ENHANCED LASER CNC MACHINE PERFORMANCE ON VARIOUS ALUMINIUM SHEET QUALITIES

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Abstract - *In this research work, we have studied to increase or improve the performance of the CNC laser machine at the different grade of the aluminium sheet or plate; in this research work we have selected three grade of the aluminium sheet or plate such as Al 5086, Al 6070, and Al 7075. The length and width of the all these three grade of the aluminium sheet are kept constant such as 1000mm*45mm, the thickness of these three aluminium plate get varies from 6.0mm, 7.0mm, 8.0mm, 9.0mm, and 10.00mm, we have taken the different thickness of the aluminium to check the effect of cutting speed. In this research work, we have studied on the basis of the Power of laser vs. Cutting Speed, Diameter of nozzle vs. surface roughness, Gas Pressure vs. cutting Speed, Plate thickness vs. Cutting Speed, Plate thickness vs. Surface Roughness, and Power of laser vs. Surface Roughness. We have used the CO_2 CNC laser machine to cut the different grade of the aluminum sheet. In this research, we have increase or decrease the power of the laser to see the effect on the cutting speed, some time increase or decrease the diameter of the nozzle of the CO_2 CNC laser machine, and sometime increase or decrease the gas pressure to see the effect of the cutting speed of these three grade of the aluminum sheet. On the basis on this parameter, we will see that which parameter is playing an important role to improve the performance of the CO_2 CNC laser machine.*

Key Words: (Al 5086, Al 6070, Al 7075, CO_2 Laser, CNC Machine, Aluminum Sheet.

1. INTRODUCTION

The researchers have created a variety of methods for enhancing a variety of product attributes. Design and build a portable laser cutting and engraving device with the primary objective of creating one that can be easily controlled by an Arduino CNC. It was made more inexpensive than CO2 laser cutters, one of the most accurate and practical cutting methods now available. Common methods for pumping CO2 lasers include employing radio frequency energy or running a current through the gas mixture [1]. The graphical picture was transformed into the G coding language using the ELEKSMAKER Software.

Led laser Modules with a 500mw power output and a 450nm wavelength are used for a variety of applications that call for small sizes, extended working lives, and low power consumption. Solid works programme was used to create all design outlines. The model's stepper motor is managed by an Arduino CNC Shield Driver microcontroller. Producing a laser cutting and engraving equipment with laboratory-like accuracy was the main objective [2]. The outcome appears to be for better-quality engraving and cutting. described the creation of a microcontroller-based plotter and concentrated on the industry's sketching component. By employing these kinds of equipment, sophisticated designs from many industrial workplaces may be obtained. To acquire the range of motion over the three translational axes, X, Y, and Z, three motors were employed in this research [1]. The microcontroller was programmed using the Arduino IDE, and the G-codes were created using the CAMotics software.

A small pen plotter machine was created that can use G codes to write on paper or other writing surfaces and draw intricate drawings. This little device could be moved around and was simple to construct. Two Stepper motors were utilised for precise movement in the X and Y axes, respectively, and one servo motor was used to raise the pen in the Z direction. Drivers were utilised by the author to provide the stepper motors and servo motor with G codes in sequence [3]. The Arduino UNO microcontroller board was utilised by the author to programmatically control the position of the motors. Arduino is equipped with a CNC shield, which distributes current during Arduino commands and uses a stepper motor to transform G-code commands into digital pulses. The machine took design input in the form of G codes and transformed them using software before sending it to an Arduino, CNC shield, stepper motors, and a servo motor [4].

1.1. LASER CUTTING

The most well-known laser material processing technology, laser cutting, is a way to separate and shape a work item into segments with the necessary geometry. A concentrated laser beam is moved at a consistent distance over the surface of the work item to perform the cutting operation, producing small cut kerfs [5]. Along the intended cut shape, these kerfs completely penetrate the material [6].

The absorbed energy warms and changes the potential kerfs volume into a volatile or readily removeable condition (molten, evaporated, or chemically altered). Typically, a gas jet that impinges coaxially with the laser beam supports the removal of the material. The changed material is accelerated by the cutting gas and ejected from the kerfs [7].

