RESEARCH ARTICLE OPEN ACCESS

Effect of Focal Length on Surface Roughness of 1mm Thin Brass Sheet

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Abstract
The Laser cutting characteristics including power level and focal length are investigated in order to obtain surface roughness with maximum cutting speed. The surface roughness is investigated for a laser power range of 1000–1500W and focal length 122-132, gas pressure 18 bar constant for brass materials.This paper is studied the effect of focal length on surface roughness 1mm thin brass sheet using an nitrogen as assist gas. The cutting cross section was measured surface roughness. The variation was analyzed with laser power and focal length. We use here plasma detector sensor for predetermined cutting speed. The full factorial method is used for cutting speed and surface roughness. Result revealed that good quality cuts can be produced in brass sheets, at a window of laser power1500 watt and focal length 122 mm surface roughness is 1.941µm and 7500mm/min cutting speed is achieved.

I. Introduction

Laser (light amplification by stimulated emission of radiation) is a coherent and amplified beam of electromagnetic radiation. The key element in making a practical laser is the light amplification achieved by stimulated emission due to the incident photons of high energy. [1]. Laser cutting of metals has become a reliable technology for industrial production. Currently, it is considered as a feasible alternative to mechanical cutting and blanking due to its flexibility and ability to process variable quantities of sheet metal parts in a very short time with very high programmability and minimum amount of waste. Laser cutting does not need special fixtures or jigs for the work piece because it is a non-contact operation. Additionally, it does not need expensive or replaceable tools and does not produce mechanical force that can damage thin or delicate work pieces. [2]. Laser cutting is the process of melting or vaporizing material in a very small, well defined area. Processes of heating, melting, and evaporation are produced by the laser beam affecting a workpiece surface. A desired cut is obtained by moving the laser beam along a given contour. Laser beam is a cutting tool able to cut all materials, focused into a very small spot diameter concentrating thousands of Watts. [3] To achieve a maximum efficiency from the laser, the laser beam needs to be properly focused on the workpiece. [4]. Various focal length (122,127 & 132 mm) are used for 1mm thin Brass sheet.

II. Experimental Procedure

The experiments were performed on as received 1 mm thin sheets of brass. Experiments were conducted using a continuous wave Bhramastra futurex fiber laser cutting machine with the 2 kW maximum output power. We cut 25 mm × 25 mm piece from the brass sheet. Surface roughness was inspected using Mitutoyo surface roughness tester SJ-210.

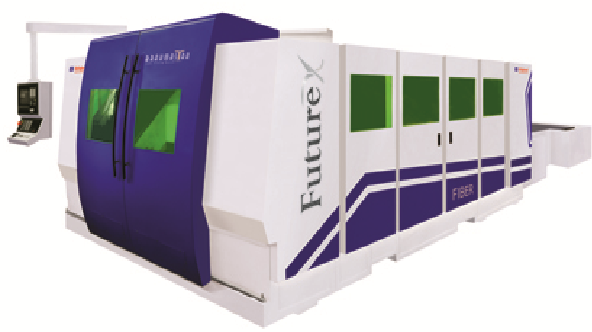

Fig: 1 Bhramastra futurex- Fibre Laser Cutting Machine

Table 1 Technical specifications

	Parameters	**Unit**	
CW power	Operation mode		CW/QCW
	Nominal output power	KW	2
Beam	Emission wave length	nm	1070-1080
	Beam Parameter product	Mm*rad	6
	Output fiber core diameter of feeding fiber	µm	150
	Fiber length	m	10
	Polarization		Random

Electrical	Operating voltage 3-phase	VAC	400-460
	Power Frequency	Hz	50/60
	Power consumption	KW	15
Cooling	Laser cooling water Temperature Range	^{o}c	22-24
	Laser cooling water Flow rate	I/min	5
Environment	Operating ambient air temperature range	^{o}c	10-50
	Humidity with Built in conditioner	%	95
	Storage temperature	^{o}c	-40 to +75
Working area	X Y Z	mm	3030×1550×150
Weight		Kg	750

III.Plasma detector sensor

In this paper the cutting speed is decided by plasma detector sensor as plasma formation starts cutting speed reduces we consider it as maximum cutting speed. The cutting speed is predetermined in sensor. Machining condition changing means for changing to decrease feeding speed as output of laser beam radiation which is instructed by said machining program. When said plasma detection judging means outputs result judged that said plasma was detected. [5]

Table 2 Technical specification of plasma detector sensor

Carrier gases	Oxygen and nitrogen
Power	80 to 240 VAC, 50-60Hz
Gas connections	1/16"
OPERATION outlet pressure	Atmospheric or vacuum
Operating temperature	10^0 to 50^0C
Filter	10u SS particle filter on the gas inlet
Detector signal output connection	BNC coaxial type
Power consumption	Max 10 watts

III. Chemical composition of material

Table 3 Brass chemical composition

Elements	**% Compositions**
Tin	0.240
Lead	0.330
Zinc	41.330
Nickel	0.100
Iron	0.136
Copper	57.680

IV.Parameters

(a) Input parameters

Table 4 Input parameters and their levels

No.	**Factors**	**Levels**	**Factors levels value**
1	LP(watt)	3	1000/1200/1500
2	FL(mm)	3	122/127/132

Here,
LP = Laser power, (watt)
FL = Focal Length, (mm)
CS = Cutting speed, (mm/min)
SR = Surface Roughness, (μm)

Gas pressure is constant at nitrogen 18bar for all runs and all other parameters are constant. Focus position on the surface (0.0mm).

