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Surface Roughness Measurement of Stainless Steel 304 Cut by LBM

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Abstract: ***Laser beam machining is a form of non-traditional machining that can machine almost any known materials. It is thermal, non-contact process, which does not induce any mechanical stresses in the work-piece. Laser beam machining (LBM) is one of the most widely used thermal energy based non-contact type advance machining process which can be applied for almost whole range of materials. Laser beam is focussed for melting and vaporizing the unwanted material from the parent material. It is suitable for geometrically complex profile cutting and making miniature holes in sheetmetal. The objective of the present study is to investigate the effect of the machining variables like cutting speed, laser cutting power during machining of AISI 304 stainless steel work piece. Based on experimental results, surface roughness is measured and analysed.***

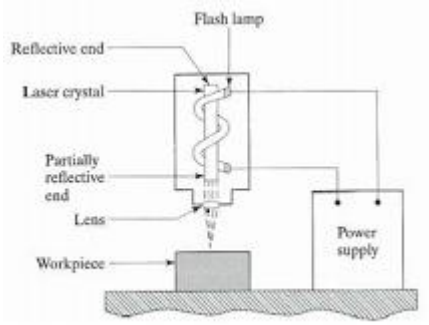
1. Introduction

Laser beam machining is a thermal energy based on the non-conventional machining process.

In LBM the external energy source should be efficient enough to stimulate the atoms in a Lasing medium (Solid-Ruby or gas-Co2, He or N2) to higher energy levels. Thus the generation of a photon from a single atom results in simulated emission of photons from all the stimulated atoms. The light energy gets multiplied as the photons increase. The generated photons are made to reciprocate in the lasing medium using reflectors thus helping the generation of multiple photons. Laser is produced by population inversion-it is a stage where the members of excited atoms or molecules in a system are more than the members of atoms or molecules in a non excited state. Light energy of a particular frequency can be used to stimulate the emission of photons from atoms in a lasing medium. The photons emitted are of the same characteristics (wave length, phase, direction and energy) as the stimulating light source. Since Laser beam is mono-chromatic a simple lens can be used to converge & focus the beam to drill small holes. Laser light is coherent in nature (i.e. it travels in a phase), because of which we can get highly focused intensities. Laser light is Mono-chromatic, it has high degree of coherence, it has high pulse energy and it can be focused as a spot of very small size.

Laser Concept

- Add energy to make electrons "jump to higher energy orbit.
- Electron "relaxes" and moves to equilibrium at ground state energy level
- Emits a photon in this process.(key laser components)
- Two mirrors reflects the photon back and forth and "excite" more electrons
- One mirror is partially reflective to allow some light to pass through: creates narrow laser beam.



Schematic of laser beam machining setup

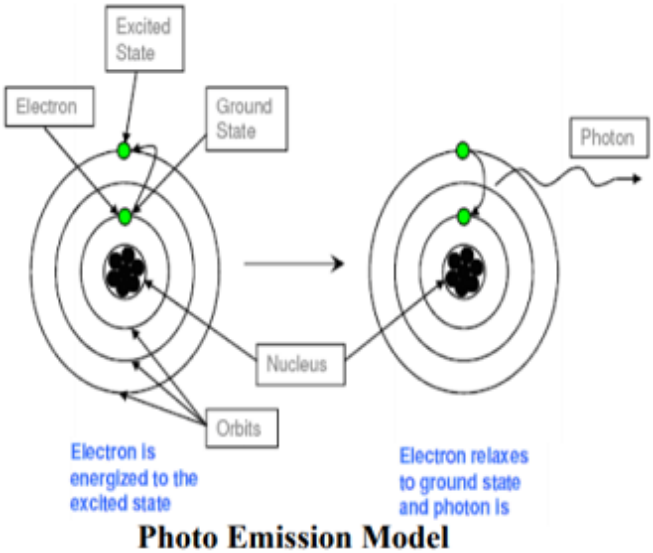


Photo Emission Model

Types of lasers

Lasers can be classified into three groups based on the state of the lasing medium:

- Solid state lasers (Ruby, Nd-YAG
- Gas lasers (CO_2 Laser and Argon Laser)
- Liquid lasers (Nitrobenzene)

2. Produce Used in Experimentation

Setup Used:

Machine Used	AMADA LCG3015
Bed size	120" * 60"
Maximum job weight:	8.200 kg
Power supply	3 phase, 200V, AC, 60Hz
Max working capacity (laser)	3.5 KW
Pulse frequency	1-10000 hz
Laser wavelength	1.08 micrometer
Laser medium	O_2 gas

Machine used: AMADA LCG3015

Instruments Used:

1) Polishing Paper.
2) Surface Roughness Tester.
3) Optical Microscope.

