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Investigation of Process Parameters of CO₂ Laser Beam Machining on Acrylic

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ABSTRACT: Laser beam machining is an advance precision machining process which uses to cut different type of material according our need. CO₂ laser beam machine is use to cut brittle material because brittle material surface roughness is very high after cutting operation. LBM gives very high surface smoothness due its non-contact process concept. LBM process is use for high accuracy and high precision. The main input process parameters for LBM in this study are scan/scan speed and laser power. In this study the one process parameter constant and another parameter vary according to our need and find out processing time. The relation between process parameters and processing time will be finding out in this study.

KEYWORDS: Laser Beam Machining, Acrylic Sheet, Scan Speed, Laser Power

I. INTRODUCTION

LASER is stand for Light Amplification by Stimulated Emission of Radiation. Laser beam is a group of photons. Einstein proposed that when an atom at M energy level has light of normal frequency light working on it, it collected photons of that light and the transition takes place from lower energy level M to higher energy level L. Photon has very high energy due to state change of electrons. When an electron has been excited to high energy level then electron comes to low energy level this whole process generate a photon. This phenomenon of the movement of an atom to the higher energy level is called absorption. On the other hand, transition of an atom from the higher energy level L back to the lower energy level M is known as emission. The emission could be one of the two kinds -

- Spontaneous emission is independent of light intensity.
- Stimulated emission is influenced by the intensity of light.

Laser cutting is a thermal based non-contact process capable of cutting complex contour on materials with high degree of precision and accuracy. It involves process of heating, melting and evaporation of material in a small well defined area and capable of cutting almost all materials. Laser has a wide range of applications, ranging from military weapons to medical instruments. In industries laser is used as an unconventional method for cutting and welding. The main advantage of laser cutting is that, it is a non-contact operative method from which a good precise cutting of complicated shapes can be achieved. Also laser can be used to cut variety of materials like wood, ceramic, rubber, plastic and certain metals

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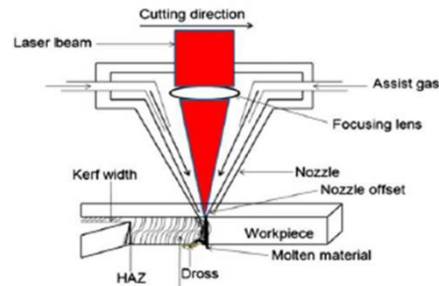


Fig.1. Schematic Diagram of LBM

II. PROCESS DETAILS FOR LASER CUTTING

As the name may suggest, this is the process of cutting a material using a laser beam. This can be done to either trim down a material or to help cut it into complex shapes that more conventional drills would struggle with. A vast range of materials and thickness sizes can be cut with lasers, making it a handy and adaptable process. The process works by having a focused and precise laser beam run through the material that you are looking to cut, delivering an accurate and smooth finish. Initially, the beam pierces the material with a hole at the edge, and then the beam is continued along from there. The laser essentially melts the material away that it is run over, so is more like melting than cutting. This means that it can easily cut light materials such as cloth up to tougher metals and gemstones such as diamonds.

The different process parameters considered are:

- A. Laser Power
- B. Scan Speed

A. Laser Power: Laser power is the intensity of photons in a laser beam. If numbers of photons is very high then laser power is very high due to energy concept of electron state change. Laser power has a great impact on cutting time of different materials. In this investigation we will find out the relation between cutting time and laser power. Laser power is also vary for according to thickness. Laser power is for cutting generally in the range (60 - 80 W). We know that if laser power is high then material removal rate is high. The optimisation of laser power is necessary for better cutting time. Optimum laser power is necessary for high surface finish because if laser power is not optimum for the material then material removal rate and surface finish are not found according to our desire.

B. Scan Speed: Scan speed is the distance per second which travelled by the tool during cutting operation in LBM. Scan speed is also has a great impact on cutting time. If scan speed is low then total cutting time is low on the other hand if scan speed is very high then cutting time is very low.

III. EXPERIMENTATION

The experimental apparatus consisted of a CO₂ laser with a maximum continuous-wave output of 120 W. The cutting experiments were performed on acrylic sheet. This facilitates cutting of various combination of selected parameters at a time. In this experiment the work piece of acrylic sheet of different thickness is used by us. We use CO₂ laser beam machine for this study. In this investigation we take acrylic sheets of 2.35 mm & 4.00 mm thickness.

