PERFORMANCE IMPROVEMENT OF LASER CNC MACHINE USING DIFFERENT GRADES OF ALUMINIUM SHEET

A Thesis

Submitted

In Partial Fulfillment of the Requirements

for the Degree of

MASTER OF TECHNOLOGY

In

Production and Industrial Engineering

Submitted by

Arman Khan

Department of Mechanical Engineering

Faculty of Mechanical Engineering

INTEGRAL UNIVERSITY, LUCKNOW, INDIA

June, 2022

CERTIFICATE

This is to certify that **Mr. Arman Khan** (Enroll. No. 1600101395) has carried out the research work presented in the thesis titled **"Performance Improvement of Laser CNC Machine Using Different Grades of Aluminium Sheet"** submitted for partial fulfilment for the award of the **Degree of Master of Technology** in **Production and Industrial Engineering** from **Integral University, Lucknow** under my supervision**.**

It is also certified that:

(i) This thesis embodies the original work of the candidate and has not been earlier submitted elsewhere for the award of any degree/diploma/certificate.

(ii) The candidate has worked under my supervision for the prescribed period.

(iii) The thesis fulfills the requirements of the norms and standards prescribed by the University Grants Commission and Integral University, Lucknow, India.

(iv) No published work (figure, data, table etc.) has been reproduced in the thesis without express permission of the copyright owner(s).

Therefore, I deem this work fit and recommend for submission for the award of the aforesaid degree.

Signature of Supervisor

Name: **Dr. Mohd Anas**

Designation: Associate Professor

Address: Department of Mechanical Engineering, Integral University, Lucknow

Date :

Place: Lucknow

DECLARATION

I hereby declare that the thesis titled "Performance Improvement of Laser CNC Machine Using Different Grades of Aluminium Sheet" is an authentic record of the research work carried out by me under the supervision of Dr. Mohd Anas (Associate Professor), Department of Mechanical Engineering, Integral University, Lucknow. No part of this thesis has been presented elsewhere for any other degree or diploma earlier.

I declare that I have faithfully acknowledged and referred to the works of other researchers wherever their published works have been cited in the thesis. I further certify that I have not willfully taken other's work, para, text, data, results, tables, figures etc. reported in the journals, books, magazines, reports, dissertations, theses, etc., or available at web-sites without their permission, and have not included those in this M.Tech. thesis citing as my own work.

Date:

Signature of Student

Arman Khan

Enroll Number: 1600101395

ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude and respect to my supervisor **Dr. Mohd Anas** for his invaluable guidance, motivation, constant inspiration and above all for his ever cooperating attitude that enable me in bring up thesis in the present form. I consider myself extremely lucky to be able to work under the guidance of such a dynamic personality.

I am also thankful to **Dr. P.K. Bharti,** Head of Department of Mechanical Engineering for his support and motivation.

My very special thanks go to all my family members. Their love, affection and patience made this work possible and the blessings and encouragement of my beloved parents greatly helped me in carrying out this research work.

Arman Khan

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

ABSTRACT

In this research work, we have studied to increase or improve the performance of the CNC laser machine using the different grades 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.

CHAPTER-01
INTRODUCTION

As more of these materials become accessible, there is an increasing need for efficient machining techniques for ceramic materials with unique features. Mechanical machining is one of the most coveted and reliable methods for attaining dimensional precision and surface polish [1]. Laser machining is a method for treating hard, brittle materials like ceramics that is an alternative to melting, evaporating, ablation, and other procedures. For the best surface finishes, an extra mechanical post-treatment is always required. This barrier makes it difficult to machine pottery using laser cutting and machining processes. The options for laser cutting have been broadened by the advent of high-quality, high-power fiber lasers with direct engine stages, as well as modern short- and ultra-short-beat lasers with accuracy stages or the salvo reflect scanner [1].

1.1. CNC MACHINE

CNC machining is a cycle where assembling machines and instruments are moved as per pre-modified PC programming. Accordingly, makers can create parts quicker than expected, lessening waste and disposing of human blunder [2]. This creation strategy is utilized to work an assortment of perplexing machines, will be canvassed later in this article. Fundamentally, CNC machining makes it conceivable to perform three-layered cuts by adhering to a solitary arrangement of guidelines [2].
This is the figure of the CNC machine:

Figure-1.1: CNC Machine.

1.2. TYPE OF THE CNC MACHINE

The CNC machine is classified into eight types, which are given below:

I. CNC Milling-Machine.
II. CNC-Router.
III. CNC-Plasma Cutting Machine.
IV. CNC-Lathe Machines.
V. CNC-Laser Cutting Machine.
VI. CNC-Water jet Cutting Machine.
VII. CNC-Electrical Discharge Machine.
VIII. CNC-Grinder

1.2.1. CNC Milling Machine

One of the most popular types of CNC machines is the processing model, which has built-in tools mostly for cutting and drilling. Numerous tasks, including cutting, drilling, turning, and shoulder processing, may be carried out with CNC processing. After the part is put up in the factory, the PC will take charge. CNC mills are used to manufacture hard metals, whereas CNC routers are used to work with soft materials like wood, plastic, and soft metals [3].

Figure-1.2: CNC Milling Machine.

1.2.2. CNC Router

One of the most popular types of CNC machines is the processing model, which has built-in tools mostly for cutting and drilling. Numerous tasks, including cutting, drilling, turning, and shoulder processing, may be carried out using CNC machines. Inventible, Avid CNC, BobsCNC, Onefinity, and Carbide 3D are a few of the most well-known CNC router manufacturers on the market right now. The majority of CNC routers can work in all three dimensions on a work piece, which makes them perfect for little jobs and prototypes of simple and complex designs [3]. The following is a diagram of the CNC router:

Figure-1.3: CNC Router

1.2.3. CNC Plasma Cutting Machine

In that both perform a similar material cutting task, CNC plasma cutters and CNC processing machines are comparable. The material or work item being cut must be conductive in order for a CNC plasma shaper to function properly. Metal, copper, aluminum, steel, and tempered steel are the materials that plasma cutting is most commonly used for. In a CNC plasma cutting machine, the torch is produced by feeding high-velocity gas via a nozzle. The material being sliced melts at this temperature because of the amount of heat produced [4]. STV CNC and Torch Mate are two examples of well-known CNC brands for plasma cutting.

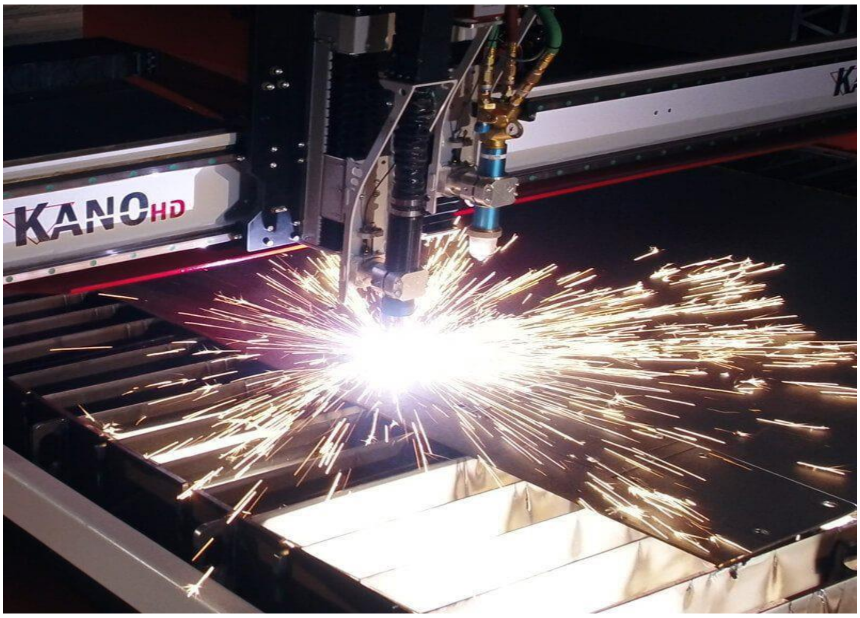

Figure-1.4: CNC Plasma Cutting Machine.

1.2.4. CNC Lathe Machines

When a blade or knife is applied to the work piece’s surface while it is rotating at a high speed, CNC mills and CNC lathes produce the required result. The two tomahawks of a CNC machine are normally two smaller, more mobile tomahawks [4]. A PC limits the machine's focal machine, which pivots and puts the unpolished components into the proper place. CNC machines are mostly utilized to create the outside and interior components of leaves, such as bores, strings, and bores [4]. The machine requires and has fewer tomahawks for device creation since it is capable of twisting natural materials, resulting in a more modest structure factor. Both the G-code and the restricted programming language are supported by CNC machines, which operate in essentially the same way as CNC processing machines [4]. Coming up next is a drawing of a CNC machine:

Figure-1.5: CNC Lathe Machines.

1.2.5. CNC Water jet Cutting Machine

As implied by the name, a high-tension water stream is used by a CNC water jet cutting machine to cut through the material. Water can be used to cut this, but additional abrasives, such as garnet (a mineral) or aluminum oxide, are commonly added for more effective cutting. A plasma shaper with comparable specifications is more expensive than a CNC water jet machine [5]. However, based on comparisons, the price is less than that of a CNC laser cutting machine.

Figure-1.6: CNC Water jet Cutting Machine.

1.2.6. CNC Electrical Discharge Machine

High-temperature electric sparks are used by CNC EDM machines to manipulate and shape materials into desired forms. The discharger is unique in that it can make precise apertures, pinholes, points, or tighten points that are typically challenging to produce using traditional CNC techniques [6]. EDM is a form of contactless machining since it uses flashes to cut materials rather than parts or finished products. This forestalls part deformity, an unmistakable benefit while working with little, slim parts. Image of the EDM beneath:

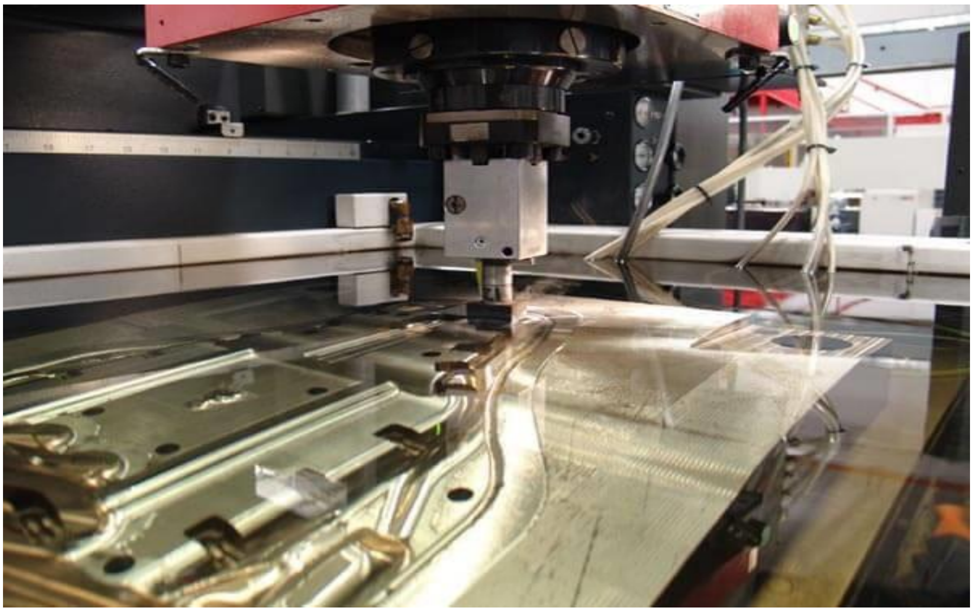

Figure-1.7: CNC Electrical Discharge Machine.

1.2.7. CNC Grinder

A CNC grinder is a piece of equipment that uses rough tools to finish and smooth the manufactured object. Processors are typically used in tasks that need extreme accuracy, including milling motor components [6]. There are several different types of CNC processors, including surface processors, roller processors, round processors, and hollow processors [6]. A variety of additional abrasives, including plated or vitrified CBN, precious stone wheels, aluminum oxide, and burned mix wheels, are also used for crushing. CNC processor number is given underneath:

Figure-1.8: CNC Grinder.