(b)Output parameters

Here main output parameter is surface roughness(μm) and cutting speed ,as cutting speed (mm/min)value is predetermined in the sensor for plasma formation but we take it before the formation of plasma so surface roughness is remain in acceptable range.

V. Experimental table

Table 5 Results of Cutting speed and surface roughness for Brass

INPUT PARAMETERS			**OUTPUT PARAMETERS**	
Sr. No	**L P (watt)**	**FL (mm)**	**CS (mm/min)**	**SR (µm)**
1	1000	122	5500	2.657
2		127	3500	4.876
3		132	1500	8.929
4	1200	122	6800	2.319
5		127	4000	3.07
6		132	2000	6.153
7	1500	122	7500	1.941
8		127	5000	2.379
9		132	2500	3.422

VI. Result and discussions

As per ANOVA Analysis we can find the percentage contribution of input parameters for Surface Roughness as shown in below Table- 6.

Table 6 Summary of ANOVA calculation for Surface Roughness Brass

Source of variation	***f***	**Sum of squares**	**Mean square**	**Variance ratio F**	**% contribution**
Factor-A, Laser power	2	12.742	6.371	6.3713	0.300
Factor-B, Focal length	2	23.641	11.82	11.820	0.557
Error –E	5	6.0024	1.000	1	0.141
Total	9				1

After the manual calculations table we obtained 14 % error in brass (N_2) for surface roughness shown in table 6, but if we consider interaction effect of both the parameters A & B than pure error comes to 0. This has been done using design expert software shown in table 7.

Table 7 Summary of Design expert ANOVA calculation for Surface Roughness Brass

Source	**Sum of squares**	**Degree of freedom**	**Mean square**
Model	42.39	8	5.30
A- LASER POWER	12.74	2	6.37
B-FOCAL LENGTH	23.64	2	11.82
AB	6.00	4	1.50
Pure Error	0.000	0	
COR TOTAL	42.39	8	

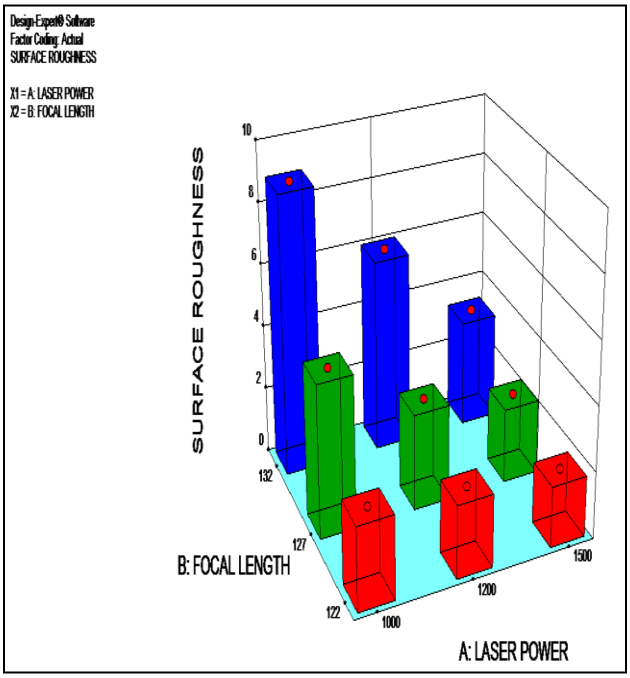

Fig .2 Laser Power, Focal Length v/s Surface Roughness of Brass (N_2)

VII. Results and discussions:

From figure 2 as the Laser Power is 1000 Watts the focal length is increases from 122 to 132 then the Surface Roughness is increases from 2.657 to 8.929 µm. Cutting speed is decreases 5500 to 1500 mm/min with increases focal length.

Similarly, for the Laser Power is taken 1200 Watts then Surface Roughness is increases from 2.319 to 6.153µm and the cutting speed decreases 6800 to 2000 mm/min with increases in focal length. The Laser Power is taken 1500 Watts the focal length increases 122 to 132 mm then Surface Roughness is increases from 1.941 (is best result of this experiment) to 3.422 µm. Cutting speed is decreases 7500 to 2000 mm/min with increases focal length.

VIII. Conclusion

The effects of focal length and Laser Power on quality characteristics of laser cut brass specimens have been studied in this work. As per ANOVA we can found that the Factor B –focal length is most significant factor for Surface Roughness of brass 1 mm thin sheet. Improper focal length affects the surface roughness and cutting speed. Results revealed that good quality cuts can be produced in brass sheets, at a window of laser cutting speed 7500 mm/min and at a power of 1500 Watts surface is 1.491 µm.

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