

A Review on Laser Beam Machining in Shaping the Composite Materials

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ABSTRACT: Laser beam machining is one of the advanced non-traditional machining technique. It is a complicated high-speed process involving high intensity laser achieved by focusing the pulsed energy emitted by its source having great potential as a tool for nearly forceless machining. It involves releasing intense energy locally to the work material. At the surface of the material, deep laser energy is transformed into heat, which is available for processing the materials especially the composite structures with high strength and hardness. In the present work the principle of laser beam cutting is studied with equipment, process parameters and applications. CO₂ laser is given more importance as it is very commonly used type of the source for producing necessary laser beam.

KEYWORDS: Laser beam, Nozzle type, Kerf width, Heat affected zone, Assist Gas.

I. INTRODUCTION

Laser can be abbreviated as Light amplification by stimulated emission of Radiation. This light is a monochromatic, coherent and collimated beam which can be focused to small spots of diameter of 0.002 mm. Thus Produced laser beam is subjected on the work piece for cutting. The mechanism of material removal is mainly by melting and evaporation. A laser beam is a non-conventional machining method in which the operation performed by the laser [4,6,7]. The laser stands for Light stimulated emission of radiation. The process used thermal energy to remove material from a metallic surface.

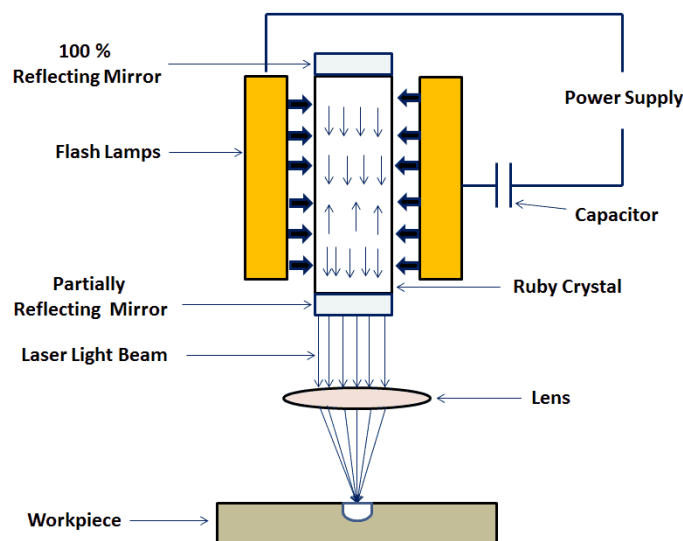


Figure1: Principle of laser beam machining.

II. EXPERIMENTAL SETUP AND PROCEDURE

Laser beam machining equipment is represented in figure 1. It is widely used for various material removal applications since it provides highly concentrated energy source to cut the materials. In laser through cutting, a kerf is created through relative motion between the laser beam and the work piece surface while profiling. The physical process of

material removal and energy losses are quite similar to those in drilling, where the incoming laser beam energy is balanced by the conduction heat, the energy for melting or vaporization of material, and the heat losses to the environment [1,3,9]. The nonlinear behaviour of the laser-material interactions play a significant role in forming the final profile and the output geometry of the machined micro features. The laser source used in this experimentation is LVD Helius Hybrid 2514 CO₂ type, where the CO₂ gas was used as the mainstream gas in this machine. CO₂ laser uses an ionized mixture of mainly helium and equal but much lower contributions of N₂ and CO₂ for the generation of invisible infrared light with a wavelength around 10 mm. However, free electrons always present in a considerable concentration in ionized gases are accelerated by an electrical field, which causes vibrations of the nitrogen molecules due to collisions and the latter handle this energy over to CO₂ molecules. Thus they start to carry out vibrations, whereas the central carbon atom remains resting and the two oxygen atoms move consistently to the right and left producing the monochromatic beam of laser as shown in figure 2.

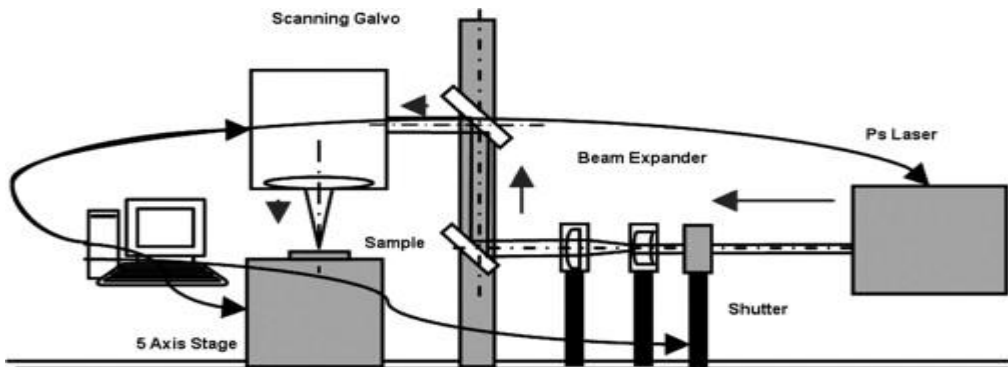


Figure 2: Components of Laser Beam Machining.