1.3. CNC LASER MACHINE

Unnecessary strength diode lasers have characteristics including their frequency, laser power, power execution, pillar arrangement, bar difference, and imbalance that make them stand apart from other types of lasers. As of right present, welding and solidifying are both done with CO2 and Nd:YAG lasers [7]. Since the primary diode programming for texture processing evolved into a 15W logical diode laser, it has been substantial. There are 3 kind of the CNC laser machine:

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

1.3.1. CO_2 Laser.

Since 1960, when the first laser was operated, extensive research and development have been undertaken leading to a rapid growth in laser types, output power and scope of applications [8]. The CO_2 laser in particular has been finding wide use in almost every aspect of laser materials processing such as cutting, welding, cladding and heat treatment. It is currently the most powerful material processing laser with commercial laser being offered up to 25 kW [8]. The pulsed Nd: YAG laser having a short wavelength (1.06 µm) and high pulse rate is being widely used in laser drilling, marking and cutting of thin materials. The excimer laser is attracting interest from researchers and manufacturers due to its very short wavelength (around 0.308 µm) which is more readily absorbed than longer wavelength and the energy of its photons which make non-thermal processing possible [8]. In fact, the exciter laser is finding many new application areas in material perforation, wire stripping and marking [8]. The CO_2 laser technology provides an alternative wavelength (5 μm) [9] to the CO_2 laser. It shows promise of improved absorption and efficiency. It is being further investigated. Japan claims to be the pioneer in this field [9]. With all these varieties the laser is becoming more and more important in industry as a powerful and efficient tool. Being one of the most mature applications, laser cutting has been widely accepted by industry, for instance, in metal sheet cutting. The advantages found for laser cutting are:

1. Narrow kerf giving a saving in materials.
2. Narrow heat affected zone giving low thermal distortion.
3. Smooth cut edge.
4. Absence of tool wear.
5. A wide range of materials can be cut with equal ease.
6. Easy automation and manipulation.

For applications requiring accurate cutting and high volume industrial manufacturing, it is desirable to establish a completely automated process. On-line control of the process is necessary to guarantee the high quality and high productivity of the cutting process. In-process monitoring of the laser process has been the main research area. Establishing a fully automated process is preferable for applications needing precise cutting and big volume production [10]. This type of laser is frequently used for tasks including dulling, etching, and decreasing. The laser power, beam mode, and cutting speed all have an impact on the cut quality, one of the most important features of laser cutting. The CO_2 lasers are used in weighty ventures for diminishing fabric like slight steel, aluminum, plastic, pure steel, titanium, wooden and textures. A mix of carbon dioxide, helium and nitrogen is flown out at extreme speed through a blower [10]. The laser generator and mindfulness focal point require cooling. For the most part coolant or air is utilized for cooling. Water is for the most part utilized for coolant and is circled through a chiller or warmness switch framework.

Figure-1.9: CO_2 Laser.

1.3.2. LASER MICROJET.

This kind of laser is a water-stream pushed laser wherein a beat laser pillar is blown at floor of thing along the edge of low strain water stream. Fundamentally its miles utilized in which designated decreasing is required [11]. The advantage of this sort over the inverse is that no chipping and negative miniature breaks are grown, no warmness impacted area as its miles water cooled. Running expense of this laser could be extremely low [11].

Figure-1.10: Microjet Laser.

1.3.3. Fiber lasers

Fiber laser is a kind of solid laser which quickly creating within side the metallic decreasing industry. It utilizes major areas of strength for a medium rather than a fuelling or fluid. The laser pillar created is intensified inside a tumbler fiber [12]. The frequency is of 1.06 micrometer which delivers a phenomenally little spot length making it best for decreasing intelligent metallic materials [12].

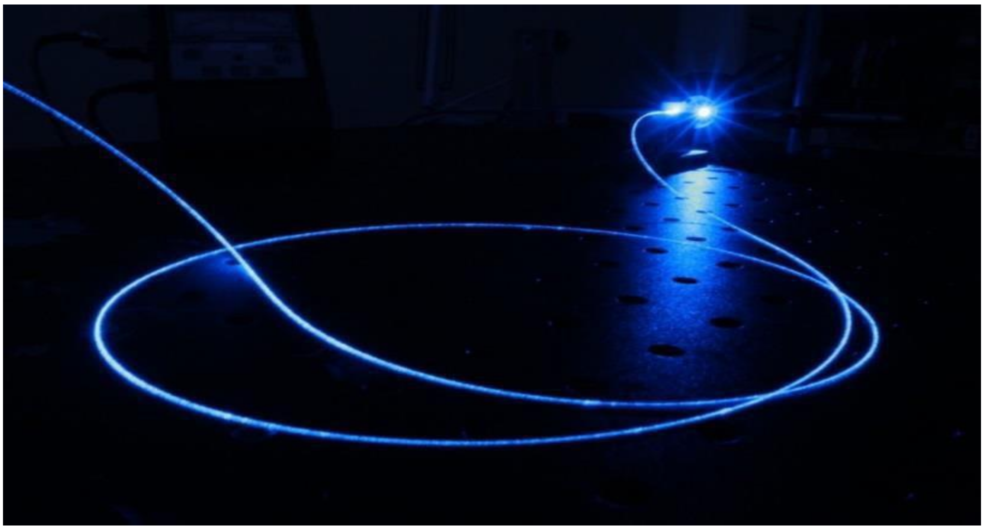

Figure-1.11: Fiber laser.

1.4. 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. The really combustible oxidized fuelling from the fuelling chamber comes with inside the spout in which it gets lighted with the enhanced gentle and creates the intense fire which grants at the material and as a result of that the lessening movement at the fabric happens [13]. By advancing a selected laser shaft towards the surface of the work item, the reducing process creates a thin reduce kerfs. This tactic works best when the mellow area completely covers the piece of art. Although reducing has been used to 100 mm steel segments, the process is most frequently used on metal sheets that are 6 mm thick or smaller [13].

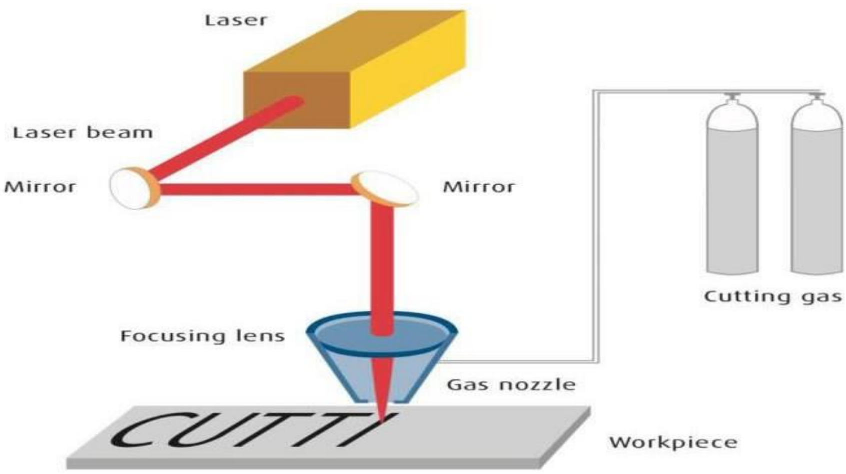

Figure-1.12: Schematic Diagram.

1.5. ADVANTAGES & DISADVANTAGE OF LASER CUTTING.

1.5.1. Advantages of CNC Laser Cutting.

A. Edges are simple and not utilizing a consume and soil development.
B. Serious level of accuracy and exactness of decrease line.
C. No material twisting in view of contactless handling.
D. Low warm impact.
E. Cutting of material of different thickness and blends in a solitary go.
F. No tooling expense

1.5.2. Disadvantages of Laser Cutting.

A. Power use and usefulness depends upon on upon the methodology for the laser for lessening and the type of area that ought to be done, is utilized. Customarily joins the laser lessen inordinate utilization of centrality stood apart from various advances utilized for lessening [14].
B. Creation charge isn't generally dependable while laser lessening is utilized. It will depend through and gigantic at the thickness of the work piece, the kind of material utilized and the methodology for laser diminishing [14].
C. Setting paying irrelevant appreciates to the division laser and the temperature can instigate the start of novel materials. A few metals will be inclined toward stain while the strain of the laser section is absurd.

D. Laser lessening of plastic, might be luxurious because of plastic sends fueloline while demonstrated to warmth. Accordingly, the total relationship of an all that significantly ventilated room, which might be incredibly pointless. Additionally, the gasses released in the midst of the methodology of being hazardous and might be perilous [15].

E. Recklessness in changing laser division and temperature can likewise furthermore start imitating of a several materials. Certain metals by and large will generally stain on the off chance that the strength of the laser shaft isn't dependably as steady with need.

1.6. THESIS ORGANISATION

This thesis is written in the five sections, which are given below in details:

Chapter-01: Introduction Part of CNC and Type of CNS Machine.

Chapter-02: Literature Survey and Problem statement.

Chapter-03: Methodology, material parameter

Chapter-04: Result and analysis.

Chapter-05: Conclusion

CHAPTER-02

LITERATURE REVIEW

In the section outline of the archive, concentrated on the functioning system of CNC laser machines, plan and activity of CNC machines.

Gerck, Lima et.al. (1997): From a naturally visible perspective, the fundamental determination is that for a 1.5 mm thick gentle steel plate, the presence of a 20 mm thick layer of zinc or aluminum can change the quality. Last amount, normal for a CO_2 laser cut part, in the event that it is worked in CW mode and with a similar laser cutting boundaries, with a 1087 effect more prominent than a 0.5 mm expansion in base metal thickness of sheet without surface covering [16]. The aftereffects of laser cutting on work pieces have horrible mathematical attributes contrasted and CW laser activity (like sharp internal and external corners, openings and spaces. all around) can be enormously improved with the utilization of the laser's mathematical hyper-throb, though with a penance of cutting rate [16].

Zelený et.al. (2014): Currently, testing is being done on the gadget. Energy chains with integrated links are installed in the structure [17]. The laser connection with the control framework is now being tested. One additional type of capacitive sensor shaper is something we want to prepare for the. This makes it possible to cut created surfaces without removing the substance. It will be related to training and testing [18].

Gadallah, Abdu et.al. (2015): Kerfs tighten and mean surface harshness are at the same time upgraded during beat Nd:YAG laser cutting of tempered steel (316L). Closes as follows: Taguchi advancement results show that the best draining quality is 150W low-level power, 0.5MPa gas pressure, -125 Hz significant level heartbeat recurrence and 0 cm cutting velocity. /minute. At a similar surface unpleasantness the normal is 150 W low end powers, 0.5 MPa gas pressure, 25 Hz low end beat recurrence and 20 cm/min cutting velocity. Power and Support gas pressures essentially influence the nature of the kerfs over the working scope of cycle boundaries. Ta is essentially impacted by the power, oxygen voltage appropriation, beat recurrence, cut-off rate, and the cooperation impact of the tension division and oxygen recurrence. Then again, Ra is essentially impacted by power, oxygen pressure, beat recurrence, cutting velocity, the cooperation impact of oxygen tension and cutting pace [19]. Approval of the RSM models demonstrated that the mean percent deviations in kerfs tighten and surface unpleasantness in view of S/N proportion values were 21.1 % also, 2.86%, individually. From the plot of the reaction surface, it is seen that the beat recurrence also, the cut-off rate have less effect on Ta than different boundaries. Be that as it may, lower upsides of Ra can be gotten at lower levels of cycle boundaries aside from cutting velocity in the current review [20].

Ranjan et.al. (2015): For low-end utilizations of CNC innovation doesn't need too high accuracy, minimal expense computerization can be given by utilizing this program. These developments are intended to be less difficult and have great exactness. Numerous other comparable items, (for example, drills, processors, punchers, and so forth) can be created at a much lower improvement cost, making them reachable for little and medium enterprises [21].

Jamaleswara et.al. (2018): According to the modern practicality, the expense of laser cutting and etching machine has been enhanced with a force of 500 mW, frequency of 05 nm. In view of a record survey and work process steps, the laser cutting and etching machine has been improved [22]. Basically you need to know how to fabricate a displayed laser etching and cutting machine in the lab. The outcome is the best cutting and etching quality [23].

Habsi, Rameshkumar et.al. (2016): Due to the developing interest for 3axix scaled down CNC machines with high accuracy parts in different ventures, the retail cost of 3 pivot little CNC machines has expanded essentially [24]. For the assembling area, little parts should be presented in an adaptable and effective way in an assembling approach and decrease all out costs that are reasonable for people and private ventures. Because of effective body part determination and exact adjustment, testing and get together, CNC machines have accomplished the ideal accuracy and precision [24]. In this work, a small 3 hub CNC machine is planned and produced for modest 150 Omani Rials. During the underlying model stage, numerous famous CNC structures were found and tried. The most reasonable construction is the support type structure chose and planned by French in England [25]. Basic parts, for example, liners, stepper engines, microcontrollers and modules are unequivocally chosen from countless various choices to meet prerequisites. The best expense parts are chosen to give exactness and straightforwardness as well as financial plan requirements. The gathering of a mechanical part and its appearance in an electronic part is impeccably anticipated. The CNC machine model is collected in-house utilizing and in the research facility to satisfy pre-gathered testing of machine parts. The means to construct a wooden design were continued exhaustively from a CNC structure organization that was followed to meet accuracy while joining it into electronic and mechanical parts together [26]. The setup and alignment steps are plainly demonstrated with every one of the subtleties. The whole capacity of the machine is tried utilizing different tests from programming testing to mechanical tests; the underlying imperfections have been explained and distinguished to guarantee the dependability of the machine [27].

