

Optimisation Of Cutting Parameters Of Composite Material Laser Cutting Process By Taguchi Method

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Abstract: The aim of this work is to develop a laser cutting process model that can predict the relationship between the process input parameters and resultant surface roughness, kerf width characteristics. The research conduct is based on the Design of Experiment (DOE) analysis. Response Surface Methodology (RSM) is used in this work. It is one of the most practical and most effective techniques to develop a process model. Even though RSM has been used for the optimization of the laser process, this research investigates laser cutting of materials like Composite wood (veneer) to be best circumstances of laser cutting using RSM process. The input parameters evaluated are focal length, power supply and cutting speed, the output responses being kerf width, surface roughness, temperature. To efficiently optimize and customize the kerf width and surface roughness characteristics, a machine laser cutting process model using Taguchi L9 orthogonal methodology was proposed.

Keywords : Laser Cutting Machine, Composite Materials, Taguchi's Method, Minitab.

1. Introduction :

LASER cutting is a precise method of cutting a design from a given material using a CAD file to guide it. The parameters of laser cutting process play a main role on the cutting edge quality features. But, there are main obstacles that limit the laser extensive use in applications of routine material processing such as a beam size limitation, high cost of installation and replacement, additional and costly accessories, and need for skilled workers. Researchers studied the impact of different laser parameters on cut edge quality, kerf dimensions, roughness and surface finish. There are studies of the process parameters impacts, such as laser power, spot size and dimensions, and cutting speed on the resulting kerf size. Yilbas[1] studied the effect of laser power and oxygen gas pressure on the kerf width variation. Ghany and Newishy[2] indicated a positive relationship between laser cutting quality and the laser power, pulse frequency, cutting speed. Dubey & Yadava[3], Samant & Dahotre[4]. There are machines capable of interpolating up to five axes, simultaneously. These type of machines are designed for cutting complex forms and their programming is much more complex than the 2D case. The cut can be executed in two dimensions (2D), for instance on metal sheets, or in three dimensions (3D) in the case of components that need to be cut in width, length and height such as tubes ICS-UNIDO2008[5]. The most widely used industrial lasers for the cutting of sheet metals are gaseous CO₂, solid state Nd:YAG and recently fibre. The gas laser CO₂ and solid state Nd:YAG laser have low beam power, better efficiency and good beam quality Choudhury & Shirley[6]. The fibre gains too much interest and development recently. There has been growing interest in recent years in the use of pulsed Nd:YAG lasers for precision cutting of thin sheet metals because of its high intensity, low mean beam power, good focusing characteristics, and narrow Heat Affected Zone (HAZ)⁴. The CO₂ laser is usually more expensive than the Nd:YAG laser Sivarao et al.,[7]. CO₂ laser systems are available with reasonably a good beam quality at high output powers sufficient for thick-section metal cutting Wandera[8].



2. LASER CUTTING MACHINE:

A LASER cutting machine as shown in fig. 1. is a machine which is used to cut the materials with high accuracy and with very good surface finish. It is used to engrave many kinds of non-metal materials, such as acrylic, bamboo products, cloth, plastic, marble, glasses, woods, PVC. etc. This engraver can process the plexi glass products, acrylic display panel lenses, wood carving, wood percutaneous flowers, advertising products, crystal characters, packing boxes, models, toys and furniture. The table 1. Shows the specifications of LASER cutting machines.



Fig. 1, LASER CUTTING MACHINE

Table 1. machine parameters of LASER cutting machine

Parameter	Specifications
Max. Engraving speed	0-1000 mm/s
Max. Cutting speed	0-600 mm/s
Max. Cutting depth	max. 10mm / acrylic
Drive type	leadshine 3-ph stepper driver and motor
Laser type	Reci Glass Co ₂ Laser Tube
Laser power	60w / 80w / 100w
Gross power	<1200 w

3. Material Used For Experiment:

Acrylic is a plastic manufactured using one or more derivatives of acrylic acid. Polymethyl Methacrylate acrylic, or PMMA, is one of the more widely used forms of acrylic due to its exceptional weatherability, strength, clarity and versatility. PMMA acrylic sheet exhibits glass-like qualities – clarity, brilliance, transparency, translucence – at half the weight with up to 10 times the impact resistance. Because it's thermoplastic and softens under extremely high temperatures, acrylic can be formed to virtually any shape. Incredibly durable, acrylic is a suitable solution for over a broad temperature range, and has superior weathering properties compared to other plastics.