Work Specimen

Material	Stainless Steel
Composition	**1.2% C ; 10.5%cr**
specimen dimension:	10*10*5 mm.

Tool used: CO_2 LASER BEAM.

DOE Plan:

This experiment concerns a L9 orthogonal array by using design of experiments from Taguchi's method.

Table: Machining parameters and their level

Machining Parameter	Symbol	Unit	Levels		
			Level 1	Level 2	Level 3
Laser Speed	v	m/sec	400	700	800
Laser power	W	Watt	3000	3500	3800
O2 pressure	p	bar	4	4	4

Experimental Run Table

Run Sr. no	power (w)	speed (m/min)	O_2 pressure (bar)
A1	3000	400	4
A2	3000	700	4
A3	3000	800	4
A4	3500	400	4
A5	3500	700	4
A6	3500	800	4
A7	3800	400	4
A8	3800	700	4
A9	3800	800	4

3. Result Analysis

Microstructures:

Following figure shows the cutting surface for each condition. The micrographs of cutting edges revealed that cutting conditions affected on surface of cutting edge. Laser cutting left Striations parallel to cutting direction.

These striations were visible at high cutting speeds and high power.

The figure revealed that there is no correlation between the size of Striations and the parameters of cutting, and that striation size are depending on the thermal temperature during laser cutting.

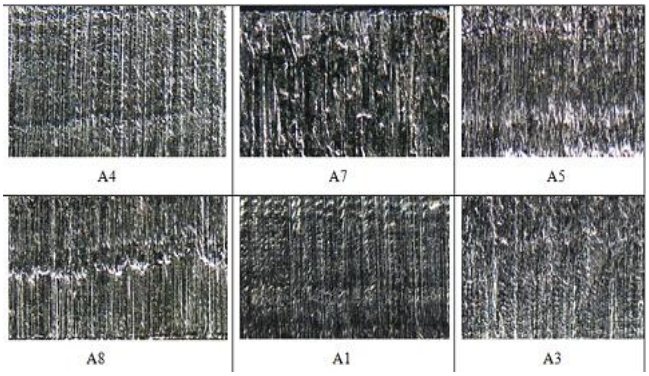


Figure: Cutting surface for some samples at different conditions

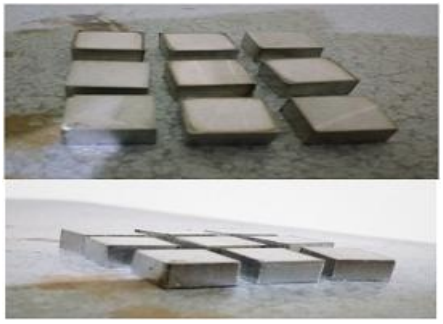
- Using high power leads to deeper striations. The figures reveal also, that the amount of laser power was the most significant factor in striations formation, and fine striations have appeared at high power and speed.
- Straight cut edges were found at low cutting speed and at low power.

Surface roughness properties

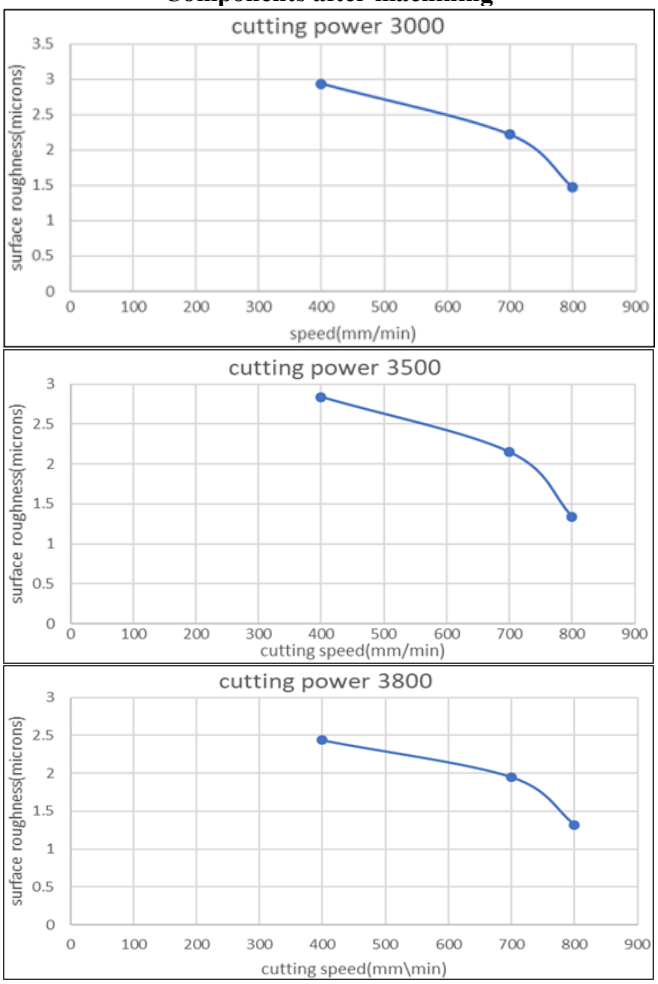
In this experiment, we are discussing about the effects or influence of machining parameter, i.e. laser power, laser speed on surface roughness (SR) of Stainless steel 304 machined work piece with laser cutting and find out which parameter is most important during an experiment with the help of Taguchi design.

