# Experimental Analysis of Laser Beam Machining for Product Manufacturing.

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**Abstract** - LASER (Amplification by Stimulated Emission of Radiation) cutting is considered one of the most excellent technologies created for operations like cutting, welding, boring, sintering, micromachining, and heat treatment. It is one of the thermal energies based unconventional processes utilized for cutting complex profile materials with a high degree of accuracy and precision. fiber lasers offer a particular advantage over established laser systems in regard to power efficiency, beam guidance, and quality. This paper reviews the effects of variation in machining parameters of fiber Laser Cutting and its effect parameters on the material, thickness, MRR, and surface roughness.

**Key Words** - Laser cutting, MRR, Stainless Steel, Mild Steel, Surface Roughness.

## I. INTRODUCTION (HEADING 1)

Laser beam cutting is a well-established and viable method of cutting a wide range of materials. In later times technological headway can be seen in each zone**.** Laser cutting works by concentrating a high-power pulsed laser on a specific area of the fabric to cut. The energy beam is absorbed into the surface of the fabric and the vitality of the laser is changed over into the heat, which melts or vaporizes the material.

In 1960, the first laser was invented which was an optically pumped laser that used ruby crystal as the gain medium. Technology has been in constant development since then. The first demonstration of laser cutting was done in 1967 which was performed using a focused CO2 laser and an assist gas jet. It wasn't until 1978 that the primary flatbed laser cutting machine was presented for commercial utilize. This machine was really a punch/laser cutting machine, where the cutting head was a stationary unit and the workpiece can be moved within the x-y directions utilizing numerical controls. The year after (1979) Trump (German laser machine producer) presented a 500-700 W CO2 laser cutting machine (Trump, 2012). The expanding laser beam quality and laser power are of high intrigue for the fabricating industry since these factors are exceedingly impacting the reachable quality of the workpiece admissible material thickness.

There are numerous advantages of laser cutting over mechanical cutting, since the laser beam is used to cut, there's no physical contact with the fabric in this manner impurities or contaminates cannot enter or get stuck into the fabric. The advantages of laser cutting incorporate high efficiency much appreciated by the high cutting speeds, narrow kerf width which leads to minimum fabric lost, straight cut edges, low metallurgical distortions, low roughness of cut surfaces, and easy integration.

The most working parameters associated with laser machining are laser power, the spot diameter of the laser beam, feed rate and depth of cut, and cutting speed. The cut quality characteristics like Edge Surface Roughness (Ra) and Surface Hardness are considered output parameters. The performance of the laser-cutting process generally depends on laser parameters. By appropriate control of the cutting parameters, great quality cuts are conceivable at high cutting rates. Subsequently, it is critical to investigate the effect of cutting parameters on quality of the cut.

## II. WORKING PRINCIPLE.

Laser cutting operation is a thermal, non-contact, and highly automated process well suited for different manufacturing industries to deliver components in expansive numbers with high precision and surface finish. The highly flammable oxidized gas from the gas cylinder comes within the nozzle where it gets ignited with the amplified light and produces the highly intense flame which gives on the fabric and due to that the cutting action on the fabric takes place. This highly intense flame may be of diverse gasses basically the gasses utilized are CO2, O 2, N2, etc. depending on the cutting parameters different gasses with pressure are balanced to deliver the flame. The objectives of these flares are Sublimating, Melting, and Burning. The cutting process is executed by moving a focused laser beam along the surface of the workpiece at a constant distance, subsequently creating a limit cut kerf. This kerf completely penetrates the fabric along the specified cut contour. This process is effective as it were on the off chance that the melt zone totally penetrates the workpiece. Laser metal cutting is therefore generally limited to thin sections.

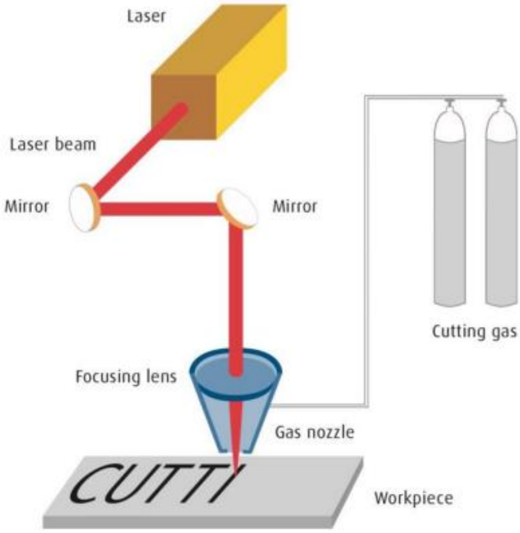


**Fig.1 Schematic Diagram.**

## III. PROCESS PARAMETERS.

The different parameter influencing the cutting quality like cutting speed, laser power, gas pressure, focal point, etc. The different parameters are recorded which influence the cutting process.