Ji et al. (2017): A possible method for creating complex patterns in clay materials is the "break free" laser cutting procedure. Black and Chua have focused on CO2 laser cutting for thick ceramic tiles with thicknesses ranging from 8.5 mm to 9.2 mm. To determine the cutting boundaries necessary for various tile computations, they used a combination of different slicing velocities to slice the tiles [28]. Break damage, which is brought on by the high temperature slope in the substrate surface, has been shown to be the primary consequence of using a CO2 laser to cut fired tiles. Black et al [28].'s focus was on different laser cutting limits that can cut earthenware tiles but barely need any post-handling. The effects of multi-line cutting and submerged slicing on managing heat load were tested. The reduction in cycle-activated break development is thought to be important for the commercial use of lasers in ceramic tile cutting. Wee et al. [28] first discussed the effect of interaction boundaries on the quality obtained by laser cutting alumina [29]. On quality result elements like periphery point, frequency, and distinct periphery distance, the effects of cooperation duration, radiation, and aid gas tension were investigated. It was discovered that the connection time had the greatest influence on the propensity of the peripheral, with radiation playing a much less role. By proving the kerfs calculation, Grabowski et al. [30] investigated the laser cutting of the AlSialloy/SiCp composite. The bleeding edge's slant is discovered to expand as the laser shaft accelerates. It has been confirmed that the CO2 laser cutting record's component is similar to that of metal. It was explained that using oxygen as an assist gas resulted in a little acceleration. At last, it was found that tiles up to 13 mm thick can be cut with an OK cutting pace at 1200 W laser power. Jiao and Wang [31] proposed a double laser pillar technique for slicing glass substrates to work on the cut quality. By proving the kerf calculation, Grabowski et al. [31] investigated the laser cutting of the AlSialloy/SiCp composite. The bleeding edge's slant is discovered to expand as the laser shaft accelerates. Hong and Li [32] focused on the SiN pottery laser cutting technique. Their goal was to get high throughput break free cuts on this designing clay. According to research, the beat length should be kept short to reduce unfavourable thermal effects during laser cutting [33].

Pushkal Badoniya et.al. (2018): Broad exploration work is being done in laser cutting for working on the nature of cut. The survey shows that nature of cut relies on many control variables or boundaries, for example, laser shaft boundaries (laser power, beat width, beat recurrence, methods of activity, beat energy, frequency, and central position); material boundaries (type, optical and warm properties, and thickness); help gas boundaries (type and strain) and handling boundaries (cutting rate) [34]. Numerous specialists have explored the impact of these cycle boundaries on various quality attributes, for example, material expulsion rate (MRR), kerfs quality attributes (kerf width, kerf deviation and kerf tighten), surface quality (cut edge surface unpleasantness, surface morphology), metallurgical quality attributes (recast layer, heat impacted zone, oxide layer and dross considerations) and mechanical properties (hardness, strength) [35].

N. Yusoff et al. (2019) concentrated on the CO_2 laser cutting strategy on light hardwood of Malaysia. They endeavored to lay out the connection between handling boundaries and wood species with various properties, deciding ideal cutting circumstances. Likewise, they present guidelines for cutting an assortment of Malaysian woods [36]. Dampness has been accounted for to lessen cutting proficiency since water promptly assimilates CO_2 laser radiation. It has likewise been demonstrated the way that utilizing an idle gas, for example, nitrogen can be gainful and produce a greater finished result. In any case, they guide out that this supposition actually needs toward be demonstrated that the related costs actually not entirely set in stone before the methodology can be legitimate [37].

Hattri et al. (2019) attempted to think about various lasers in carpentry. He inferred that the CO_2 laser was the most reasonable laser because of the way that the CO_2 laser was more straightforward to create a higher energy thickness than the YAG laser while collaborating with wood. Barnekov et al. [38] inferred that the elements influencing the laser's capacity to cut wood can be extensively arranged into three classes: laser pillar attributes, gadget and cycle factors, and work piece properties. They have revealed that most lasers for cutting wood have abilities gone from 200 to 800 W. They have expressed that for most extreme proficiency, the appropriate blend of cutting velocity and laser power will rely upon the work piece thickness, thickness and the ideal kerfs width [39]. Additionally, they have observed that more power is expected to cut wet wood than is expected for dry wood assuming the cutting velocity is held steady. One more review was done by Barnekov et al. On the laser cutting of wood composites. They have found that the ideal center position is at the surface, utilizing laser power from 00 to 500 W and a cutting velocity of 20 in/min. Besides, they utilized packed air with a spout width of 0.05 in. At last, they detailed that these primer outcomes propose that further examination on the laser slicing of wood should be done. Both Khan et al. and Mukherjee et al. directed examinations on laser cutting of development wood [40]. Both examined the significance of concentrating on LBC boundaries, for example, laser power, cutting rate, spout plan and variety in safeguard gas speed and their impact on the nature of the safeguard [41].

Lum et al. (2019) revealed ideal cutting circumstances for CO2 laser cutting of MDF. They found that the normal kerfs width diminished as the cutting pace expanded. It has been shown that the arrangement of MDF, including added substances like covers, folios, tar, and so forth, is additionally fit for causing variety in the cutting rate. Furthermore, they announced that no critical decrease in the cutting width was seen while changing the sort or tension of the safeguarding gas [42]. Furthermore, they likewise referenced that raising the gas pressure didn't further develop the Ra esteem. Be that as it may, the esteems increments as the cutting velocity increments [42]. At last, they show that the most extreme shear rate for every thickness is free of any expansion in tension or gas. Thusly it would be more efficient to utilize packed air as opposed to nitrogen to laser cut MDF. Ng et al. [43] have proceeded with their examination to assess the variety in the power dispersion with various cutting paces, material thicknesses and heartbeat proportions. They prevailed with regards to fostering a test system to decide essential power misfortunes while performing CW or beat mode laser cutting of MDF.

Letellier et al. (2020) have revealed that while cutting MDF sheets with thicknesses more noteworthy than 8 mm and keeping the central position fixed at the surface, the outcome is that the kerfs have bended sides. This sidelong shape increments as the MDF board becomes thicker [44]. Likewise, they fluctuated the central position and speed of the shaft to concentrate on their impact on the state of the horizontal stream. They suggest a central situation for each board thickness and interaction boundary blends. Moreover, they had the option to decide ideal cutting circumstances by consolidating a histogram of the central situation with the thickness of the board for least edge kerfs with a chart of the cutting velocity versus the thickness of the board, at a decent laser power [45].

Jayaprasad et.al. (2020): By utilizing the CNC regulator, item quality as well as high adaptability have expanded fundamentally. It increments efficiency and diminishes execution time [46]. This equipment coordinated effort with G-code and Mcode brings about improved efficiency and decreased responsibility. G-code and M-code make it simple to find the position data of all moving stepper engines, as the condition of our moving engine is shown straightforwardly on the PC. Building a little machine extends to adaptability with regards to doing the employment opportunity and furthermore lessens prototyping costs, making it usable for cutting paper, polystyrene and flimsy sheets [47]. In this piece, planned and produced for minimal price. Taking everything into account, the accuracy plan and production of the CNC-based laser checking machine body get together effectively met the exactness and repeatability objectives of this task.

Mehendiratta et.al. (2020): In this exploration paper, we utilize the idea of a minimal expense CNC laser etching machine that is handily controlled through a PC [48]. Our undertaking is a minimal expense project contrasted with other significant expense machines. The machine has a genuinely basic construction and can be conveyed anyplace absent a lot of exertion. Numerous different specialists have utilized various sorts of streamlining methods like GLA strategies, anova examination, and so on. Our machines are reasonable, simple to work and don't need gifted faculty.

Oktatian et.al. (2021): In this review, we directed a review to decide the ideal setting of cycle boundaries during acrylic cutting with a CO_2 CNC laser shaper. The trial was performed utilizing the Taguchi multi-reaction strategy including four responses, to be specific, treatment time, layered exactness, and surface harshness and fossil fuel byproducts [49]. Taguchi's strategy was utilized to decide the SNR for every reaction. The GRA strategy was utilized to decide the ideal setting of the interaction boundaries for every component of the trial at the same time. The reaction surface technique (RSM) was applied to decide the numerical model in view of the consequences of the trial to empower multi-objective improvement and to decide the specific worth of the ideal cycle boundaries. Simultaneously compromise the input. In light of the consequences of the trial, the ideal cycle boundaries are 65% laser power, mm/s cutting pace and mm spout separating. While as indicated by the consequences of the RSM technique, the ideal cycle boundaries are 75% laser power, 5.9 mm/s cutting pace and 3 mm spout dispersing [50].

2.1. PROBLEM STATEMENT

After studied above literature review, we found some gap between these studies studied. In this literature review, all the research kept constant gas pressure in the CO_2 laser CNC machine and also kept constant laser power supply for cutting Aluminium, steel, or any metal sheet. But in this research work, we used three grade of the Aluminium such as Al 5086, Al 6070, and Al 7075. And this aluminium sheet will be cut by using the CO_2 laser CNC machine by changing the Laser power supply and Gas pressure, and check what result come out.

CHAPTER-03

METHODOLOGY

In the methodology section, we will know details about the material parameter such as aluminum sheet details, and method of the analysis, etc.

3.1. GAS FLOW PARAMETERS

In laser gas cutting, the dominant functions of the gas flow are the mass transfer to cause chemical reaction and momentum transfer to eject molten material and dross. Thus it has been shown that the nozzle design and gas flow have considerable effects on the cutting performance [51]. The assistant gas is introduced either off-axis or co-axis to the laser beam through a nozzle. The coaxial method is however most commonly used since it is axi-symmetric and necessary for omni-directional cutting. It also has the advantage of providing protection for the beam focusing optics against damage by ejected debris [52].

3.1.1. Nozzle Diameter

The basic requirements for the nozzle diameter are: first it must be big enough to pass the laser beam and to make beam-nozzle alignment easier; second the exit pressure should be high enough to provide momentum to blow the dross away without using too much gas [53].

3.1.2. Nozzle Standoff Distance

The distance between the nozzle exit and the work piece (often called nozzle standoff distance or nozzle height) is crucial [54]. It should be kept as close to the work piece as possible to keep the pressure high on the work piece, but must be high enough off the work piece to prevent possible mechanical jamming due to the splattered dross or severe back pressure on the lens.

3.1.3. Nozzle Gas Pressure

It has been widely acknowledged that increasing the gas pressure or gas flow rate increases the cutting speed and metal cut quality [55]. However, if the nozzle pressure is very high (but still within the pressure limits which the focusing lens can withstand) then the gas flow becomes choked or even supersonic for convergent nozzles. This results in shock waves [56] between the nozzle tip and the work piece. These shock waves can cause significant reduction in cutting pressure at some specific values of the standoff distance, and thus may impede dross removal. In some cases, where very high gas pressure is required, non-circular nozzles such as lobed nozzle can be used which has been shown to reduce the tendency to form Mach shock discs [57].

3.1.4. Gas Type

The type of gas used in laser cutting affects how much heat is added to the cutting action by chemical reaction. This obviously affects the cutting speed. Usually, oxygen is used for cutting most metals since much heat is generated from the exothermic reaction with oxygen [58]. For example, in the case of cutting steel as much as 60% of the heat input comes from the exothermic reaction [58]. However in some situations, it is necessary to use inert gas to reduce oxides or dross clinging problem.

3.2. MATERIAL PARAMETERS

The ease with which a material can be cut and the quality of the resulting cut depend also on the material properties. In general, there are three main factors regarding the material properties, i.e. the thermal properties, the mechanical properties and the chemical properties [59]. A classification of materials based on these material properties is shown in below figure.

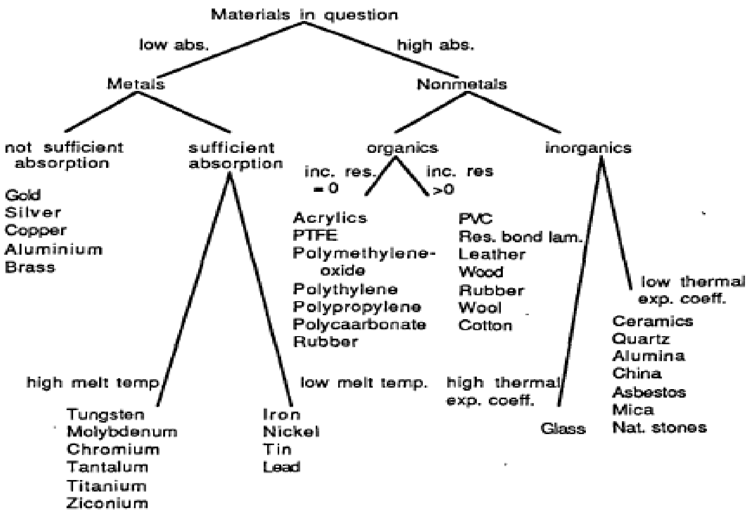

Figure-3.1: Materials in terms of their absorptive and incandescence resistance.