Response Table

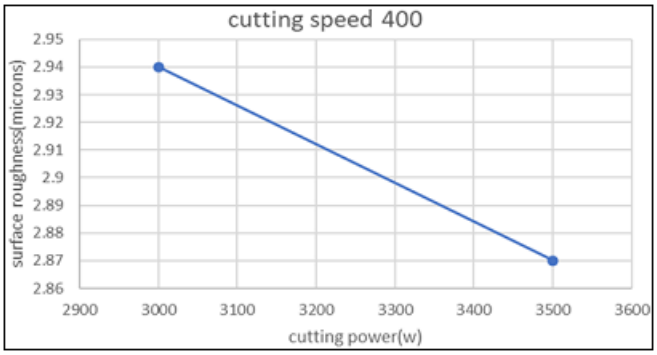
Run Sr.no	Power (w)	Speed (m/min)	O2 pressure (p)	SR (μm)
A1	3000	400	4	2.94
A2	3000	700	4	2.22
A3	3000	800	4	1.47
A4	3500	400	4	2.87
A5	3500	700	4	2.15
A6	3500	800	4	1.32
A7	3800	400	4	2.44
A8	3800	700	4	1.94
A9	3800	800	4	1.22

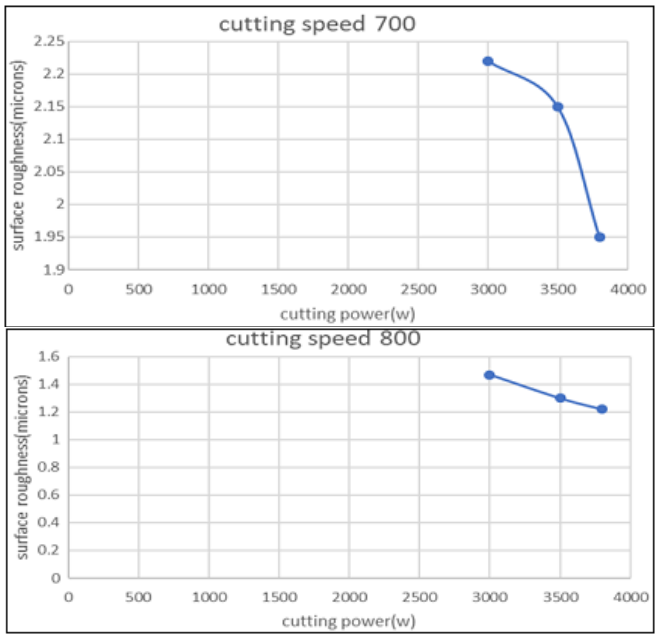


Components after machining



Cutting speed(mm/min) vs Ra(microns) at varying cutting power





Cutting power (w) vs Ra (microns) at varying cutting speed

4. Conclusion

The surface roughness tends to increase considerably with the decrease of power and speed.

It is clear from the figure that the higher surface roughness can be obtained using 3000w, 4 bar and 400 mm/min. This is due to lower power and speed exhibits higher distortion on the surface, which leads to higher surface roughness.

In general, it is evident that the surface roughness decreases with an increase in cutting speed. A decrease in laser power, generally increases surface roughness, however the effect of laser power should be considered through interaction with cutting speed and assist gas pressure.

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