4. EXPERIMENTAL DETAILS:

The Taguchi method[9,10] is a technique for optimizing a process or design using multiple parameters. A researcher should always fully understand the various experimental methods in order to properly apply them to individual studies to maximize both the efficiency and the result of a study. The complete Taguchi methods are actually comprised of three main phases, which are all intended to be conducted offline. These three phases include system design, parameter design, and tolerance design. The Taguchi parameter design stage, which is the phase used in study, is commonly referred to here. This phase requires that the factors are known and that production should be in progress. The major goal of this phase is to increase the performance of the production process by adjusting the controlled factors. The three process parameters, cutting speed(A), feed(B), depth of cut(C) are considered in study. Based on Taguchi method, an L9 orthogonal array(OA) which has 9 different experiments was developed.

Table 2. level of parameters

Section	Factors/parameters name	Level 1	Level 2	Level 3
A	Cutting speed (mm/sec)	225	330	350
B	Feed (mm/rev)	0.05	0.075	1
C	Depth of cut (mm)	1	2	3

5. RESULTS AND DISCUSSIONS:

As referred earlier, in this work L9 orthogonal array was used to carry out the experiments and the experimental results were analysed using Taguchi method. In order to analyse the difference in the results, the signal to noise ratio(S/N ratio) analysis was done with cutting time, kerf widths and temperature as the outputs. The S/N ratio of each levels was calculated and the results were plotted by using Minitab software[11].The following table 3. shows that interference of various input parameter of focallength(8mm,10mm,12mm),cuttingpower(35watts,45watts,55watts),cuttingspeed(15mm\sec,25m\sec,35mm\sec) in the output parameters such as cutting time, kerf width, temperature.

Table 3. variation of output parameters with respect to input parameters

Focal length (mm)	Cutting Power (watts)	Cutting Speed (mm/sec)	Cutting Time (sec)	Kerf width (mm)	Temperature (°F)
8	35	15	10	0.28	400
10	35	25	6	0.2	400
12	35	35	4	0.25	400
8	45	25	6	0.28	460
10	45	35	4	0.2	460
12	45	15	10	0.25	460
8	55	35	5	0.28	520
10	55	15	10	0.2	520
12	55	25	6	0.25	520

