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TESTING OF AFFECTED ZONE ON LASER CUTTING

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ABSTRACT: Laser cutting is a technology that uses a laser to slice materials. While typically used for industrial manufacturing applications, it is also starting to be used by schools, small businesses, and hobbyists. Laser cutting works by directing the output of a high-power laser most commonly through optics. The laser optics and CNC (computer numerical control) are used to direct the material or the laser beam generated. A commercial laser for cutting materials uses a motion control system to follow a CNC or G-code of the pattern to be cut onto the material. The focused laser beam is directed at the material, which then either melts, burns, vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish.
Keywords: Lasercutting, Material Removal Rate, Heat Affected Zone, Dimensional Accuracy.

I. INTRODUCTION

The word "Laser" stands for "Light Amplification by Stimulated Emission of Radiation". Laser cutting machines are more powerful and also easier to operate. Laser cutting is used in industrial manufacturing of cars, aircraft, ships, robots and much more. It can also be used in other, diverse areas – in art and sculpture, architectural model making, cutting fabric in the world of fashion, engraving glass, for film and theatre props and making the foam inserts for specialized packaging. It is an essential part of industrial fabrication and there are a wide variety of materials that can be cut or engraved using lasers depending on the type of machine used, from the most delicate paper, through styrene and acrylic to metals of all kinds. But, what is laser cutting?

How Does Laser Cutting Work?
Different types of laser are used to cut different materials but the basic principle is the same, energy is converted into a high density, highly focused beam of laser light. Everything in the path of this beam of light is either, melted, burned or vaporized, depending on the application.

It enables extreme precision, allowing inexpensive manufacturing of even very tiny objects.

It produces a high quality cut surface that rarely needs any additional finishing.

It enables the commercial manufacture of objects to a tolerance that would be incredibly expensive and time consuming to achieve by any other method, making it possible for small businesses to become competitive with larger rivals.

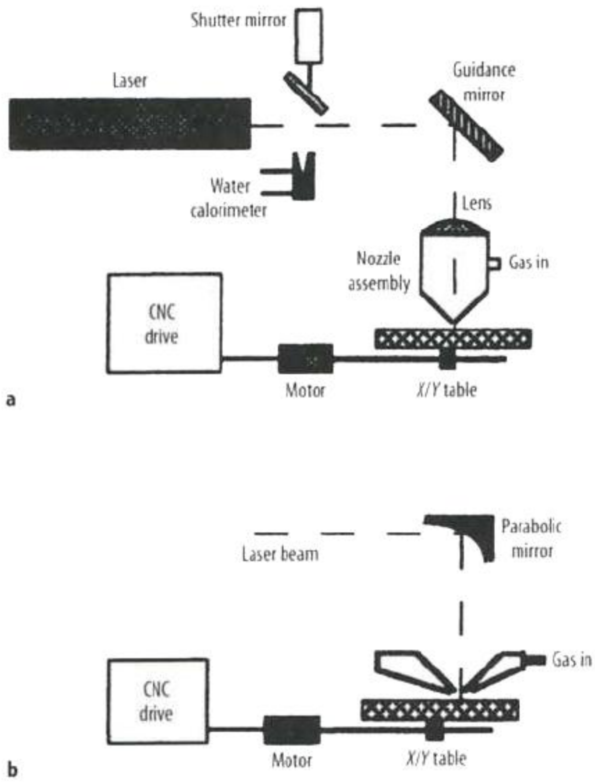

Fig 1.1. General arrangement for laser cutting: a. transmissive optics; b. Reflective optics

Difference between YAG Laser and Fiber laser cutting machine.

First type is YAG laser, YAG solid laser cutting machine has the features of low price and good stability, but low energy efficiency < 3%, most of the current product output power under 800 w, due to the smaller output energy, it is mainly used for punching and cutting of sheet.
Main disadvantages: can only cut 8 mm below the material, and the cutting efficiency is quite low

Main market positioning: cutting below 8 mm, mainly for self-use type of small and medium-sized enterprises, whose processing requirements are not high, home appliance manufacturing, kitchen utensils and appliances manufacturing, decoration, advertising and other industry users.

The second type is fiber laser cutting machine in China. It can be transferred through optical fiber, flexible degree increased a lot, less point of failure, and maintenance is convenient, fast speed, so when cutting thin plate within 4 mm fiber cutting machine has a great advantage.

The wavelength of the fiber laser cutting machine is 1.06 um, not easily absorbed by nonmetal, so can't cut non-metallic materials. But Optical fiber laser photoelectric conversion rate can reach higher than 25%.

Main advantages: high photoelectric conversion rate, less power consumption, can cut within 12 mm stainless steel plate, 20mm carbon steel plate, is the fastest machine for cutting thin plate in laser cutting machine, cutting Cerf is small, light are of good quality and can be used for precision cutting(Fiber laser cutting machine in China).