3.2.1. Thermal Properties

The main thermal properties concerned in laser cutting process are the reflectivity and conductivity of the work piece. The reflectivity determines the beam absorption process, while the heat conductivity determines how much of the absorbed energy is lost through heat conduction. Therefore, these two factors affect the overall process efficiency and cut quality. Highly reflective as well as conductive materials such as copper, aluminum and gold (materials in column 1 in Figure 3.1) are thus difficult to cut, since only a small portion of the beam energy is absorbed. However, the surface reflectivity changes its value during the processing due to the formation of plasma and the changing angle of the cut face to the incident beam as discussed before. Therefore, laser cutting of these materials becomes easier once cutting starts.

Laser cutting of materials with high absorptive and low conductivity such as paper, plastics and wood (Figure 3.1) are easily cut even at low powers with very high cutting speeds [60].

3.2.2. Mechanical Property

The main mechanical property concerned in laser cutting is the stress resistance property. Brittle materials such as glass and ceramics tend to crack during cutting and will thus need special treatment such as preheating and post-cut tempering [61]. They are usually cut by scribing followed by mechanical fracture [61].

3.3.3. Chemical Properties

The main chemical properties concerned in laser cutting are the heat of reaction and the melting point of oxides. The former determines the amount of heat input from the oxidation reaction into the cutting process and thus affects the cutting speed. The melting point of the oxides resulting from the burning reaction affects the melt fluidity and thus may cause dross clinging at the bottom cut edges [62]. For example, when laser cutting of stainless steel, chromium oxides having a high melting point are formed some of which deposit at the cut edges forming clinging dross. This dross may be difficult to remove and may thus affect the subsequent welding or finishing process.

3.3. EFFECTS OF CUTTING SPEED ON SURFACE ROUGHNESS

Figure-3.2 shows the effect of the cutting speed on surface roughness. It clearly shows that increasing the cutting speed would greatly improve the surface roughness. This can be explained by the sideways burning theory. At low speeds, the oxidation reaction moves faster than the laser traverse speed. There is then a considerable side burning resulting in very rough edge [63]. With the increase in cutting speed, the laser traverse speed matches the oxidation reaction speed leading to a fine striation pattern. However, if the cutting speed is further increased above the optimum value, the surface becomes rough again. This can be explained by figure-3.3, where the concept of "cut length difference" is introduced. It is actually a representation of the inclined angle of the surface striation pattern. It is seen from this figure that the cut length difference increases sharply with the cutting speed after the optimum cutting speed.

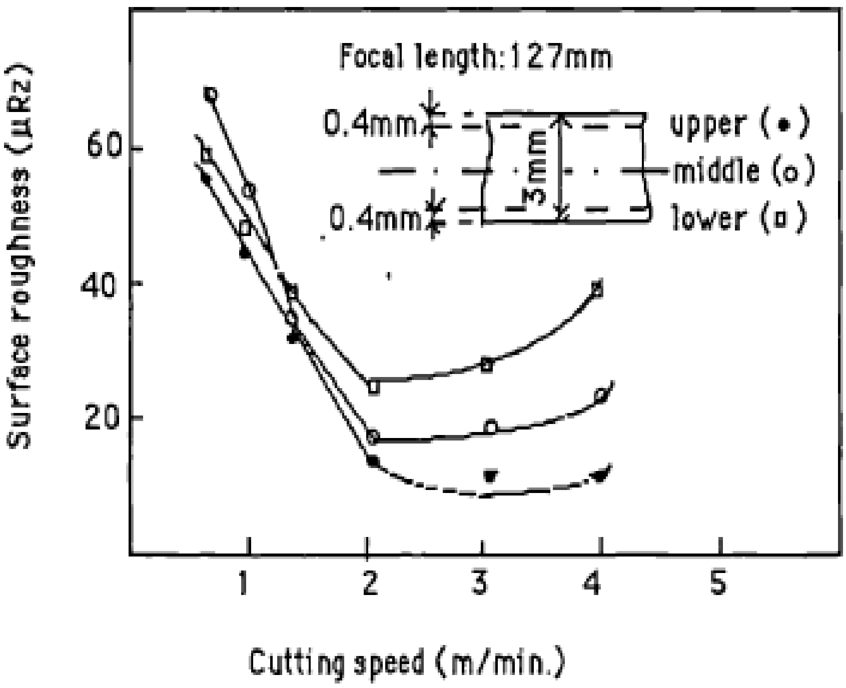

Figure-3.2: Variation of roughness of cut surface with cutting speed. Mild steel, 1 kW laser power, 46.9 kPa oxygen pressure

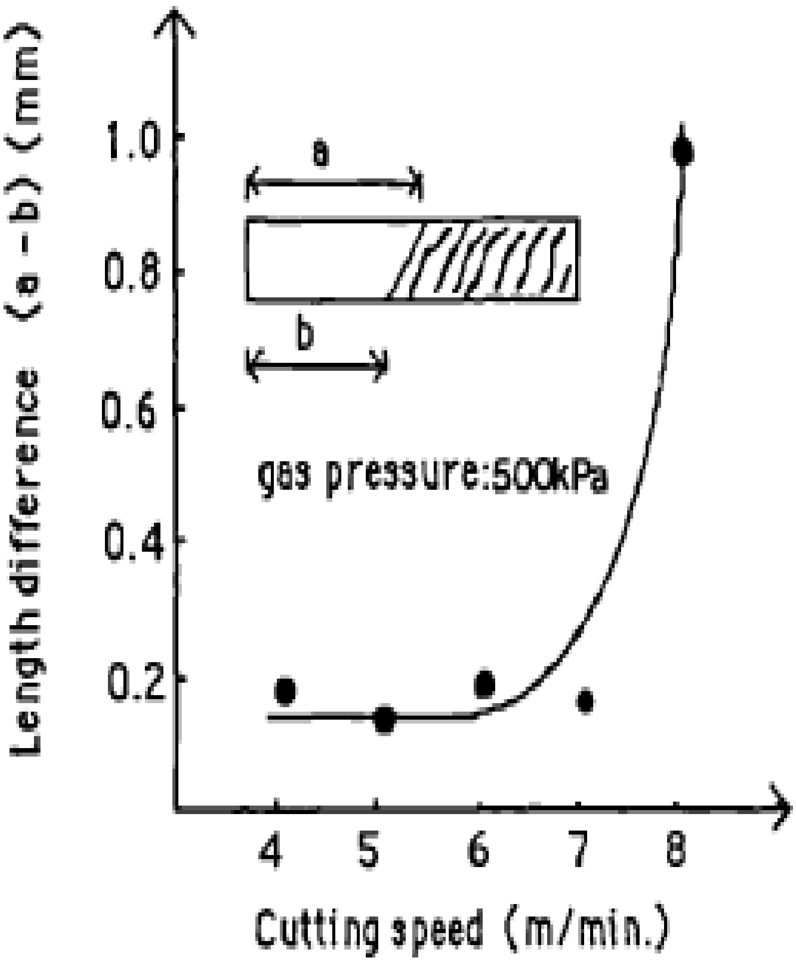

Figure-3.3: Cut front length of 1 mm mild steel sheet. Cut with CW CO2 laser at 350 W and various cut speeds and oxygen pressures

It has been noticed that the upper part of the cut face is generally smoother than the lower part [64]. This phenomenon could be understood in terms of the formation of two separated liquid layers, one near the upper surface of the work piece and one at the lower surface [64]. The reactive gas flow enters the kerf at subsonic speeds, but is heated due to the interaction with the hot liquid layer [65], as it penetrates into the bulk of the work piece. The density of the gas flow is accordingly reduced and thus the speed of the gas flow is raised. After a critical distance from the surface, the flow becomes turbulent or even sonic.

From that point on, a second molten layer exists that shows different properties due to the interaction with the turbulent gas flow [66]. That molten layer has a lower temperature, since the 'peak' of the laser beam has already struck the upper part of the cut leaving only the 'tail' of the beam and reflections previous from the cut face to heat this lower part. The oscillations of the second liquid layer can be excited by the fluctuations of the turbulent gas flow. Since the frequency of the oscillations of the liquid layer depends strongly on the temperature [66], the upper molten layer and the lower molten layer must show different oscillation frequencies and different drag angles.

3.4. HEAT BALANCE ON THE CUT FRONT

The exothermic burning reaction between the oxygen stream and the melt creates another heat source for the cutting process. In order to accomplish the cutting process, this burning reaction energy and the laser beam energy should be high enough to provide energy for melting the material and for compensating the heat loss due to convection, conduction and radiation. A heat balance describing the heat transfer on the cut front can be given as follows:

$$P\,f(1 - r) + \alpha\,P_{chem} = Q_{melt} + Q_{cond} + Q_{conv} + Q_{rad}$$

Where

P = incident laser power (W);

f = fraction of the laser beam striking on the surface as opposed to that passing through the kerf;

r = workpiece reflectivity

P_{chem} = heat generated during chemical burning reactions between oxygen and melts (W);

a = fraction of this power transferred to the process;

Q_{melt} = heat used for melting the material (W)

Q_{cond} = heat loss by conduction during laser beam and material interaction (W).

3.5. PROPERTY OF ALUMINUM SHEET

The property of these three aluminum sheets is given in detail.

3.5.1 Property of Al-5086

The mechanical property and chemical composition of the Al-5086 are given in TABLE-3.1 and TABLE-3.2

TABLE-3.1: 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-3.2: 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

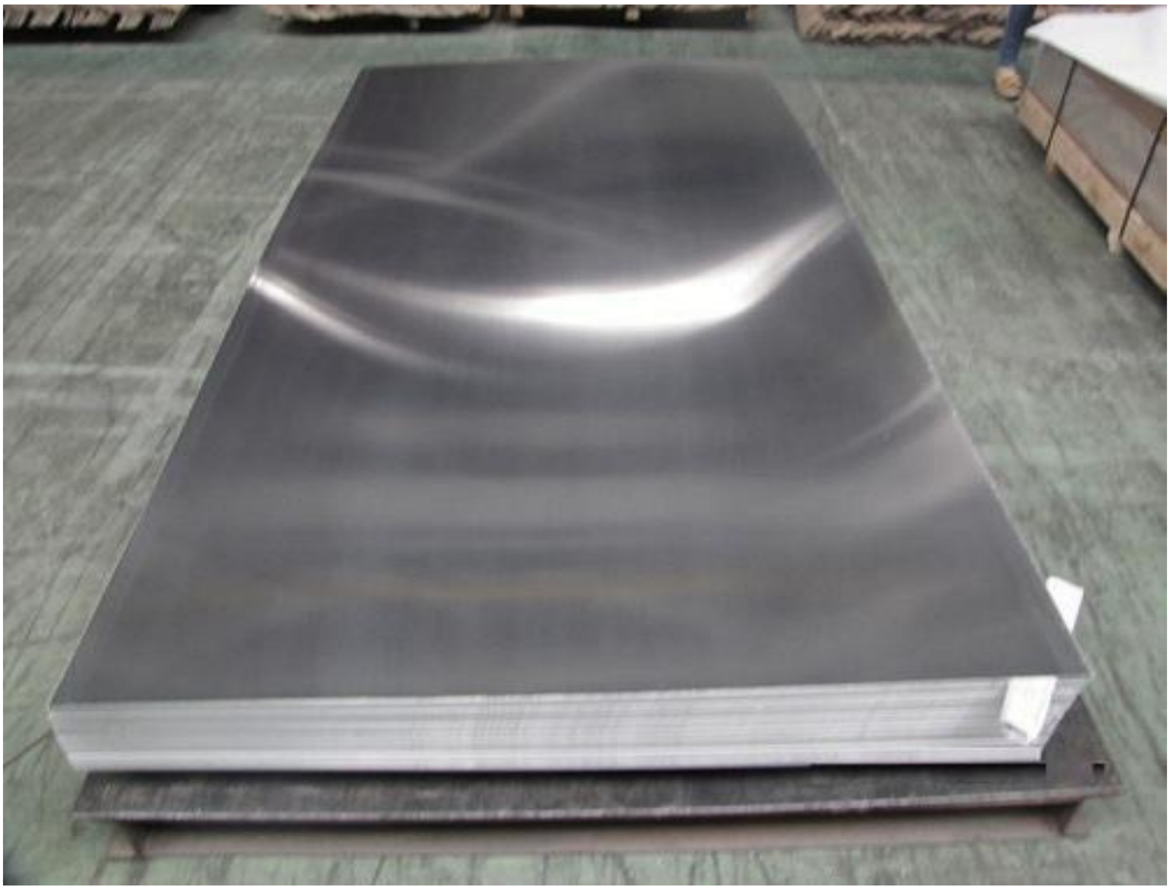

Figure-3.4: Al 5086.

