2561	0.347	4000	3500	0.7
11	0.2461	0.337	5000	3500	0.8
12	0.2461	0.269	4000	3500	0.8
13	0.2321	0.327	6000	3500	0.9
14	0.1981	0.259	5000	3500	0.7
15	0.2881	0.385	5000	2500	0.8
16	0.2651	0.359	5000	3500	0.7
17	0.2991	0.397	5000	3500	0.9
18	0.2621	0.341	4000	3500	0.9
19	0.2501	0.337	5000	2500	0.9
20	0.2101	0.279	5000	3500	0.9
21	0.2201	0.293	5000	2500	0.8
22	0.2861	0.379	5000	4500	0.8
23	0.2591	0.348	5000	4500	0.9
24	0.2781	0.367	6000	3500	0.8
25	0.2381	0.307	5000	4500	0.7
26	0.2501	0.328	4000	4500	0.8
27	0.2401	0.330	5000	2500	0.7
28	0.2421	0.341	5000	3500	0.8
29	0.2651	0.352	6000	3500	0.7

III. RESULT AND DISCUSSION

The RSM with GRA to optimize the process parameters the following procedures should be followed [9].

Table. 2. Grey relay analysis result

Sl. No	Normal TK	Normal BK	DS Kerf Width		GRC Kerf width		Grey grade	Rank
			Bottom	Top	Bottom	Top		
1	0.5128	0.6283	0.3717	0.4872	0.5736	0.5065	0.5400	7
2	0.4295	0.5575	0.4425	0.5705	0.5305	0.4671	0.4988	10
3	0.3782	0.4513	0.5487	0.6218	0.4768	0.4457	0.4613	15
4	0.3205	0.3628	0.6372	0.6795	0.4397	0.4239	0.4318	21
5	0.0641	0.0088	0.9912	0.9359	0.3353	0.3482	0.3418	28
6	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1
7	0.3205	0.4336	0.5664	0.6795	0.4689	0.4239	0.4464	18
8	0.9487	0.9735	0.0265	0.0513	0.9496	0.9070	0.9283	2
9	0.5256	0.2743	0.7257	0.4744	0.4079	0.5132	0.4606	16
10	0.3205	0.3805	0.6195	0.6795	0.4466	0.4239	0.4353	19
11	0.3846	0.4690	0.5310	0.6154	0.4850	0.4483	0.4666	14
12	0.8205	0.4690	0.5310	0.1795	0.4850	0.7358	0.6104	6
13	0.4487	0.5929	0.4071	0.5513	0.5512	0.4756	0.5134	9
14	0.8846	0.8938	0.1062	0.1154	0.8248	0.8125	0.8187	3
15	0.0769	0.0973	0.9027	0.9231	0.3565	0.3514	0.3539	27
16	0.2436	0.3009	0.6991	0.7564	0.4170	0.3980	0.4075	24
17	0.0000	0.0000	1.0000	1.0000	0.3333	0.3333	0.3333	29
18	0.3590	0.3274	0.6726	0.6410	0.4264	0.4382	0.4323	20
19	0.3846	0.4336	0.5664	0.6154	0.4689	0.4483	0.4586	17
20	0.7564	0.7876	0.2124	0.2436	0.7019	0.6724	0.6871	4
21	0.6667	0.6991	0.3009	0.3333	0.6243	0.6000	0.6122	5
22	0.1154	0.1150	0.8850	0.8846	0.3610	0.3611	0.3611	26
23	0.3141	0.3540	0.6460	0.6859	0.4363	0.4216	0.4290	22
24	0.1923	0.1858	0.8142	0.8077	0.3805	0.3824	0.3814	25
25	0.5769	0.5398	0.4602	0.4231	0.5207	0.5417	0.5312	8
26	0.4423	0.4336	0.5664	0.5577	0.4689	0.4727	0.4708	12
27	0.4295	0.5221	0.4779	0.5705	0.5113	0.4671	0.4892	11
28	0.3590	0.5044	0.4956	0.6410	0.5022	0.4382	0.4702	13
29	0.2885	0.3009	0.6991	0.7115	0.4170	0.4127	0.4148	23

In standardization formula are used for to find out the values for equation 1 and 2.

$$x_i(k) = \frac{x_i(k) - \min x_i(k)}{\max x_i(k) - \min x_i(k)} \quad (1)$$

The first standardized formula is suitable for the benefit – type factor.

$$x_i(k) = \frac{\max x_i(k) - x_i(k)}{\max x_i(k) - \min x_i(k)} \quad (2)$$

The grey relation grade is to be calculated by using this following equations 3, 4, and 5.