Main disadvantages and shortcomings: the main market positioning: 12 mm below the cutting, especially sheet high precision machining, mainly aimed at to the manufacturer of high precision and efficiency requirement, It is estimated that with the advent of 5000 w and above laser, optical fiber laser cutting machine will eventually replace high power CO2 laser cutting machine for most of the market.

II. EXPERIMENTAL METHODOLOGY

Nd:YAG Laser cutting machine will experiments on the Superalloy INCONEL 625 (340×340×8) mm size of plate.For this experiment the whole work can be done by laser cutting. The laser cutting machine, it consists of a Dc power unit, assist gas unit, a mother board for the cutting machine, a computer, a control panel display and the x- y motion assembly. The Dc power supply provides the power for all the sub units. The assist gas unit provides pure assist gas which is used to remove the debris generated during the cutting process. The focusing of the beam on the work is done with the help of solid state Nd:YAG laser.

Fig 2.1. Solid state Nd:YAG Laser(Courtesy: Sun India Company)

III. EXPERIMENTAL ANALYSIS/OPTIMIZATION

3.1 Main Effects Plot of Material Removal Rate

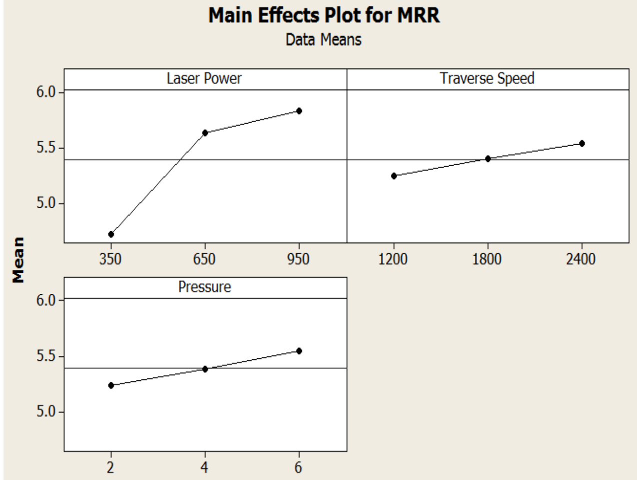

Fig.3.1 Effect of control factor on material removal rate

From the fig.3.1 it has been conclude that the optimum combination of each process parameter for High material removal rate is meeting at high laser power, high traverse speed and high gas pressure.

3.2Main Effects Plot of Dimensional accuracy [major axis and minor axis]

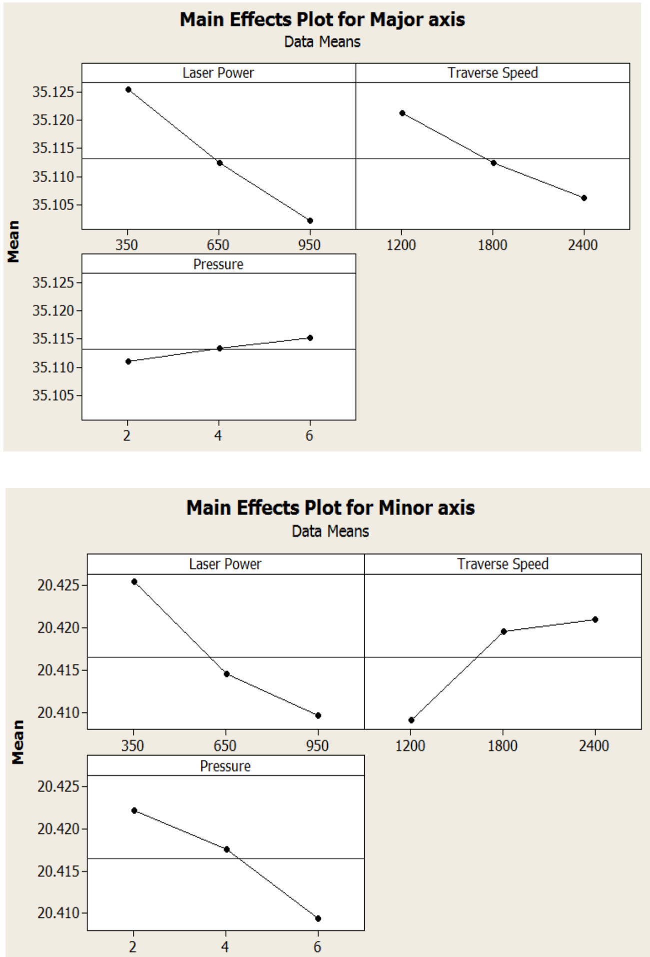

Fig.3.2 Main Effects Plot of Dimensional accuracy[major axis and minor axis]

From the fig.3.2 it has been conclude that the optimum combination of each process parameter for High dimensional accuracy [major axis and minor axis] value is meeting atlaser power, cutting speed and gas pressure.