Only when the melt zone completely engulfs the work item is this procedure successful. Therefore, laser metal cutting is typically limited to narrow parts. Although cutting through 100 mm pieces of steel has been documented, the procedure is most frequently used to metal sheets 6 mm or less in thickness [8].

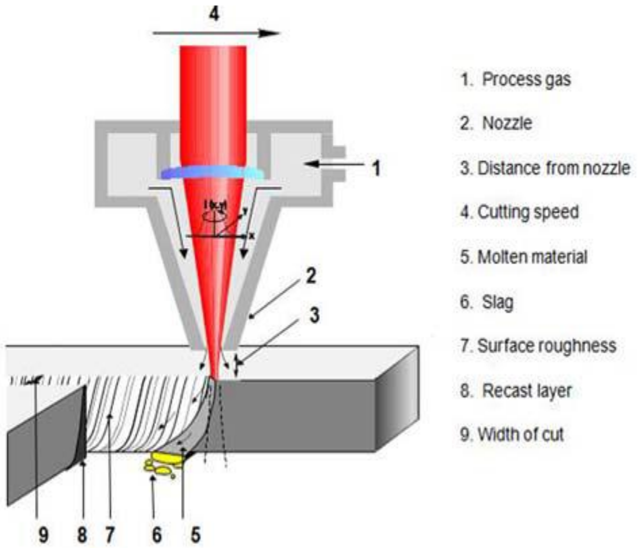

Figure-1: Laser Cutting.

1.2. CNC LASER MACHINE

Since the primary diode programming for texture processing evolved into a 15W logical diode laser, it has been substantial. In compared to those days, it has now reached a consistent peak. The benefits of inefficient power diodes are their conservatism, lifespan runtime, power efficiency, and incidental running costs [8]. As of right present, welding and solidifying are both done with CO2 and Nd:YAG lasers. Unnecessary strength diode lasers have characteristics including their frequency, laser power, power execution, pillar arrangement, bar difference, and imbalance that enable them stand out from other types of lasers [9]. There are three varieties of CNC laser machines:

I. CO_2 Laser.
II. Laser micro jet.
III. Fiber lasers.

1.2.1. CO_2 Laser.

Since the first laser was used in 1960, significant research and development have been carried out, resulting in a fast expansion in the variety of laser types, output power, and applications. Particularly in practically every element of laser materials processing, such as cutting, welding, cladding, and heat treatment [10], the CO2 laser has been used extensively. With commercial lasers available up to 25 kW [12], it is now the most potent material processing laser. In order to drill, label, and cut thin materials with lasers, pulsed Nd: YAG lasers with short (1.06 m) and high pulse rates are frequently utilized [11].

Figure-2: CNC Laser Machine.

1.3. WORKING PRINCIPLE

Laser diminishing is a warm, non-contact and programmed technique pleasantly legitimate for different creation businesses to supply added substances in monstrous numbers with exorbitant exactness and floor finish [12]. The really combustible oxidized fuelling from the fuelling chamber comes within side the spout in which it gets lighted with the enhanced gentle and creates the exorbitant intense fire which grants at the material and as a result of that the lessening movement at the fabric happens [13]. This unnecessary intense fire can be of different gases specifically the gases utilized are CO_2, O_2, N_2, and so on depending at the lessening boundaries unique gases with strain are acclimated to produce the fire [14].

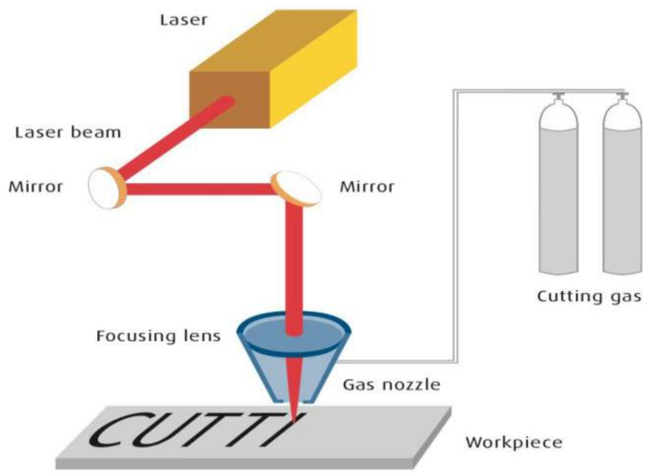

Figure-3: Schematic Diagram.