5.1. PLOTS FOR SN RATIOS:

5.1.1. Cutting Time Graphs

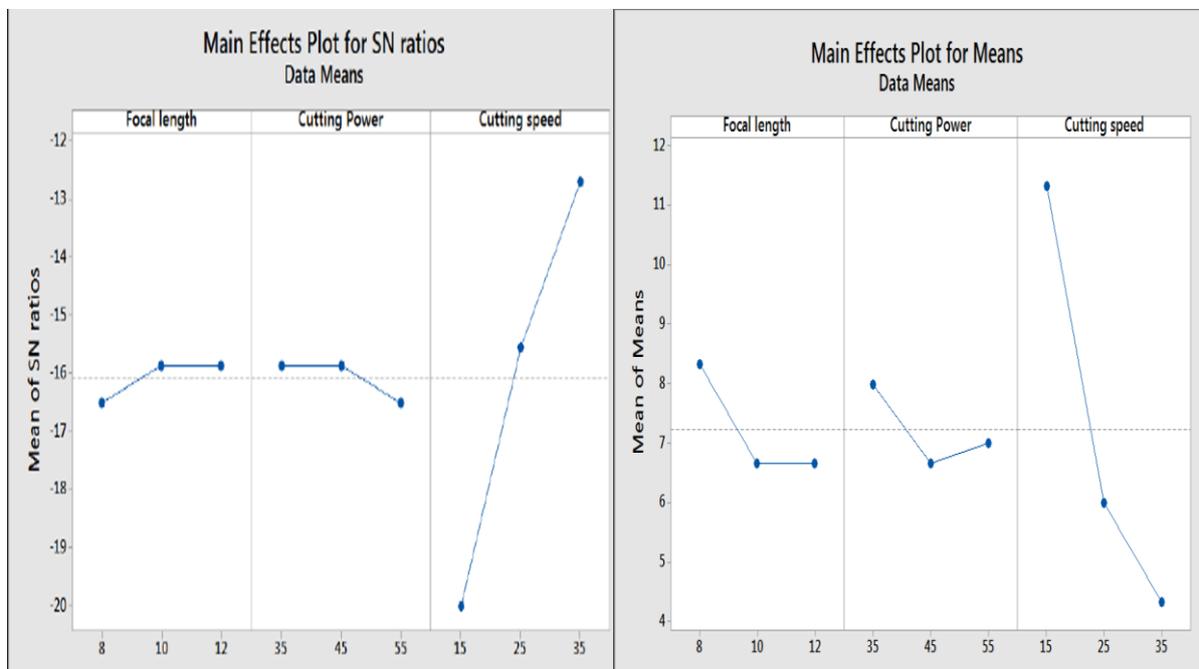


Fig.2. cutting time graphs

From the above graphs it is inferred that the cutting time decreases with increase in cutting speed whereas cutting power should be less for minimum cutting time, and the focal length should be moderate for optimum cutting time.