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The specimen size details -

$L_1 = L_2 = W_1 = W_2 = 150 \text{ mm}$, $T_1 = 2.35 \text{ mm}$, $T_2 = 4.00 \text{ mm}$

Machine specification -

Type of laser – CO₂ laser beam machine

Machine Power – 120 W

Laser cut details -

PROFILE – LINEAR

LENGTH OF CUT – 100 mm

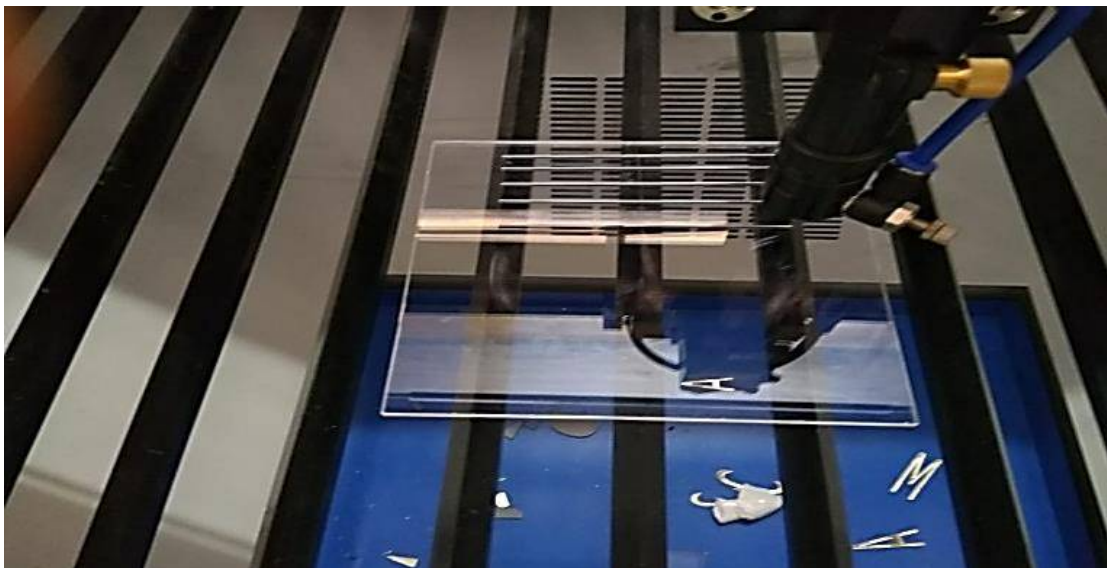


Fig.2. Shows LBC on Acrylic Sheet of different thickness

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IV. OBSERVATION TABLES

1.1. FOR 2.35 mm

A. FOR CONSTANT LASER POWER

PROCESS PARAMETER	LASER POWER (W)		SCAN SPEED	TIME
S.NO.	MIN	MAX	(mm/sec)	(SECOND)
1.	70	80	10	9.72
2.	70	80	15	6.30
3.	70	80	20	4.77

B. FOR CONSTANT SCAN SPEED

PROCESS PARAMETER	LASER POWER (W)		SCAN SPEED	TIME
S.NO.	MIN	MAX	(mm/sec)	(SECOND)
1.	50	60	10	12
2.	60	70	10	10.03
3.	70	80	10	9.72

1.2. FOR 4.00 mm

A. FOR CONSTANT LASER POWER

PROCESS PARAMETER	LASER POWER (W)		SCAN SPEED	TIME
S.NO.	MIN	MAX	(mm/sec)	(SECOND)
1.	70	80	10	9.54
2.	70	80	15	6.44
3.	70	80	20	4.89

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B. FOR CONSTANT SCAN SPEED

PROCESS PARAMETER S.NO.	LASER POWER (W)		SCAN SPEED (mm/sec)	TIME (SECOND)
	MIN	MAX		
1.	50	60	10	10.59
2.	60	70	10	9.86
3.	70	80	10	9.54

V. RESULTS

The result for this whole process is very simple finding out with the help of above given data is that the effect of scan speed and laser power on the cutting time –

- The effect of scan speed is very high on cutting time because the tool moves faster and process complete in less time.