2. LITERATURE SURVEY

Avanish Dubey's 2008 It has been discovered that the kerfs width during the laser beam cutting (LBC) process is not uniform throughout the length of cut, and the unevenness is more pronounced in case of pulsed mode of LBC[15]. In this study, two kerf qualities—kerf deviation and kerf width—that are challenging to cut with the LBC method were concurrently improved using the Taguchi quality loss function when cutting aluminium alloy sheet that was 0.9 mm thick. The quality of kerfs has significantly increased [16].

On an experimental examination and optimization of the CO2 laser cutting process on stainless steel plates, M. Madic began working in March 2015. This study examines multi-objective optimisation of the cut quality parameters for stainless steel CO2 laser cutting, including surface roughness, HAZ width, and kerf width. The used methodology incorporates formulation of the multi-objective optimization problem using weighting sum method, solving it by CSA, and modelling of the relationships between the laser cutting factors (laser power, cutting speed, assist gas pressure, and focus position) and cut quality characteristics using ANNs [17]. The cuckoo search technique is employed for optimisation.

According to Yusof et al. (2008), increasing laser power reduces sideline length and percentage over length whereas increasing laser power increases kerf width at all cutting speeds. In CW mode, increasing cutting speed with an equivalent increase in power produced improved quality and a smoother cut surface up to 8 m/min cutting speed [18], but increasing cutting speed in pulsed mode resulted in rough surfaces and partial cutting. By raising the peak power, gas pressure, pulse frequency, and duty cycle, the SR also rises. Altering spot overlap and pulse width can also alter the surface roughness of the sliced specimen [19].

Miroslav and Predrag focused on surface roughness using laser cutting in 2006. High quality is crucial. Two zones may be seen by looking at the sliced surface: one higher zone near the laser beam entry side and one lower zone near the laser beam exit side [20]. While the latter has a rougher surface marked by both slag and molten metal deposits, the former has a beautifully machined surface with correct grooves that are spaced apart by 0.1–0.2 mm. The standard roughness Rz goes up with sheet thickness but goes down with laser power. Standard roughness R for cutting with an 800 W laser is 10 m for 1 mm thick sheets, 20 m for 3 mm, and 25 m for 6 mm [21]. It is possible to employ a correlation between the mean arithmetic profile deviation and the standard roughness (ten point height of irregularities), as well as linear and exponential correlations.

Sneana Radonji and Pavel Kova defined a laser machine process parameter in 2012. An ideal cut was produced through experimental study that was done during the laser processing of AISI 314 material. The following processing settings are used to create the ideal cut: feed rate 1250 mm/min, laser power 4400 W, focus point 16 mm, gas pressure 17 bars, and nozzle distance 7 mm [22].

In April 2012, Martin Grepl1 conducted research on Laser Cutting of Materials of Various Thicknesses and discovered that Haynes may be sliced with the right conditions. The re-cast layer should be measured with a microprobe, followed by a microchemical examination, to prevent any impact from the environment on the cut [22]. We urge more focus on a study of the recast layer and its heightened reliance on cutting parameters. The original material's melting limit would be a good place to test micro-hardness, but more crucially, the recast layer itself. Our work has made a significant contribution by providing a thorough understanding of how the process parameters affect a specific subset of materials utilised in the aerospace industry.

3. METHODOLOGY

In the methodology section, we studied about the cutting the three grade of the aluminum plate such as Al5086, Al 6070, and Al 7075with help of the CO_2 laser cutting machine by changing the power of laser, diameter of nozzle, gas pressure, etc. The mechanical and chemical property of these three aluminum sheet are given below in the form of table:

3.1 Property of Al-5086

The mechanical property and chemical composition of the Al-5086 are given in Table-1 and Table-.2.