3.5.2. Property of Al-6070

The mechanical property and chemical composition of the Al-6070 are given in TABLE-3.3 and TABLE-3.4.

TABLE-3.3: 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-3.4: 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

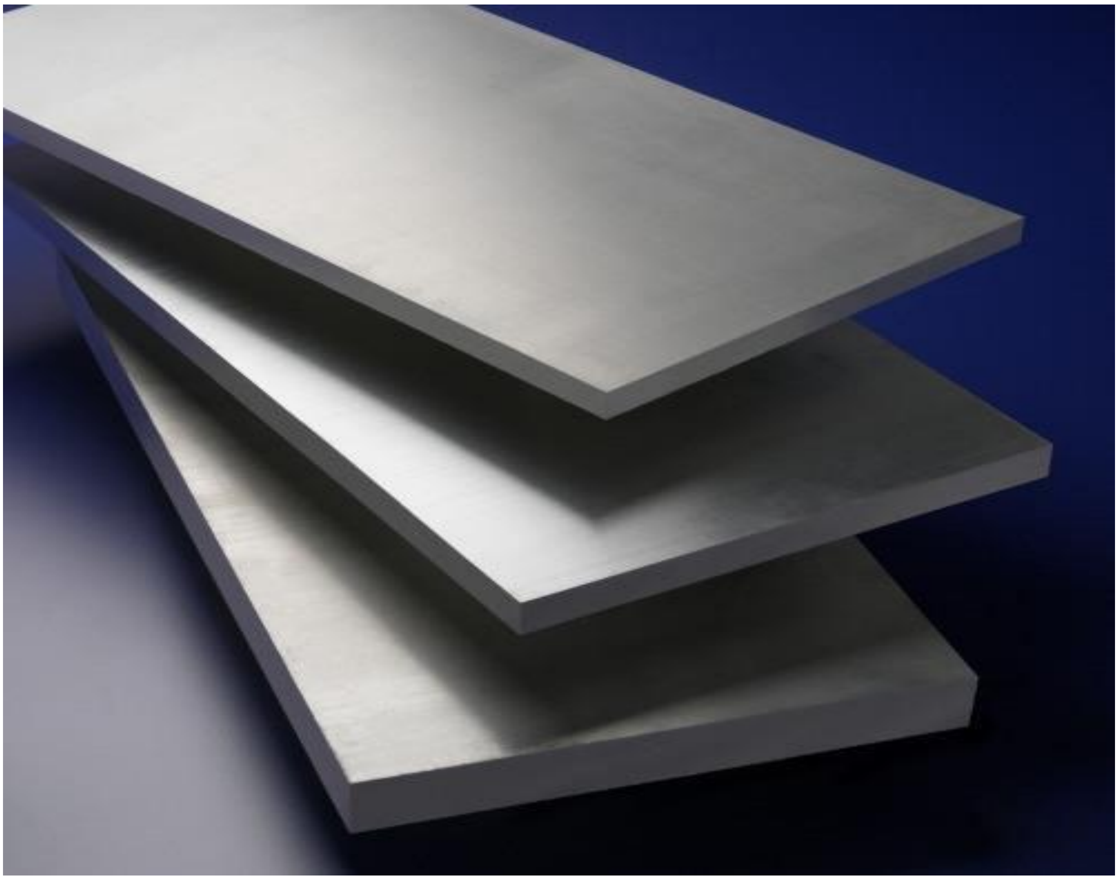

Figure-3.5: Al 6070

3.5.3. Property of Al-7075

The mechanical property and chemical composition of the Al-7075 are given in TABLE-3.5 and TABLE-3.6.

TABLE-3.5: 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-3.6: 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

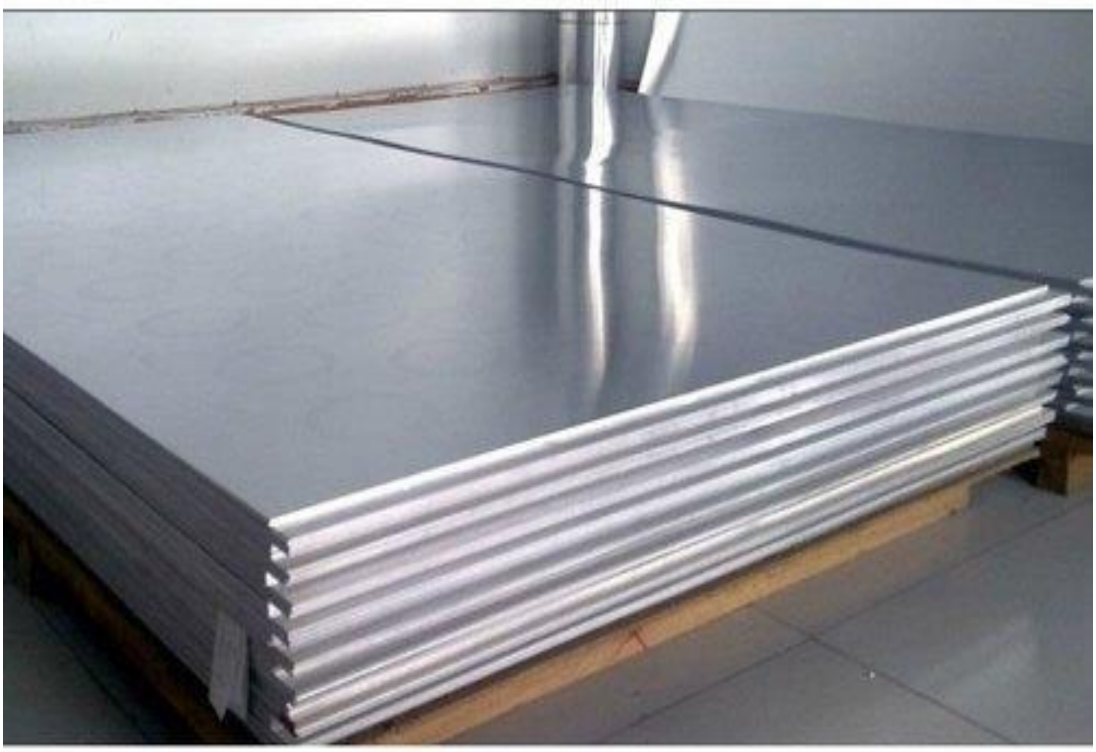

Figure-3.6: Al 7075.

3.6. 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-3.7: 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

CHAPTER-04

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 CO_2 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.

Cutting Speed is defined as the cutting the length of the aluminum sheet into two parts per minute. The table and graph of the aluminum plate at the different power supply are given below:

Table-4.1: Power of laser Vs Cutting Speed

Serial Number	Laser Power (KW)	Cutting Speed of Al 5086 (m/min)	Cutting Speed of Al 6070 (m/min)	Cutting Speed of Al 7075 (m/min)
1	1	0.9	0.721	0.43
2	1.1	1.1	0.845	0.49
3	1.2	1.17	0.95	0.58
4	1.3	1.26	1.14	0.62
5	1.4	1.33	1.23	0.71

6	1.5	1.45	1.29	0.78
7	1.6	1.523	1.38	0.85
8	1.7	1.61	1.43	0.94
9	1.8	1.751	1.51	1.13
10	1.9	1.875	1.624	1.21
11	2	2.12	1.73	1.29

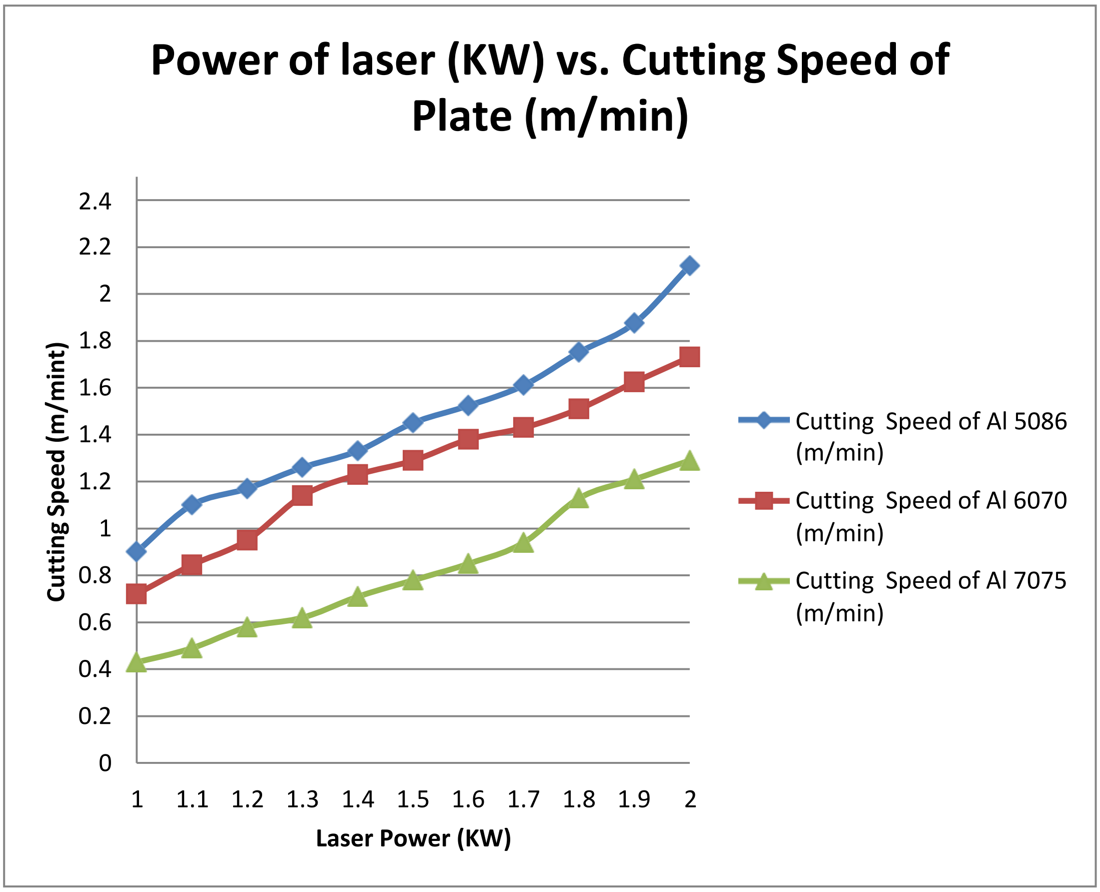

Figure-4.1: Power of laser Vs Cutting Speed

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.

