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Laser Beam Machining – An Overview

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ABSTRACT: Laser beam machining (LBM) is a noncontact type non-conventional thermal machining processes. When laser beam focus on metal surface then material melts, vaporize and removes from the work piece .There have no.of process parameters that affects on quality of workpiece.In recent years researchers have discovered various ways to enhance the performance of laser beam cutting (LBC) by examining different factors that affects on quality characteristics of laser beam cutting. The experimental analysis shows that performance of process can be improved by selecting correct laser parameters, operatingparameters, and material parameters. This paper gives detailed literature review of laser beam machining process.

KEYWORDS: Laser beam machining(LBM),laser beam cutting(LBC)

I INTRODUCTION

[1]There have restriction to use conventional machining processes due to development of advanced engineeringmaterials,strict design requirement, and complex shape and unusual size of work piece which can limit the use of conventional machining methods. To overcome these barriers some nonconventional machining methods are developed known as advanced machining processes. Currently following methods are used in industries such as Electron Beam Machining (EBM), Electro Chemical Machining (ECM), Electrical Discharge Machining (EDM), Ion Beam Machining (IBM), Laser Beam Machining (LBM) and Abrasive Water Jet Machining (AWJM) etc. are progressively being used as substitute to conventional machining techniques .LBM is one of the advanced machining process which is used for giving required shape to entire range of engineering materials. Laser beam is mostlyused for cutting of metals and non-metals, for giving desired shape to soft and hard materials.

[2].Laser Beam can travel to vast distance without dispersion. It is a monochromatic and collimated beam which have diameter of 0.002 mm. The laser beam is pass along the work piece during metal cutting process. When Laser beam is focus on the work piece then Due to high temp of laser beammaterial is melt & remove from the work piece.

[3].In Lbm process photon formation is as follows: In the model of atom, negatively charged electrons rotate around the positively charged nucleus in specified orbital paths. Each orbital electron is associated with a unique energy level. At absolute zero temperature an atom is said to be at ground level. The electrons at ground state can be excited to higher state of energy by absorbing energy from external sources: increasing the electronic vibration at elevated temperatures, through chemical reaction, and also by absorbing energy of a photon. Then the electron moves from a lower energy level to a higher energy level. Once the higher energy level is attained, the electron reaches an unstable energy band. Therefore it comes back to its ground state by releasing a photon, in a small duration. Photons are the main source of energy in laser beam machining.

[4]Light is used for everything ranging from eye surgeries to telephone technologies. One important property of photons is that they have no volume and no charge. Therefore they do not repel each other like electrons, when concentrated in the form of a beam at particular point. When they encounter with matter, the photons behave like particles of energy.

laser beam machining

[5] (LBM) is one of the most widely used thermal-based processes applied for processing a wide variety of materials. In LBM the material is melted by focusing the laser beam on the work-piece surface. It is a high energy process that works quickly on complex shapes and is applicable to almost all materials. This process generates nomechanical stress on the work-piece, reduces waste, provides an ecologically clean technology, and can bemodified to work in the micro range.

[6] Laser light differs from ordinary light because it has thephotons of same frequency, wavelength and phase. Thus, unlike ordinary light laser beams are highly directional, have high power

density and better focusingcharacteristics. These unique characteristics of laser beam are usefulin processing of materials. Among different type of lasers,Nd:YAG and CO2 are most widely used for LBMapplication. CO2 lasers have wavelength of 10 mm ininfrared region. It has high average beam power, betterefficiency and good beam quality. It is suitable for finecutting of sheet metal at high speed [7]. Nd:YAG lasershave low beam power but when operating in pulsed modehigh peak powers enable it to machine even thickermaterials. Also, shorter pulse duration suits for machiningof thinner materials. Due to shorter wavelength (1 mm) itcan be absorbed by high reflective materials which aredifficult to machine by CO2 lasers

II LITERATURE REVIEW

A literature review of the newly published research work on LBM is carried out to understand the research problems involved and is presented here, Singh et al. [1] studied the effect of process parameters such as, cutting speed,laser power, gas pressure on heat affected zone (HAZ) for polymethyl methacrylate (PMMA) material. L-27 orthogonal array was selected for full factorial design for better understanding of interaction between process parameters. For this Response Surface Methodology is used to investigate the relationship between laser machining parameter with responses Heat Affected zone for polymethyl methacrylate (PMMA) material. They concluded that, Heat affected zone is directly proportional to laser power i.e.as Heat affected zone increases laser power increases and Heat affected zone decreases with increase in cutting speed. They also concluded that gas pressure has very little effect on heat affected zone. The influence of laser power on the heat affected zone is more as compared to the effect of cutting speed.

Prabhakaran et al. [9] examined the influence of laser cutting of thick non ferrous metal sheet i.e. aluminium alloy BS 1100 2mm thick sheet using CO2 laser. The effect of thecutting speed,control factors, laser power, gas pressure and stand-off distance on the cut quality features surface roughness and kerf width wasstudied by them. They found that substantial improvement in the quality of surface roughness.

Argade and Arakerimath [10] calculated the effect of process parameters of CO2 laser cutting such as, input power, cutting speed and gas pressure on the quality of the machined surface by using laser beam on AISI 409.He has measured the quality of cut in terms of response parameters such as surface roughnessand kerf width. No. of Design of experiments was employed by using a Taguchi method.cutting speed & gas pressure are responsible for surface roughness and gas pressure was responsible for kerf width laser power .