$$\Delta x_i(k) = |x_0(k) - x_i(k)| \quad (3)$$

$$\xi_i(k) = \frac{\Delta \min + p\Delta \max}{\Delta x_i(k) + p\Delta \max} \quad (4)$$

$$r_i = \sum [w(k)\xi(k)] \quad (5)$$

In equation (5), ξ is the Grey relational coefficient, w (k) is the proportion of the number k influence factor to the total influence indicators. The sum of w (k) is 100%. The result can be obtained when using the table.2 shows the grey relay analysis procedures can be applied to measure the quality of the CO_2 laser cutting of Austenite type two wheeler structure materials [10].

From the table.2 the find out the grey relay analysis grade and the grade to found optimized input parameters for CO_2 laser cutting of austenite materials. The gas pressure is 0.8 Mpa, cutting speed is 5000 mm/min, and beam power is 4500 watts. Best output for the GRA analysis.

Table. 3. ANOVA Table for Grey relational grade

Source	df	F Value	Sum of Squares	Mean Square	Prob > F
Model	9	0.1006	0.0340	0.0038	0.0993
A	1	0.0234	0.0009	0.0009	0.0799
B	1	0.1466	0.0055	0.0055	0.0610
C	1	0.1664	0.0062	0.0062	0.0879
AB	1	0.0067	0.0003	0.0003	0.9356
AC	1	0.0342	0.0013	0.0013	0.8553
BC	1	0.0687	0.0026	0.0026	0.7961
C^2	1	0.1121	0.0042	0.0042	0.7414
B^2	1	0.0416	0.0016	0.0016	0.8406
A^2	1	0.0086	0.0003	0.0003	0.9269
Residual	19		0.7131	0.0375	
Pure Error	10		0.5712	0.0571	
Lack of Fit	9	0.2761	0.1419	0.0158	0.9671
Cor Total	28		0.7471		

Based on the table 3 Model F-value of 0.10 indicated that the particular model is not significant due to tis relative noise. It is clearly evident that there is 99.93 % of chances for large Model F-value, because of its noise. Then due to the pure error the lack of fit f-value produce 0.28 and it is not significant. Similar to the model f-value, the lack of fit f-value possibly high at 96.71% of chances due to its noise [11].

$$\begin{aligned} GRG = &-0.79 + 8e^{-5}A - 4.7e^{-5}B + \\ &3.15C + 7.9e^{-9}AB - 1.79e - 4AC + \\ &2.5e - 4BC + 6.9e^{-9}A^2 - 1.53e^{-8}B^2 - 2.5C^2 \end{aligned} \quad (6)$$

The non-significant lack of fit value is acceptable, the Eq. (6) can be used to find the GRG value for cutting performance for this materials.

The finally to confirm the validity for the GRA and verify the performance of optimum parameters values, experimental value of GRG at Beam power of 4500 Watts, 5000 mm/min Cutting speed and 0.8Mpa Gas pressure was calculated using regression analysis and then compared with the predicted value of GRG suggested by RSM with the help of Design expert software [12]. We found the value of experimental GRG with the help of regression equation which is 1 and predicted value of GRG to be 0.999. Analyzing experiment result we found that experimental value of GRG obtained by regression analysis at optimum input parameter settings and the values predicted by RSM are very close which revealed good relation between them and confirms that control parameters. The predicted GRG are calculated by the equation.7. The percentage error are experimental GRG and predicted GRG is 0.1% which is within the limits of acceptable level of 5% error. So that results are satisfied and GRA methods are acceptable for within limits.

$$Percentage\,Error = \frac{Predicted\,GRG - Experimental\,GRG}{PredictedGRG} \quad (7)$$

IV. CONCLUSION

In this study are focused on multi objective optimization of CO2 laser cutting of Austenite type AISI 304 Stainless steel using the RSM based GRA. The following conclusions were drawn from the proposed experimental analysis and performance:

To analysis the performance characteristics the cutting speed and laser beam power are calculated. The optimal cutting parameters for Grey relational grade was to be found the laser beam power are 4500 watts, gas pressure is 0.8 Mpa and cutting speed is 5000mm/min. The conformation test the considerable the improvement of multi performance index for grey relational grade as 0.999 for experimental values. The result of this investigations will be wide support to the two wheeler manufacturing automobile industries for improvement of productivity and quality in the cutting of austenite type AISI304 stainless steel material using CO2 laser cutting of two wheeler frames.

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