The table and graph of the Diameter of Nozzle vs. Surface Roughness are given below:

Table-4.2: Diameter of Nozzle vs. Surface Roughness

Serial Number	Diameter of Nozzle (mm)	Surface Roughness of Al 5086 (μm)	Surface Roughness of Al 6070 (μm)	Surface Roughness of Al 7075 (μm)
1	0.01	0.121	0.195	0.984
2	0.02	0.134	0.223	1.154
3	0.03	0.139	0.251	1.292
4	0.04	0.143	0.2731	1.384
5	0.05	0.1495	0.2993	1.53
6	0.06	0.153	0.328	1.671
7	0.07	0.1561	0.351	1.756
8	0.08	0.1594	0.3759	1.82
9	0.09	0.1624	0.4135	1.935
10	0.1	0.1697	0.451	1.986
11	0.11	0.1732	0.483	2.548

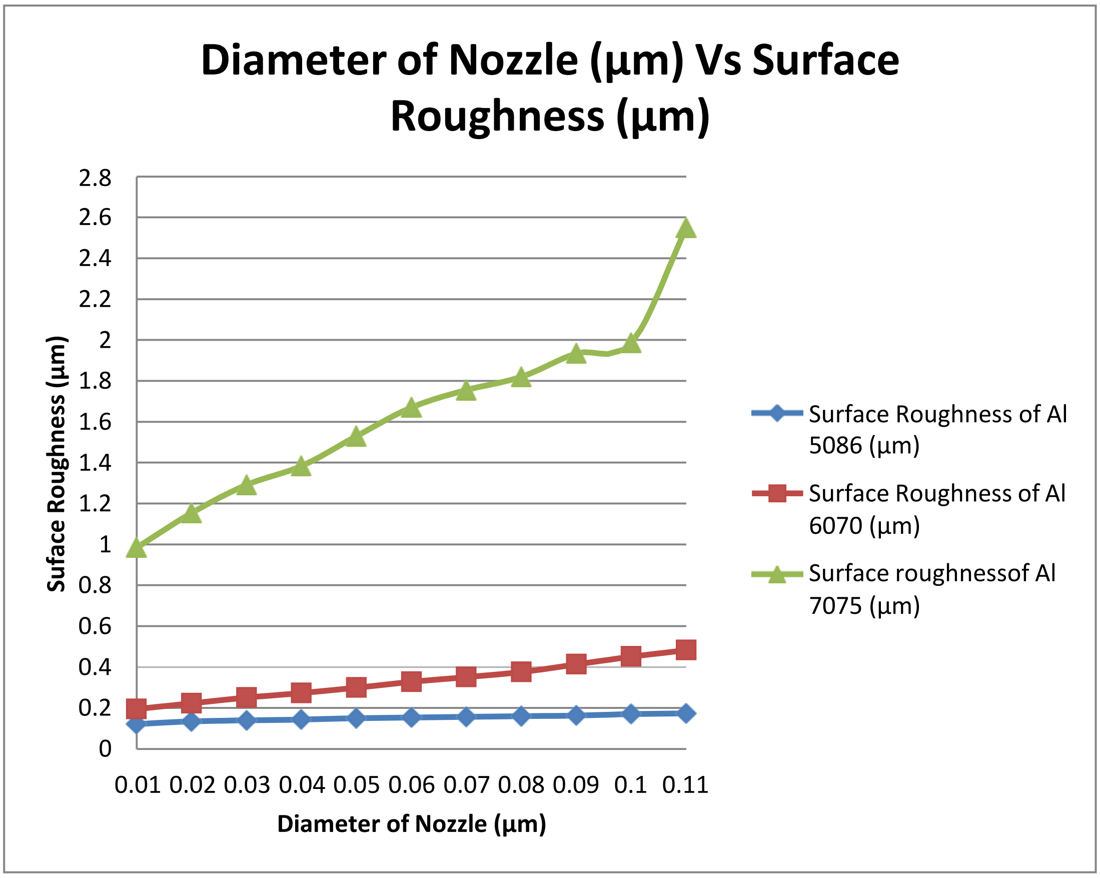

Figure-4.2: Diameter of Nozzle vs. Surface Roughness

From the above graph as well as table of Diameter of Nozzle vs. Surface Roughness, we can see that value of the surface roughness is increasing by increasing the diameter of the nozzle.

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 CO_2 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.

We know that,

1 bar gas pressure = 100000 Pascal [67].

So we can say that, the gas pressure 500000 Pascal is minimum and 1500000 Pascal is maximum which applied at the CO_2 laser CNC machine.

The table as well as graph of the gas pressure vs. cutting speed is given below:

Table-4.3: Gas Pressure vs. Cutting Speed

Serial Number	Gas Pressure (Bar)	Cutting Speed of Al 5086 (m/min)	Cutting Speed of Al 6070 (m/min)	Cutting Speed of Al 7075 (m/min)
1	5	0.32	0.195	0.132
2	6	0.341	0.223	0.159
3	7	0.363	0.251	0.173
4	8	0.392	0.2731	0.195
5	9	0.423	0.2993	0.219
6	10	0.453	0.328	0.235
7	11	0.473	0.351	0.253
8	12	0.495	0.3759	0.281
9	13	0.511	0.4135	0.315
10	14	0.545	0.451	0.334
11	15	0.593	0.483	0.3612

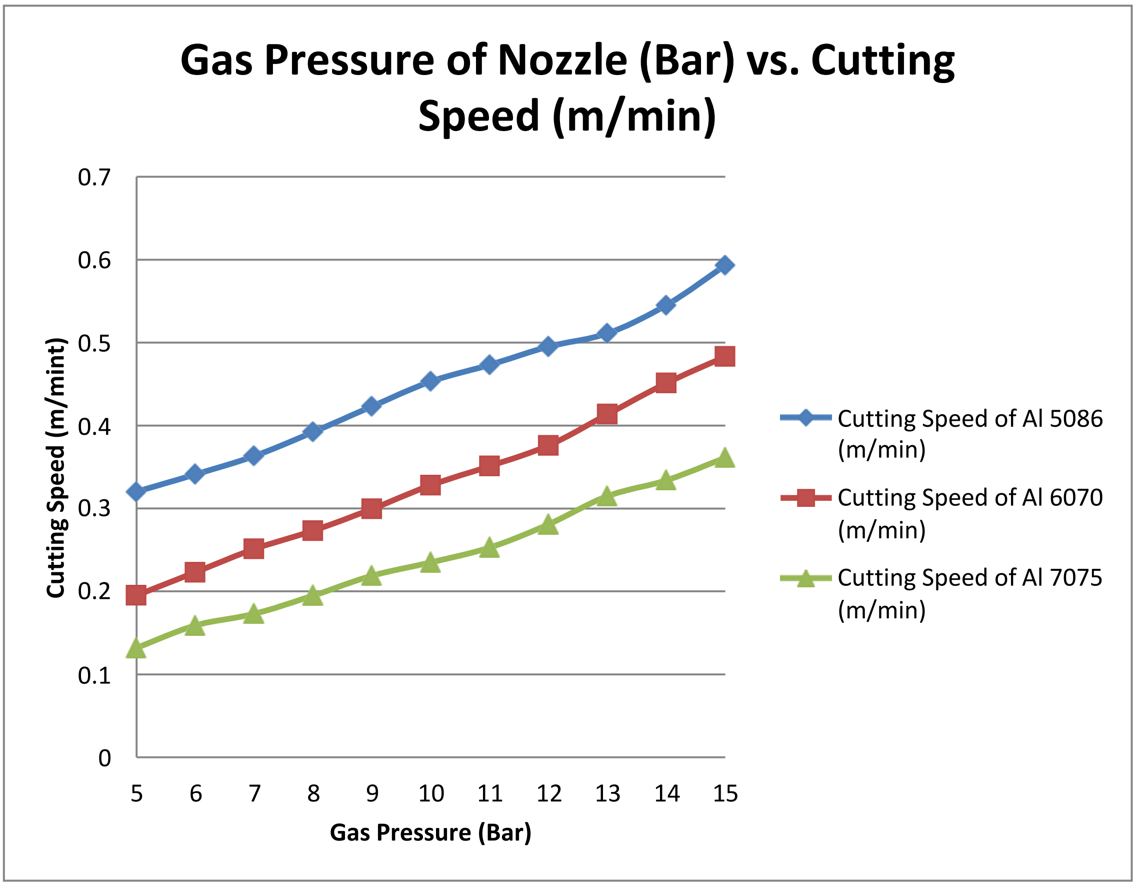

Figure-4.3: Gas Pressure vs. Cutting Speed

From the above graph as well as table of the gas pressure vs. cutting speed is cutting speed of the these three grade of the aluminum sheet is getting by increasing the gas pressure, and if we decrease the gas pressure then the value of the surface roughness is getting increase.

4.4. PLATE THICKNESS VS. CUTTING SPEED

In this section, we have studied at the different thickness of these three grade of the aluminum sheet such as Al 5086, Al 6070, and Al 7075.

We kept the constant power of the laser (1KW), gas pressure = 6 = bar.

The table as well as graph of the plate thickness vs. cutting speed is given below:

Table-4.4: Plate Thickness vs. Cutting Speed

Serial Number	Plate Thickness (mm)	Cutting Speed of Al 5086 (m/min)	Cutting Speed of Al 6070 (m/min)	Cutting Speed of Al 7075 (m/min)
1	6	3.178	3.01	2.785
2	7	3.023	2.913	2.321
3	8	2.632	2.51	2.123
4	9	2.501	2.341	1.654
5	10	2.319	2.067	1.491

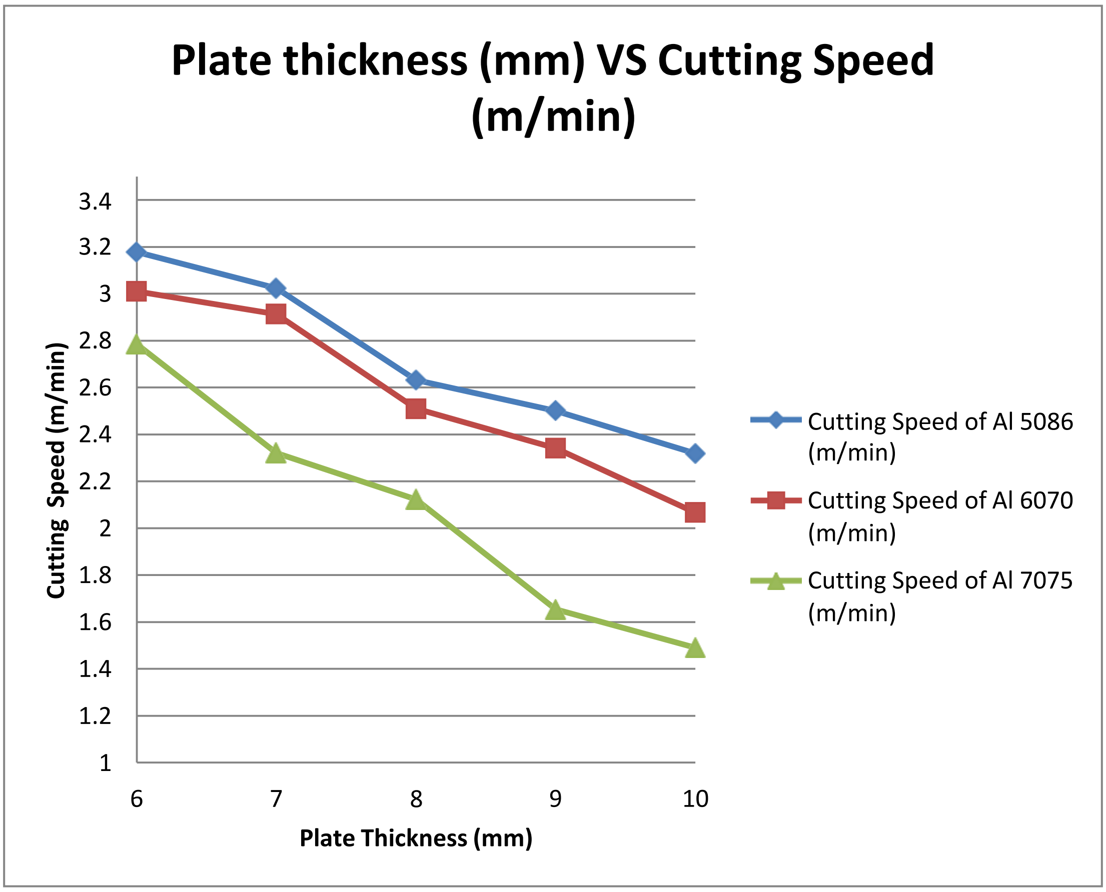

Figure-4.4: Plate Thickness vs. Cutting Speed

From the above graph as well as table of the Plate thickness vs. cutting speed, we can see that by increasing the thickness of the aluminum sheet the value of the cutting speed decreasing at the constant gas pressure, diameter of the nozzle.

4.5. PLATE THICKNESS VS. SURFACE ROUGHNESS

In this section of the plate thickness vs. surface roughness, we have changing the thickness of these three grades of the aluminum [late such as Al 5086, Al 6071, and Al 7075.

We kept the constant power of the laser (1KW), gas pressure = 6 = bar.