Senthilkumar et al. [11] examined the influence of parameters related with CO2 laser cutting of Aluminium plate of 6 mm thickness. The experiment was designed and carried out on the basis of Taguchi's L9 orthogonal array in which the four laser cutting parameters i.e. cutting speed,laser power stand-off distance, and assist gas pressure were organized at three levels. The width of laser cut, quality of the cut edges were affected by laser power, assist gas pressure,cutting speed, and standoff distance between nozzle and the work piece material. The relations between the input parameters and the response were finding out. Cutting speed,power and stand-offdistance these parametershave major influence over kerf width, and surface roughnesswhile, the influence of assist gas pressure over surface roughness and kerf width was substantially less

Prajapati et al. [12] examined the effect of laser beam machine processing parameters such, gas pressure, laser power, thickness, and cutting speed on measured response like surface roughness. This experiment was performed according to Taguchi L27 orthogonal array by using three different level of each input parameter.Investigation of variance was accompanied for result interpretation and best parameter was nominated on the origin of the signal to noise ratio, which gives the experimental result. The result shown that work piece thickness and cutting speed of plate have high involvement on surface roughness while laser power had less influence on surface roughness.

Madia and Patel [13] deliberate the influence of focal length on surface roughness of 1 mm thin brass sheet using assist gas as oxygen. The cross section which was cut is measured& from that surface roughness is found out. The difference was analysis with focal length and laser power. By using ANOVA [14] it is found that focal length was most substantial factor for surface roughness of brass 1 mm thin sheet. Inappropriate focal length affects the and cutting speed and surface roughness.Results discovered that in case of brass sheetsgood quality cuts can be produced.The laser cutting speed should be 6000 mm/min having power of 1500 Watts and surface is 4.220 µm.

Madic et al. [15] demonstrated the use of Taguchi method for optimization of surface roughness in CO2 laser cutting in case of mild steel using assist gas as oxygen.experiment was carried out according to the Taguchi's experimental design Three laser cutting

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parameters,i.e. laser power,cutting speed, and assist gas pressure were considered by using L25 orthogonal array. conclusion of this Experimental was that cutting speed and assist gas pressure were the most important parameters which affects the surface roughness variation, while the effect of the laser power is considerably smaller, by using ANOVA it is found that less than 5% error showing that the interaction effects of the laser cutting parameters should be minor, it was detected that the cutting speed should be set at the highest level i.e.7m/min, pressure of assist gasshould be set at lowest level i.e. 3 bar, whereas laser power should be set at an intermediate level i.e. 0.9 kW for getting nominal surface roughness.

Grepl et al. [16] examined effect of CO2 gas laser on the Inconel 625 nickel alloy byusing metallographic methods. In this experiment the cut quality, roughness, shape and width of the cut,was examined .the areaof Inconel 625 nickel alloy was influenced by temperature, and burr. If there is change in parameters of laser cutting then less burrs was formed in sample part therefore it would be convenient to attention on the sample part.

III LASER BEAM MACHINE SET-UP

[8] LBM process is a thermal energy based machining process in which the material is removed in the following order

 Melting
 Vaporization
 Chemical bond breakage

[2] When a high energy density laser beam is focused on work surface the thermal energy is absorbed which heats and transforms the work volume into a molten, vaporized or a chemically changed state that can be easily removed by flow of high pressure assist gas jet which in turn removes the materials from the machined surface

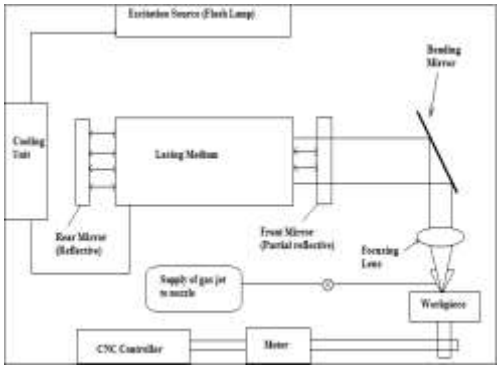

Figure 1: Laser Beam Machine Schematic diagram

The setup consists of a cylindrical ruby/Nd-YAG crystal in the case of solid laser or cylindrical vessel filled with gas in the case of gas lasers. One end face of the cylinder is partially reflective and the other end is fully reflective. A flash tube contains inert xenon gas which is placed around the outside of the cylindrical lasing medium. The flash tube converts the electrical energy into light energy which is imparted to the lasing medium in the form of thousands of flashes per second. The imparted light energy excites the atoms in the cylindrical lasing medium to a higher energy level. The excited atoms then return back to their original state, during which they radiate the energy which was absorbed from the flash tube, in form of photons. This energy is seen in the form of red fluorescent light called laser. A schematic setup of the entire laser machining process as shown in figure 1.Cooling mirrors and mirrors for guiding the beam and provisions for manipulating the position of the target are also important.

LBM is mainly used for various applications such as cutting, welding, aerospace,military weapons, medical instruments. Materials cut by LBM are ceramic, rubber, plastic, aluminium alloy, wood,brass Hardox-400 etc.

IV CONCLUSION

Parameters such as .cutting speed, laser power, nozzle distance, assist gas pressure, pulse frequency, focal length,stand-off distance, pulse width, are responsible for performance of LBC. effect of process parameters is measured on machined surface as, material removal rate (MRR),surface roughness (SR), heat affected zone (HAZ),kerf width, surface hardness. From the literature reviewit is concludedthat if we decrease power and increase feed rate it can decrease kerf width and heat affected zone. If we increase feed rate it will increase surface roughness. Laser power can have less effect on surface roughness.So it is necessary to find the ideal conditions of process parameters which can givesuperior quality of cutting surface.It was seen that techniques like Taguchi method, ANOVA, Regression analysis can be used by various researchers to find out the best cutting condition for LBM operation.

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