3.3 Main Effects Plot of Heat Affected Zone

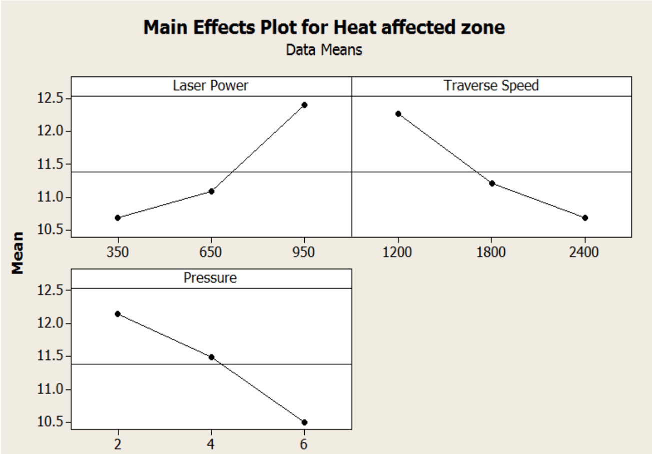

Fig. 3.3 Effect of control factor on heat affected zone

From the fig.3.3 it has been conclude that the optimum combination of each process parameter for low Heat Affected Zone value is meeting atlaser power, cutting speed and gas pressure.

4 Analysis of Variance for Material Removal Rate

Table 4.1 ANOVA: MRR versus Laser Power, Cutting Speed, Gas Pressure

General Linear Model: MRR versus Laser Power, Traverse Speed, Gas Pressure

Analysis of Variance for MRR, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Laser Power	2	6.4177	6.4177	3.2088	76.80	0.000
Traverse Speed	2	0.3794	0.3794	0.1897	4.54	0.024
Pressure	2	0.4329	0.4329	0.2165	5.18	0.015
Error	20	0.8357	0.8357	0.0418		
Total	26	8.0656				

S = 0.204409 R-Sq = 89.64% R-Sq(adj) = 86.53%

4.2 Analysis of Variance for Dimensional accuracy[major axis and minor axis]

Table 4.2 ANOVA: Dimensional accuracy[major axis and minor axis] versus Laser Power, Cutting Speed, Gas Pressure

General Linear Model: Major axis versus Laser Power, Traverse Speed, Gas Pressure

Analysis of Variance for Major axis, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Laser Power	2	0.0024607	0.0024607	0.0012303	71.35	0.000
Traverse Speed	2	0.0010382	0.0010382	0.0005191	30.10	0.000
Pressure	2	0.0000762	0.0000762	0.0000381	2.21	0.136
Error	20	0.0003449	0.0003449	0.0000172		
Total	26	0.0039200				

S = 0.00415264 R-Sq = 91.20% R-Sq(adj) = 88.56%

General Linear Model: Minor axis versus Laser Power, Traverse Speed, Gas Pressure

Analysis of Variance for Minor axis, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Laser Power	2	0.0011742	0.0011742	0.0005871	11.77	0.000
Traverse Speed	2	0.0007576	0.0007576	0.0003788	7.59	0.004
Pressure	2	0.0007549	0.0007549	0.0003774	7.56	0.004
Error	20	0.0009980	0.0009980	0.0000499		
Total	26	0.0036847				

S = 0.00706399 R-Sq = 72.91% R-Sq(adj) = 64.79%

4.3 Analysis of Variance for Heat Affected Zone

Table 4.3 ANOVA: Heat affected zone versus Laser Power, Cutting Speed, Gas Pressure

General Linear Model: Heat affected Zone versus Laser Power, Traverse Speed, Gas Pressure

Analysis of Variance for Heat affected zone, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Laser Power	2	14.6230	14.6230	7.3115	13.92	0.000
Traverse Speed	2	11.7696	11.7696	5.8848	11.20	0.001
Pressure	2	12.3141	12.3141	6.1570	11.72	0.000
Error	20	10.5074	10.5074	0.5254		
Total	26	49.2141				

S = 0.724824 R-Sq = 78.65% R-Sq(adj) = 72.24%

V. CONCLUSION

Experimental investigation on laser cutting machining of INCONEL 625 has been done using laser cutting machine. The following conclusions are made.

- From the responses ANOVA plot the optimum parameter settings for material removal rate at, ie. Laser power 950 watt, Cutting speed 2400 mm/min and Gas pressure 6 bar.
- From the ANOVA plot dimensional accuracy [major axis and minor axis] optimum parameter setting for dimensional accuracy[major axis and minor axis] at, ie. Laser power 350 watt, Cutting speed 1200 mm/min and Gas pressure 6 bar.
- From the ANOVA plot heat affected zone optimum parameter setting for heat affected zone at, ie. Laser power 350 watt, Cutting speed 2400 mm/min and Gas pressure 6 bar.

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