The table as well as graph of the plate thickness vs. surface roughness is given below:

Table-4.5: Plate thickness vs. Surface Roughness

Serial Number	**Plate Thickness (mm)**	**Surface Roughness of Al 5086 (µm)**	**Surface Roughness of Al 6070 (µm)**	**Surface roughness of Al 7075 (µm)**
1	6	3.942	3.612	3.134
2	7	3.751	3.407	2.971
3	8	3.51	3.276	2.758
4	9	3.356	3.01	2.419
5	10	3.035	2.861	2.112

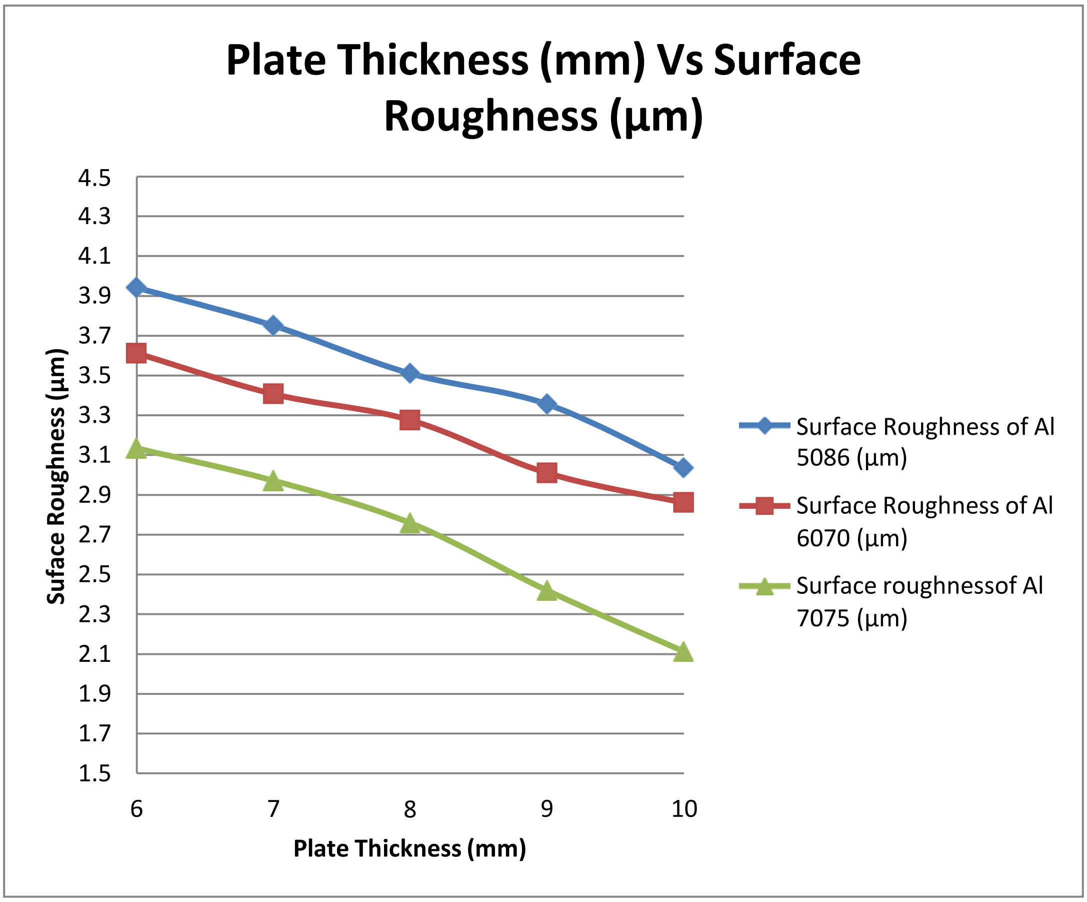

Figure-4.5: Plate Thickness vs. Surface Roughness.

From the above graph as well as table of the plate thickness vs. surface roughness, we found that the value of the surface roughness is increasing by increasing the thickness of the plate at the constant gas pressure and power of the laser of CO2 laser CNC laser machine.

4.6. POWER OF LASER VS. SURFACE ROUGHNESS

In this section of the power of laser vs. surface roughness, we have studied about to increase the power of the laser from 1KW to 2KW at the power difference of 0.1KW [68].

We have kept Constant gas pressure = 6 Bar and thickness of these three aluminum plate is 06 mm.

The graph as well as table of laser power vs. surface roughness is given below:

Table-4.6: Power of laser vs. Surface Roughness

Serial Number	Laser Power (KW)	SR of Al 5086 (µm)	SR of Al 6070 (µm)	SR of Al 7075 (µm)
1	1	73.12	87.102	98.014
2	1.1	69.54	84.547	93.154
3	1.2	64.13	80.964	89.1245
4	1.3	61.47	76.45	86.145
5	1.4	57.23	72.14	83.1547
6	1.5	53.21	69.78	70.985
7	1.6	49.21	66.12	67.354
8	1.7	46.156	63.141	64.254
9	1.8	42.951	59.145	61.842
10	1.9	38.145	56.234	58.561
11	2	34.3601	52.941	55.984

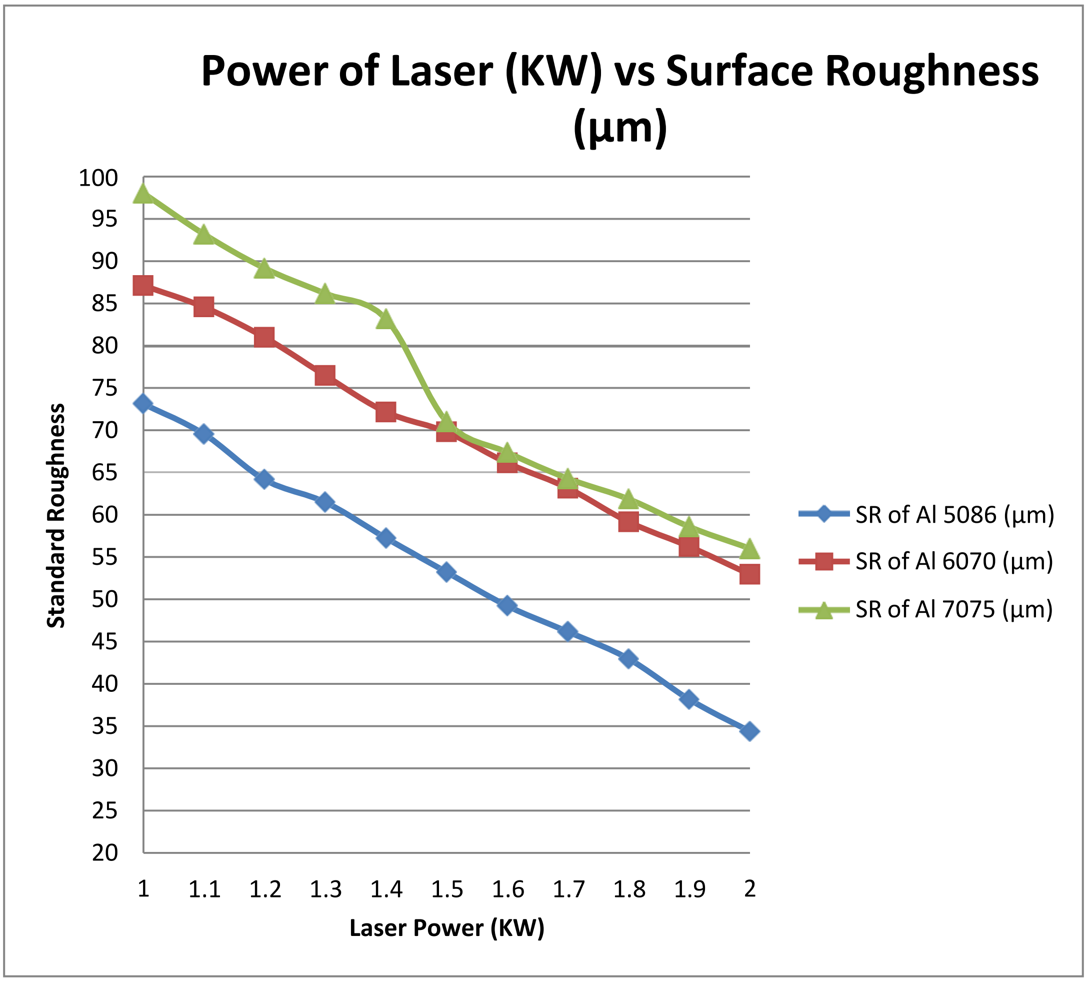

Figure-4.6: Power of laser vs. Surface Roughness

From the above graph as well as table of the laser power vs. surface roughness, we can see that the value of the surface roughness is decrease by increasing the power of the CO_2 CNC laser machine. If we decrease supply the power in the CNC laser machine as per requirement of the laser machine.

CHAPTER-05

CONCLUSION

After analyzing the result and discussion chapter, 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.
- With reference to the diameter of the nozzle vs. surface roughness, We saw that the value of the surface roughness is increasing by increasing the diameter of the nozzle at the constant power supply of the CNC laser machine as well as at the constant gas pressure that is 06 bar. For the smooth cutting of these three aluminum sheets as well as increasing the cutting speed, we need to decrease the diameter of the nozzle, if the diameter of the nozzle is decrease then automatically the pressure of the nozzle is increase.
- 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.

REFERENCE

1. Gabzdyl J. T., “Effects of gases on laser cutting of stainless steels”, In Laser Materials Processing: Proceedings of the International Congress on Applications of Lasers & Electro-Optics ICALEO '96 held in Detroit, Michigan, USA; 14-17 October 1996, pp. C39-C44
2. Rajaram N., Sheik-Ahmad J. and Cheraghi S. H., “CO_2 laser cut quality of 4130 steel”, International Journal of Machine Tools & Manufacture Volume 43 (2003) pp. 351-358
3. Anon., “Stainless Steel Overview: Applications”, http://www.ssina.com/overview/app_intro.html, referenced 10/01/2006
4. Anon., “Stainless Steel”, http://www.nisshin-steel.co.jp/nisshin-steel/english/profile/stain.htm, referenced 10/01/2006
5. Anon., “Types of Stainless Steel: Austenitic” http://www.assda.asn.au/asp/index.asp?pgid=18041&cid=34330&id=56984, referenced 10/01/2006.Balbi M., Silva G., “Stainless steel plate cutting: thermal and mechanical cutting. Laser cutting - some observations”, Avesta Stainless Bulletin, Oct.-Nov.-Dec. 1982, Volume 6, Number 4, pp. 3-11
6. Crafer R. C. and Oakley P. J., “Laser Processing in manufacturing”, Chapman & Hall, ISBN 0-412-41520-8, pp. 1, 13-15
7. Dirk Petring, “Laser Cutting”, LIA Handbook of Laser Materials Processing, Ist edition, 2001, Laser Institute of America, ISBN 0-912035-15-3, pp. 425-433
8. Thomas R. Kugler, “Nd:YAG Lasers”, LIA Handbook of Laser Materials Processing, 1st edition, 2001, Laser Institute of America, ISBN 0-912035-15-3, pp. 37- 44
9. Rajendran Natarajan, Ph.D. Dissertation: “An experimental and theoretical study of heat transfer effects during a laser-cutting process”, Iowa State University, 1990, U.M.I Dissertation Information Service, Order Number 9100495, pp. 1, 10-12, 69
10. Hügel H., “New solid-state lasers and their application potentials”, Optics and Lasers in Engineering, Volume 34 (2000), pp. 213-229

11. Adolf Giesen, "Thin Disk Lasers - Power scalability and Beam quality", http://www.pro-physik.de/Phy/pdfs/NEWS_PDF_GER_6737.pdf and http://www.wiley-vch.de/berlin/journals/ltj/05-02/LTJ02_42_45.pdf, referenced 20/10/2005
12. Thomy C., Seefeld T. and Vollertsen F., "High-Power Fiber Lasers – Application Potentials for Welding of Steel and Aluminium Sheet Material", Advanced Materials research, Volumes 6-8, (2005) pp. 171-178, available online at http://www.scientific.net/
13. Anon., "High-Powered Disk Laser" from http://www.trumpf-laser.com/208.img-cust/Disk_Laser.pdf; "The Disk Laser" from http://www.trumpf-laser.com/208.img-cust/Scheibenlaser_engl.pdf; "The HLD cw Lasers" from http://www.trumpf- laser.com/208.img-cust/HLD_Laser_engl.pdf, and "Disk lasers – Technical data" from http://www.trumpf-laser.com/208.index.html, referenced 29/09/2005
14. Anon., "DS series (disc): principle", http://www.rofin.com/index-e.htm, referenced 24/09/2005
15. Zapata L. E., Beach R. A., Mitchell S. and Payne S. A., "Yb Thin Disk Laser results", http://www.llnl.gov/tid/lof/documents/pdf/246177.pdf, referenced 24/09/2005
16. Reinhart Poprawe and Wolfgang Schulz, "Development and application of new high-power laser beam sources", Fraunhofer Institut Lasertechnik ILT, Germany, http://www.ilt.fraunhofer.de/ilt/pdf/ger/50_003.pdf, referenced 24/09/2005
17. Anon., "The Thin Disk Laser Technology", http://www.fgsw.de/homepage/leistungen/produkte/scheibenlaser/ThinDiskTechnology_LOT_2005.pdf, referenced 29/09/2005
18. Anon., "Laser Focus World May, 1999" http://lfw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=31572, referenced 20/09/2005
19. Wolfram Rath, "Disc lasers and their applications", ROFIN-SINAR Laser GmbH, Open House Rofin Sinar 2004, 20th April 2004