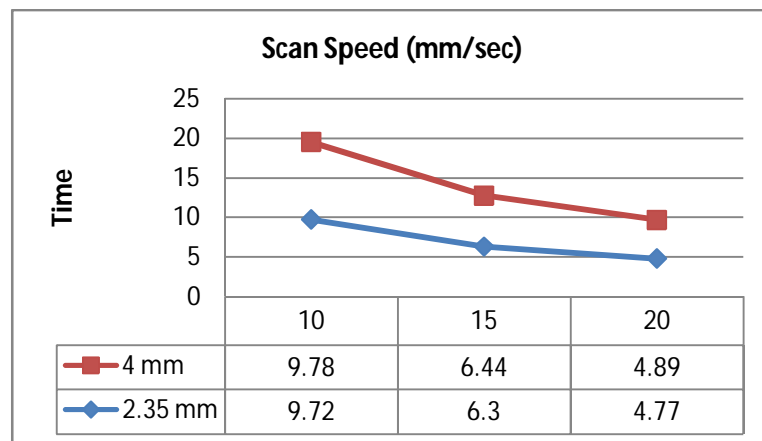


Fig.3. Scan Speed V/S Time at Constant Laser power

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- The effect of laser power is also may create some difference but not in a huge amount with respect to effect of scan speed.

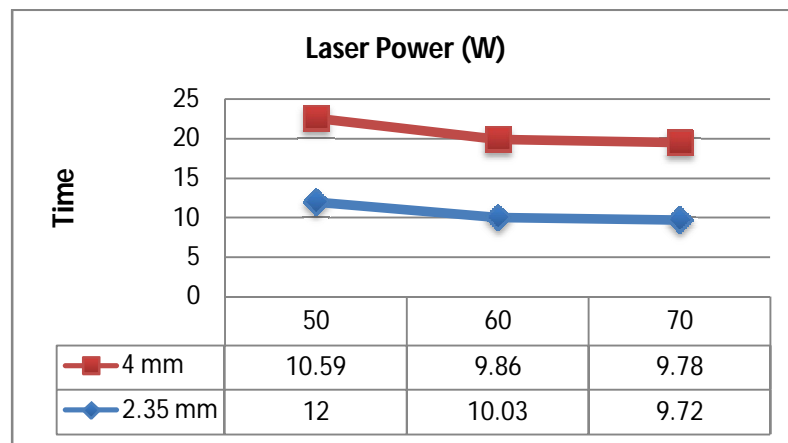


Fig.4. Laser Power V/S Time at Constant Scan Speed

The cutting time is directly affected by scan speed from the above graph there is a large difference in cutting time with difference in scan speed. The laser power is not affected scan speed as scan speed. For high production rate from laser beam machining the optimization of scan speed according material properties and thickness of sheet for full depth of cut is very necessary. Thickness of material sheet is also affect cutting time in a little amount but it is not affected as scan speeds at a certain limit of thickness because high material removal rate is not possible in a single pass so after a certain limit thickness is also affected cutting time more.

VI. CONCLUSIONS

In this investigation we use CO₂ Laser Beam Machine of 120 W laser power. In this investigation we use thickness of acrylic sheets 2.35 mm and 4.00 mm. In this investigation we perform linear cut profile. The conclusion for this investigation, the optimisation of scan speed is necessary for the optimum cutting time for linear cut profile. Thickness not affected cutting time as scan speed at a certain limit because if thickness crosses certain limit according to laser power cutting time increase due to multi pass operation may occur. The difference in laser power of machine not affected cutting time as scan speed in this investigation but it will possible for high laser power capacity machine laser power may affected as scan speed for high thickness of sheet.

The result may different for different thickness, laser power, scan speed and cutting profile. The cutting profile like square, rectangle, circle etc. These cutting profiles may take some extra cutting time compared to simple linear cut. The high laser power capacity of machine may also affect the cutting time for large thickness of sheet because single pass will sufficient. The different thickness of acrylic had not affected the cutting time because this investigation on high laser power as compare to thickness of the material.

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