TABLE-1: Chemical composition of Al-5086

S.No	Component	Percentage (%)
1	Al	93 - 96.3
2	Cr	0.05 - 0.25
3	Cu	Max 0.1
4	Fe	Max 0.5
5	Mg	3.5 - 4.5
6	Mn	0.2 - 0.7
7	Si	Max 0.4
8	T	Max 0.15
9	Zn	Max 0.25

TABLE-2: Mechanical Property of Al-5086

S.No	Property	Value
1	Hardness, Brinell	35
2	Hardness, Knoop	38
3	Hardness, Vickers	43
4	Ultimate Tensile Strength	290 MPa
5	Tensile Yield Strength	207 MPa
6	Elongation at Break	12%
7	Modulus of Elasticity	71 GPa
8	Compressive Modulus	72.4 Gpa
9	Ultimate Bearing Strength	552 MPa
10	Bearing Yield Strength	331 MPa
11	Poisson's Ratio	0.33
12	Fatigue Strength	150 MPa
13	Fracture Toughness	49 Mpa-m^0.5
14	Machinability	30 %
15	Shear Modulus	26.4 GPa
16	Shear Strength	175 MPa

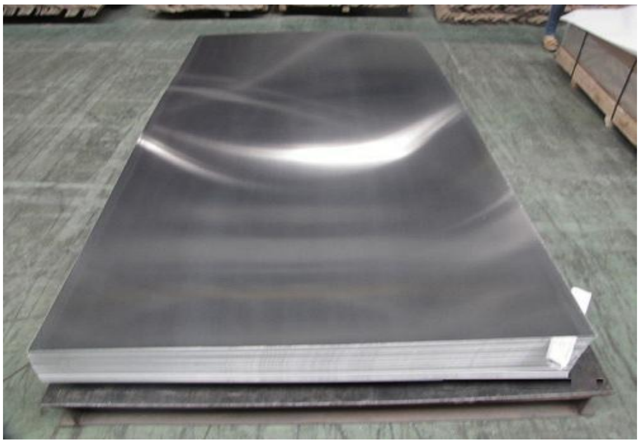

Figure-4: Al 5086.

3.2. Property of Al-6070

The mechanical property and chemical composition of the Al-6070 are given in Table-.3 and Table-.4.

TABLE-3: Chemical Composition of Al-6070

S.No	Component	Percentage (%)
1	Aluminium / aluminium, (Al)	97
2	Silicon (Si)	1.40
3	Magnesium (Mg)	0.80
4	Manganese (Mn)	0.70
5	Copper (Cu)	0.28

TABLE-4: Mechanical Property of Al-6070

S.No	Property	Value
1	Tensile strength	145 MPa
2	Yield strength	69 MPa
3	Shear strength	97 MPa
4	Fatigue strength	62 MPa
5	Elastic modulus	70-80 GPa
6	Poisson's ratio	0.33
7	Elongation	20%
8	Hardness	53.5

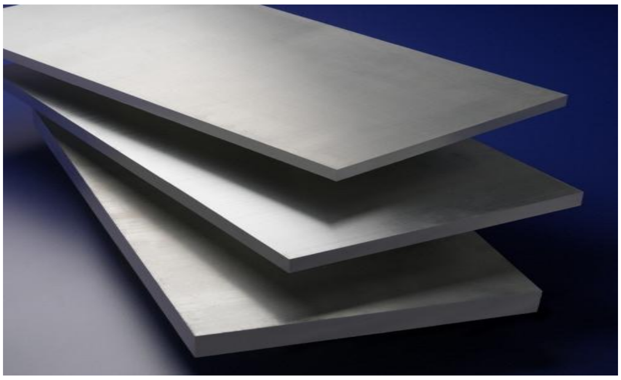

Figure-5: Al 6070

3.3. Property of Al-7075

The mechanical property and chemical composition of the Al-7075 are given in TABLE-5 and TABLE-6.

TABLE-5: Chemical Composition of Al-7075

S.No	Component	Percentage (%)
1	Aluminium / aluminium, (Al)	94 to 95.1
2	Silicon (Si)	0.4
3	Magnesium (Mg)	2.1 to 2.9
4	Manganese (Mn)	0.30
5	Copper (Cu)	1.2 to 2
6	Fe	0.5
7	Zn	2.1 to 3.3

TABLE-6: Mechanical Property of Al-7075

S.No	Property	Value
1	Tensile Yield strength	503 MPa
2	Ultimate Tensile strength	572 MPa
3	Shear strength	331 MPa
4	Fatigue strength	159 MPa
5	Elastic modulus	71.85 GPa
6	Poisson's ratio	0.33
7	Elongation	11%
8	Hardness	78