20. Paul Denney, “New Lasers in Automotive Applications”, http://www.laserinstitute.org/publications/lia_today/archive/articles/newfiberlaser/index.php3, referenced 24/09/2005
21. John Canning, “Fibre lasers and related technologies”, Optics and Lasers in Engineering, Volume 44, Issue 7, July 2006, pp. 647-676, available online at www.sciencedirect.com, referenced 22/08/2005
22. Bill Shiner, “Fiber Lasers for Material Processing”, Laser institute of America, http://www.laserinstitute.org/publications/lia_today/archive/articles/fiberlaser/index.php3 /, referenced 25/01/2006
23. Anon., “Fibre Laser Technology at TWI Yorkshire”, http://www.twi.co.uk/j32k/unprotected/band_1/twi_yorks_fibre.html, referenced 28/10/2005
24. Anon., **“**ELR Series: 1-100W Single Mode Erbium Fiber Lasers”**,** http://www.ipgphotonics.com/apps_mat_single_ELR.htm/, referenced 30/04/2006
25. David R. Whitehouse, “Guide to Laser Materials Processing”, Laser Institute of America, 1993, ISBN 0-912035-11-0, pp. 46-50
26. Yilbas B. S., “The analysis of CO_2 laser cutting”, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of. Engineering Manufacture, Volume 211, Number 3 (1997), pp. 223-232
27. Anon., “Diode-pumped cw solid-state lasers”, http://www.trumpf-laser.com/208.index.html, referenced 25/04/2006, referenced 2/05/2006
28. Guillas C., Le Gall C., Theveney S. and Lefebvre P., “Comparative performances of CO_2 and YAG lasers in the cutting of stainless steel”, Proceedings of SPIE: High-Power Solid State Lasers and Applications, August 1990, Volume 1277, pp. 244-255
29. Anon., “YLR-HP Series: 1-20kWatt Ytterbium Fiber Lasers”, http://www.ipgphotonics.com/html/90_1-20kw_mm_@1070nm.cfm, referenced 27/02/2006
30. Anon., “CNC Laser Cutting”, http://www.emachineshop.com/machines-kerf/laser-cutting.htm, referenced 22/09/2005

31. Anon., “Benefits of Direct Diode Lasers for Welding”, http://www.nuvonyx.com/overview/index.html, referenced 22/09/2005
32. Robert Lambert, Rodolfo Cortes Martinez, Alan Greenaway, Julian Jones and Duncan Hand, “Monitoring of high power laser beams and their application to laser machining”, http://www.aop.hw.ac.uk/Projects/mat17.htm, referenced 12/02/2006
33. Olsen Flemming O., “Polarization Effects in Laser Cutting: Basics”, LIA Handbook of Laser Materials Processing, I[st] edition, 2001, Laser Institute of America, ISBN 0-912035-15-3, pp. 433 – 436
34. Modest Michael F., “Reflectivity and Absorptivity of Opaque surfaces”, LIA Handbook of Laser Materials Processing, I[st] edition, 2001, Laser Institute of America, ISBN 0-912035-15-3, pp.180
35. Kanaoka M. and Kitani M., “Report on Current CO_2 Laser Applications in Japan”, SPIE Volume 952 (Proceedings of the Conference on Laser Technologies in Industry, Oporto 1988) (188) pp. 600-608
36. Olsen, F.O., “Cutting with polarized laser beams”, DVS-berichte 63 (1980), Deutsche Verband für Schweisstechnik, ISBN 3-87155-364-6, pp. 197-200
37. Ivarson Anders, PhD Thesis: “On the physics and chemical thermodynamics of laser cutting,” Luleå University of Technology, Sweden. 1993: 114D, ISSN 0348-8373, pp. 7, 35-37, 73-74,105-124
38. Fieret J., Terry M. J. and Ward B. A., “Overview of flow dynamics in gas assisted laser cutting”, Presented in the fourth International Symposium on optical and Optoelectronic Applied Science and Engineering, Topical Meeting on High Power Lasers: Sources, Laser-Material interactions, High Excitations, and Fast Dynamics in Laser Processing and Industrial Applications, 30 March – 3 April 1987, The Hague, The Netherlands, (Culham laboratories) report CLM-P 818
39. Chen Kai, Yao Lawrence Y. and Modi Vijay, “Gas jet – Workpiece interactions in laser machining”, Journal of Manufacturing Science and Engineering, August 2000, Volume 122, pp. 429 – 438.
40. W.M. Steen and J. Kamalu "Laser Cutting", Chapter Two, Laser Materials Processing, (Ed.) M. Bass, North-Holland Publishing Co. (U.S.A.), 1983.

41. M. von Allmen, Laser-Beam Interactions with Materials, Springer-Verlag, Material Science, Vol. 2, 1987.
42. A. L. Schawlow "Laser Interactions with Materials", Laser-77, Opto-electronics, (Ed.) W. Waidelich, Munich, June 1977, pp 263 - 266.
43. D. Schuocker "Laser Cutting", Industrial Laser Handbook, (Eds.) D. Belforte and M. Levitt, PennWell Publishing Co., 1986, pp 87 - 106.
44. D. Schuocker "Dynamic Phenomena in Laser Cutting and Cut Quality", J. Phys. B 40, 9-14, 1986.
45. D. Schuocker, W. Abel "Material Removal Mechanism of Laser Cutting", Proc. SPIE 455, 88, 1984.
46. D. Schuocker "Laser Cutting of Bulk Steel Due to Guided Flow of Radiation and Reactive Gas in the Workpiece", Proc. G.F.C.L., Italy, Sept. 1982, pp 647 - 654.
47. D. Schuocker "Reactive Gas Assisted Laser Cutting-Physical Mechanism and Technical Limitations", Industrial Applications of Laser Technology, (Ed) W. Fagan, SPIE Proc. 398, 1983, pp 388 - 392.
48. D. Schuocker "Physical Mechanism of Laser Cutting", Industrial Laser Annual Handbook, 1987, PennWell Publishing Co., pp 65 - 79.
49. Y. Arata "Dynamic Behaviour of in Laser Gas Cutting of Mild Steel", Trans. of J.W.R.I., Vol.8, No.2, Dec. 1979, pp 175 - 186.
50. G. Hertziger, Feinw , Messtech, 1983, 91, pp 156 - 163.
51. F.O. Olsen "Investigation in Optimising the Laser Cutting Process",Lasers in Materials Processing, 1984, pp 64 – 80
52. F.B. Thomassen and F.O. Olsen " Experimental Studies in Nozzle Design for Laser Cutting ", LIM-I, Birmingham U.K., 1983, pp 169 - 180.
53. M. Vicanek, G. Simon, H.M. Urbassek and I. Decker " Hydrodynamic Instability of Melt Flow in Laser Cutting ", J. Phys. D: Appl. Phys. 20, 1987, pp 140 - 145.
54. M. J. Adams, Metal Construction and British W. J., No.1, 1, Jan. 1970.
55. N. Forbes " The Role of Gas Laser in Metal Cutting with CO 2 Laser", Laser-75, Opto-Electronics, Munich, 1975, p 93.
56. E Beyer, G. Hertziger et.al . "Optical Feedback During Laser Materials Processing", Laser-83, Munich 1983, pp 259 - 263.

57. E. Beyer, 0. Marten, K. Behler and J.M. Weick "Laser Optoeletronics", 17, 282, 1985.

58. I.P. Shkarofsky, RAC Review, 36, No.2, 336, 1975.

59. F.O. Olsen "Laser Cutting with Polarised Laser Beam", DVS-berichte 63, 1980, pp197-200.

60. F.O. Olsen "Studies of Sheet Metal Cutting with Plane-polarised CO2 Laser", Laser-81, 1981, pp 227 - 231.

61. J. F. Ready."Development of Plume of Material Vaporised by Giant-Pulse Laser", Appl. Phys. lett., Vol.3, 1963, pp 11 - 13.

62. M. Abbett "The Mach Disk in Underexpanded Exhaust Plumes", A.I.A.A, 8th Aerospace Science Meeting, new York, 1976.

63. . Lepore, C. Dell'Erba et.al ., ICALE0'83, Los Angles, 9183, pp 160 - 165.

64. F.W. Lanua and B.C. Doxey "The Laser Cutting of Steel Rule Dies", Proc. of 2nd Int. Conf. on Product Development and Manufacturing Tech., London, 1973.

65. F.O. Olsen"Contribution to the Oxygen Assisted Laser Cutting", LIM-6, Birmingham, U.K., 1989, pp 67 - 79.

66. C.H. Miller and T.A. Osial"Status Report on 250 Watt CO2 Laser for Applications in the Pulp and Paper Industry", 15th Annual IEEE Pulp and Paper Conf., Georgia, May 1969.

67. M. Moriyasu, S. Hiramoro et.al ." Adaptive Control for High Speed and High Quality Laser Cutting", ICALEO' 85, San Francisco, U.S.A., Nov. 1985, pp 129 - 136.

68. J-M. Weick and W. Bartel " Laser Cutting Without Oxygen and Its Benefits from Cutting Stainless Steel", LIM-6,1989, pp 81 – 89

LIST OF PUBLICATIONS

Khan, A, and Anas M. (2022). Improving the Performance of Laser CNC Machine at different Grades of Aluminium sheet. International Research Journal of Engineering and Technology, 9(6),2753-2758.

Improving the Performance of Laser CNC Machine at Different Grade of Aluminium Sheet: A Review

Arman Khan[1], Mohd Anas[2]

[1]*M.Tech, Production and Industrial Engineering, Integral University, Lucknow, India.*
[2]*Assistant Professor, Department of Mechanical Engineering, Integral University, Lucknow, India.*

---***---

Abstract - *This paper studied the performance of the CNC machine for cutting the different metal sheets. The summary of the all research paper is given in detail in the literature review section. Alumina is one of the most commonly used engineering ceramics for a variety of applications ranging from microelectronics to prosthetics due to its desirable properties. Unfortunately, conventional machining techniques generally lead to fracture, tool failure, low surface integrity, high energy consumption, low material removal rate, and high tool wear during machining due to the high hardness and brittleness of the ceramic material. Laser machining offers an alternative for the rapid processing of brittle and hard engineering ceramics. However, the material properties, especially the high thermal expansion coefficient and low thermal conductivity, may cause ceramic fracture due to thermal damage. Striation formation is another defect in laser cutting. These drawbacks limit advanced ceramics in engineering applications. In this work, various lasers and machining techniques are investigated to explore the feasibility of high-quality laser machining different thicknesses of alumina. The main contributions include: (i) Fibre laser crack-free cutting of thick-section alumina (up to 6-mm-thickness). A three-dimensional numerical model considering the material removal was developed to study the effects of process parameters on temperature, thermal-stress distribution, fracture initiation, and propagation in laser cutting. A rapid parameters optimization procedure for crack-free cutting of thick section ceramics was proposed. (ii) Low power CW CO2 laser underwater machining of closed cavities (up to 2-mm depth) in alumina was demonstrated with high quality in terms of surface finish and integrity. A three-dimensional thermal-stress model and a two-dimensional fluid smooth particle hydrodynamic model (SPH) were developed to investigate the physical processes during CO2 laser underwater machining.*

Key Words: *CNC machine, CO2 laser machine, Metal Sheet, Aluminum Sheet, Pin Profile.*

1. INTRODUCTION

CNC machining is a cycle where assembling machines and instruments are moved as per pre-modified PC programming. Accordingly, makers can create parts quicker than expected, lessening waste and disposing of human blunders. This creation strategy is utilized to work an assortment of perplexing machines, which will be canvassed later in this article. Fundamentally, CNC machining makes it conceivable to perform three-layered cuts by adhering to a solitary arrangement of guidelines. This is the figure of the CNC machine:

Figure-1: CNC Machine.

1.1. TYPE OF THE CNC MACHINE

The CNC machine is classified into eight types, which are given below:

1. CNC Milling-Machine.
2. CNC-Router.
3. CNC-Plasma Cutting Machine.
4. CNC-Lathe Machines.
5. CNC-Laser Cutting Machine.
6. CNC-Water jet Cutting Machine.
7. CNC-Electrical Discharge Machine.
8. CNC-Grinder

1.2. CO2 Laser.

This kind of laser is regularly used for diminishing, dull, and etching reasons. The co2 lasers are used in weighty ventures for diminishing fabric like slight steel, aluminum, plastic, pure steel, titanium, wooden, and textures. A mix of carbon dioxide, helium, and nitrogen are flown out at extreme speed through a blower. The laser generator and mindfulness focal point require cooling. For the most part coolant or air is utilized for cooling. Water is for the most part utilized for coolant and is circled through a chiller or warmness switch framework.

17

ORIGINALITY REPORT

16%	11%	6%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ijert.org Internet Source	7%
2	Submitted to Universiti Teknologi Petronas Student Paper	1%
3	Submitted to Texas A&M University, College Station Student Paper	1%
4	eprints.utas.edu.au Internet Source	1%
5	Dilbag Singh, P. Venkateswara Rao. "Optimization of Tool Geometry and Cutting Parameters for Hard Turning", Materials and Manufacturing Processes, 2007 Publication	<1%
6	Submitted to The Scientific & Technological Research Council of Turkey (TUBITAK) Student Paper	<1%
7	Submitted to Deakin University Student Paper	<1%

www.iaeme.com