III. PROCESS PARAMETERS IN LBM

The process of laser cutting involved many parameters as shown in table 1, can be generally divided into two main categories such as beam parameters and process parameters [7, 9, and 11]. Beam Parameters that characterize the properties of the laser beam which include the wavelength, power, intensity and spot size, continue wave and pulsed power, beam polarization, types of beam, characteristics of beam, beam mode. The wavelength depends on stimulated emission with respect to the physical mechanisms involves in energy coupling and the process efficiency, stability and quality, the wavelength plays a significant role. It has important effect on material 's surface absorptivity. For a specific material type, there is a certain wavelength which can have maximum absorption of laser energy with a lowest reflection. Due to the shorter wavelength of fiber lasers same as Nd-YAG laser within range of 1 μm compared to CO₂ lasers (10.6μm), it leads to the higher absorption in metallic material.

Table1: Process Parameters of Laser beam machining.

Laser Parameter	Influence on Material Processing
Power (average)	Temperature (steady state) Process throughput
Wavelength (μm)	Optical absorption, reflection, transmission, resolution, and photochemical effects
Spectral line width (nm)	Temporal coherence Chromatic aberration
Beam size (mm)	Focal spot size Depth of focus Intensity
Lasing modes	Intensity distribution Spatial uniformity Speckle Spatial coherence Modulation transfer function
Peak power (W)	Peak temperature Damage/induced stress Nonlinear effects
Pulse width (sec)	Interaction time Transient processes
Stability (%)	Process latitude
Efficiency (%)	Cost
Reliability	Cost

The Power utilized depends on the intensity and spot size. The power of laser system is the total energy emitted in the form of laser light per second. Without sufficient power, cutting cannot be started. The intensity of the laser beam is the power divided by the beam concentrated area. The high intensity of laser beam causes rapid heating of the material, which means that little time is available for heat to dissipate into the surrounding material. Additionally, the reflectivity of most metals is much lower at high intensities, compared to the low beam intensity. Moreover, the intensity determines the thickness of material which can be cut. Spot size is the irradiated area of laser beam. In laser cutting application, it is required to focus beam into minimum spot size. Due to the better beam quality of fibre laser with very low divergence, the user can get spot diameters smaller than conventional lasers producing longer working distances. Continuous wave (CW) and pulsed laser power Both the continuous wave and pulsed laser power can achieve the high intensity needed for laser cutting. The cutting speed is determined by the average power level. Average power level with CW laser is higher compared to the pulsed laser.

IV. APPLICATIONS OF LBM

Laser can be used in wide range of manufacturing applications like Material removal – drilling, cutting and trepanning, Welding, Cladding, Alloying, drilling micro-sized holes using laser in difficult – to – machine materials is the most dominant application in industry. In laser drilling the laser beam is focused over the desired spot size. For thin sheets pulse laser can be used. For thicker one’s continuous laser may be used. Modern automotive vehicles made from fiber reinforced composites demands the use of LBM for their shaping needs.

Table2: List of LBM Uses with their type of laser used.

APPLICATION	TYPE OF LASER
<ul style="list-style-type: none"> ▪ Large holes upto 1.5 mm dia. ▪ Large holes (trepanned) ▪ Small holes > 0.25 mm dia. ▪ Drilling (punching or percussion) 	<ul style="list-style-type: none"> • Ruby, Nd-glass, Nd-YAG • Nd-YAG, CO2 • Ruby, Nd-glass, Nd-YAG • Nd-YAG, Ruby
<ul style="list-style-type: none"> ▪ Thick cutting ▪ Thin slitting of metals ▪ Thin slitting of plastics 	<ul style="list-style-type: none"> • CO2 with gas assist • Nd-YAG CO2
<ul style="list-style-type: none"> ▪ Plastics Metals Organics ▪ Non-metal Ceramics 	<ul style="list-style-type: none"> • CO2 • Nd-YAG, ruby, Nd-glass • Pulsed CO2 • Pulsed CO2, Nd-YAG

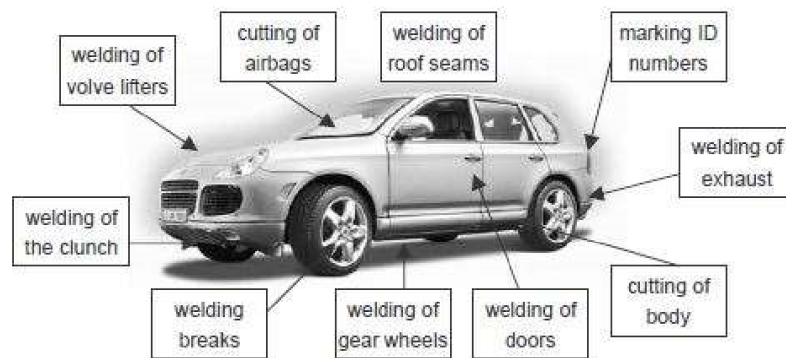


Figure 3: Application of LBM in car body parts.

V. CONCLUSION

From considerable research studies it can be concluded that the laser beam machining can be used as one of the advanced machining technique for hard and extremely difficult to cut materials. This Non-traditional process shall be used for both metallic and non-metallic surfaces. The process parameters affect the material and the properties of

machined component both macroscopic and microscopically. Due to increase in surface roughness this LBM process can be used for brittle materials in a large scale application.

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