5.1.2. Kerf Width Graphs

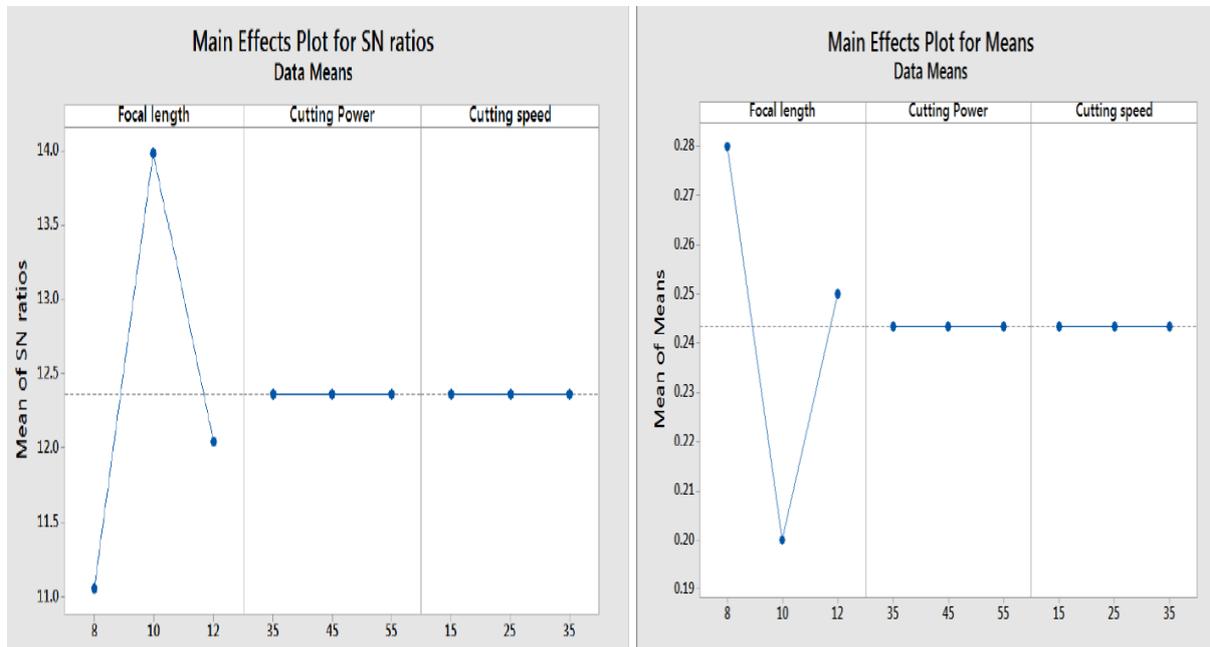


Fig.3. kerf width graphs

From the above graphs it is inferred that for obtaining good Kerf width the cutting power and the cutting speed should be as low as possible and the focal length have to be moderate.

5.1.3. Temperature Graphs

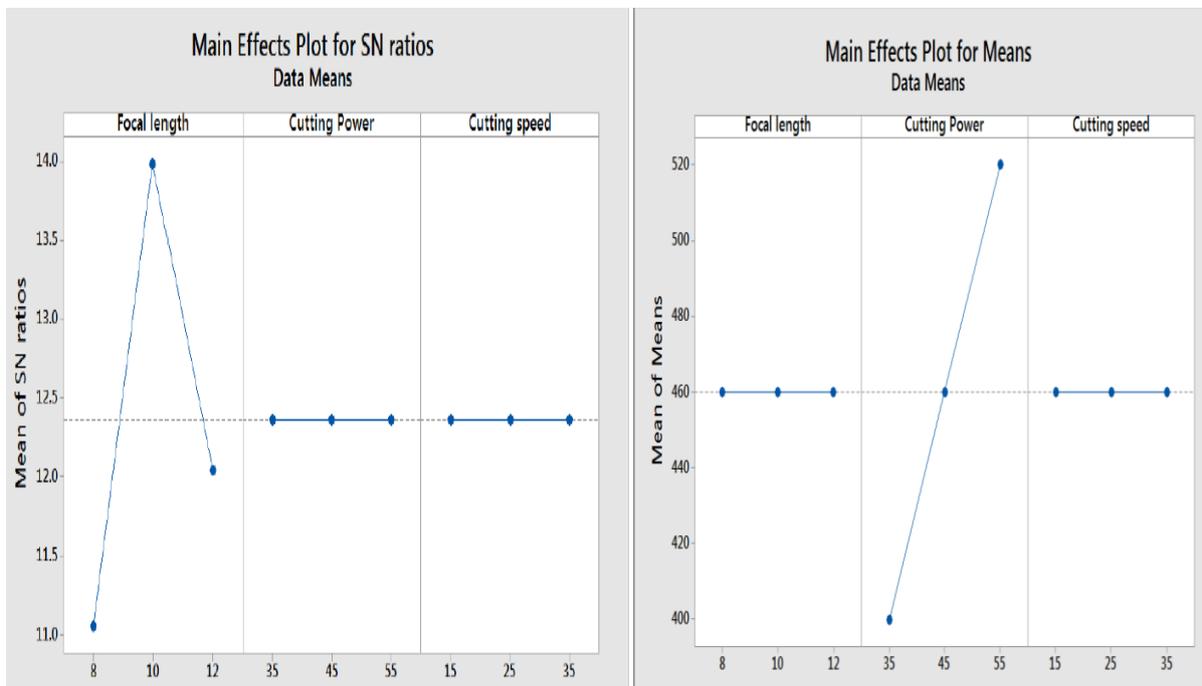


Fig.4. temperature graphs

Form the graph we came to know that for getting the optimum temperature level the focal length and cutting speed should be high and the power should be less.

6. Conclusion:

The experiment presented here is an overview of research work carried out in laser cutting process from the above discussion it can be concluded that Kerf width is best when power and speed are low and focal length is medium Temperature is best when power is medium, speed and focal length are maximum. Cutting time is best when power is minimum, speed is maximum and focal length is low.

7. References:

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