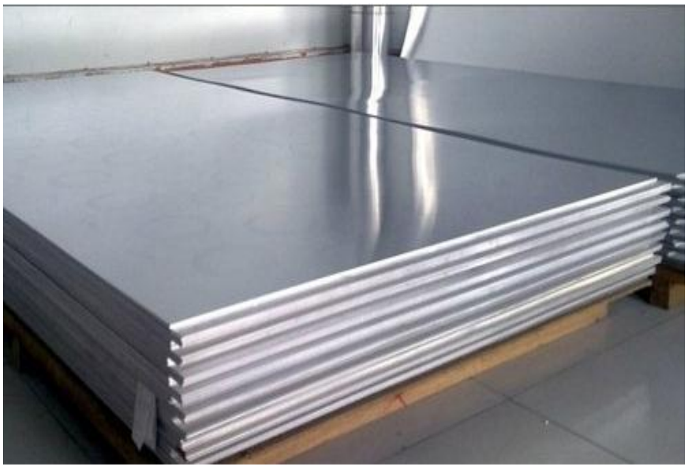

Figure-6: Al 7075.

3.4. DIMENSION OF ALUMINUM PLATE

There are three aluminum plate used in this research work, the dimension of the aluminum pate are given blow in the table:

Table-7: Dimension of Aluminum Sheet

Serial Number	Parameter	Al 5086	Al 6070	Al 7075
1	Length	1000 mm	1000 mm	1000 mm
2	Width	45 mm	45 mm	45 mm
3	Thickness-1	06 mm	06 mm	06 mm
4	Thickness-2	07 mm	07 mm	07 mm
5	Thickness-3	08 mm	08 mm	08 mm
6	Thickness-4	09 mm	09 mm	09 mm
7	Thickness-5	10 mm	10 mm	10 mm

4. RESULT AND DISCUSSION

In the result and discussion chapter, we studied about the cutting the three grade of the aluminum plate such as Al5086, Al 6070, and Al 7075with help of the CO2 laser cutting machine by changing the power of laser, diameter of nozzle, gas pressure, etc.

The result of all research work as given below:

1. Power of laser vs. Cutting Speed
2. Diameter of nozzle vs. surface roughness
3. Gas Pressure vs. cutting Speed
4. Plate thickness vs. Cutting Speed
5. Plate thickness vs. Surface Roughness
6. Power of laser vs. Surface Roughness

4.1. Power of Laser vs. Cutting Speed

Power of laser is defined as the amount of the electricity consumers to cut the aluminum plate into two parts.

We kept the gas pressure of the laser CNC machine 6 bar and thickness o f the all these three aluminum sheet is 06mm.

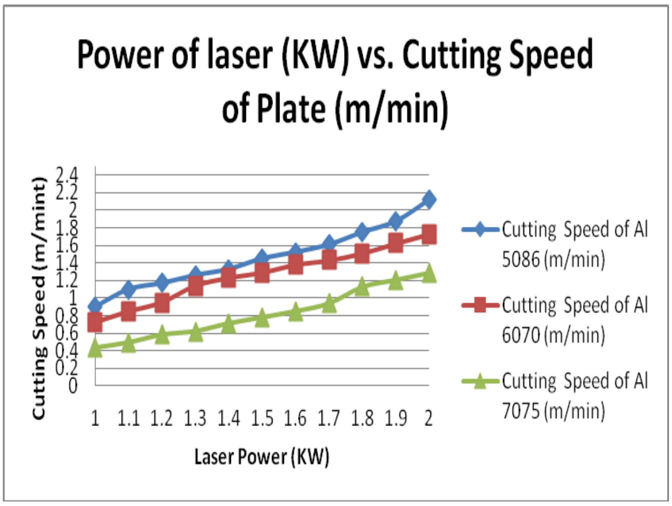

Figure-7: Power of laser Vs Cutting Speed

4.2. Diameter of Nozzle vs. Surface Roughness.

In the Diameter of Nozzle vs. Surface Roughness, we change the diameter of the nozzle to see the effect of the cutting speed of three different grade of aluminum sheet. We taken constant power of laser (1KW) and gas pressure is 5 bars.

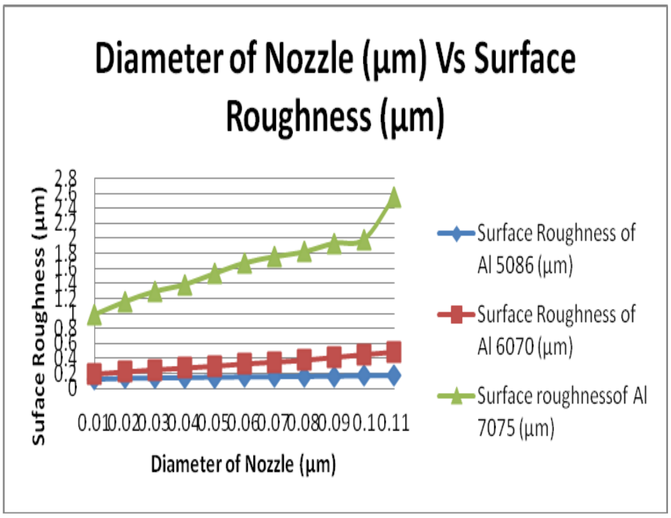

Figure-8: Diameter of Nozzle vs. Surface Roughness

4.3. Gas Pressure vs. Cutting Speed

Gas pressure is defined as the amount of the gas (bar) required cutting the aluminum plate into two pieces in the CO_2 laser CNC machine

We kept the Power of laser (1KW) constant and diameter of the nozzle is 0.02mm, and thickness of sheet is 6mm

We have kept minimum gas pressure for CO2 laser CNC machine is 5 bar and maximum gas pressure for CO_2 laser CNC machine is 15 bars. The changing the gas pressure from 5 bar to 15 bar at the difference of 1 bar gas pressure.

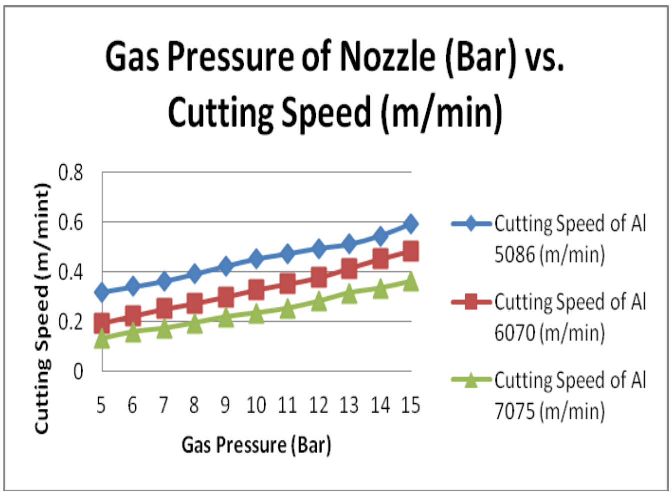

Figure-9: Gas Pressure vs. Cutting Speed

5. CONCLUSION

After analyzing the result and discussion section, we found conclusion about three grades of the aluminum sheet such as Al 5086, Al 6070, and Al 7075 by cutting the CNC laser machine at the different diameter of the nozzle, different power of the laser, different gas pressure, etc. The conclusion of these result are given below:

- When the power supply of the CNC laser machine is 1KW, gas pressure is 6 bar and thickness of these three grade of aluminum sheet is constant which are 06mm, then we can see that cutting speed of these three grade of the aluminum sheet is increasing by increasing the power supply of the laser CNC machine. The maximum cutting speed is in the Al 5086 due to the mechanical property (hardness), the value of the hardness is low in the Al 5086. To increase the cutting speed of the aluminum plate, we need to increase the gas pressure as well as either increase the power supply or decrease the diameter of the nozzle. The cutting speed of the Al 5086 is approximately 20 percent higher than Al 6070, and approximately 52.22 percent higher than Al 7075 at the supply of the 1KW power in the laser CNC machine.

- As the reference to the gas pressure of the nozzle vs. cutting speed in the result and discussion chapter, The cutting speed of these three aluminum sheet is increase by the increasing the supply of the gas pressure of the nozzle at power of laser (1KW) constant and diameter of the nozzle is 0.02mm, and thickness of sheet is 6mm. This method is not economical to increase the cutting speed because if we increase the supply of the gas to increase the gas pressure. Increasing the supply of the gas pressure is directly proportional to the increasing cost.

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