- Surface roughness: - It is the effective parameter that represents the quality of a machined surface. With the increment in cutting speed and frequency and decreasing laser power and gas pressure roughness diminishes. The laser-cut surface reveals a particular form of unevenness.
- Cutting Speed: - The cutting speed must be coordinated with the type and thickness of the workpiece. Increased roughness, burr formation, and too-large draglines are formed due to a speed that is too fast or too slow. The cutting speed must be adjusted with the gas flow rate and the power. At sharp corners, the speed must be decreased with a reduction in beam power in order to avoid burning.
- Laser Power: - The laser power must be balanced to suit the sort and thickness of the workpiece. A reduction in the laser power may be fundamental to achieving high precision on complexly formed workpieces or exceptionally little parts. Laser power is the whole energy emitted within the form of laser light per second while the intensity of the laser beam is the power divided by the area over which the power is concentrated.
- Gas Pressure: - The thickness of the material workpiece must be matched with the gas pressure. When cutting, the thin metal material is cut by higher gas pressure than the thicker material. The quality of the cut is highly affected even with a slight change in the gas pressure, so it must be regulated carefully.
- Nozzle diameter: - The cutting gas is delivered to the cutting front through the nozzle and it ensures that the gas is coaxial with the laser beam as well as stabilizes the pressure on the workpiece. The orifice of the nozzle determines the shape and quality of the cut. The diameter of the nozzle ranges from 0.8mm to 3mm.

## IV. EXPERIMENTAL PROCEDURES.

The experiment was performed on Bodor Optic Fibre Laser Cutting Machine with a capacity of 3KW which used Nitrogen ($N_2$) gas. The cutting operation was performed on two different materials Mild Steel of 2mm thickness and Stainless Steel of 2mm and 5mm thickness. We used a laser of 3kW power. For the experiment, we used different cutting speeds for cutting different holes. The diameter of the hole is 20mm.

**Fig.2 Bodor Fibre laser 3kW.**

The surface roughness was inspected by Mitutoyo SJ.201P Surface Roughness measuring instrument.

**Fig.3 Mitutoyo SJ. 201P**

## V. Parameter Considered For Experiment.

**Cutting Speed**: - 0.1 m/min, 0.3 m/m, 0.5 m/min, 0.7 m/min
**Laser Power**: - 3 KW
**No. of Holes**: - 4
**Diameter of Holes**: - 20mm
**The thickness of the Workpiece**: - Mild Steel 2mm
Stainless Steel 2mm and 5mm.

## VI. RESULTS AND DISCUSSION.

TABLE I. Result for Mild Steel with 2mm Thickness.

| Hole no. | Diameter | Time | Volume | MRR | Cutting Speed | Surface Roughness |
|---|---|---|---|---|---|---|
| 1 | 20 | 37.49 | 628 | 16.75 | 0.1 | 1.725 |
| 2 | 20 | 12.77 | 628 | 49.18 | 0.3 | 1.71 |
| 3 | 20 | 7.5 | 628 | 83.73 | 0.5 | 2.31 |
| 4 | 20 | 5.6 | 628 | 112.14 | 0.7 | 1 |


**Fig.4 Mild Steel with Thickness 2mm.**

TABLE II. Result For Stainless Steel With 2mm Thickness.

| Hole no. | Diameter | Time | Volume | MRR | Cutting Speed | Surface Roughness |
|---|---|---|---|---|---|---|
| 1 | 20 | 37.67 | 628 | 16.67 | 0.1 | 1.325 |
| 2 | 20 | 12.54 | 628 | 50.08 | 0.3 | 1.33 |
| 3 | 20 | 7.5 | 628 | 83.73 | 0.5 | 1.645 |
| 4 | 20 | 5.33 | 628 | 117.82 | 0.7 | 1.315 |

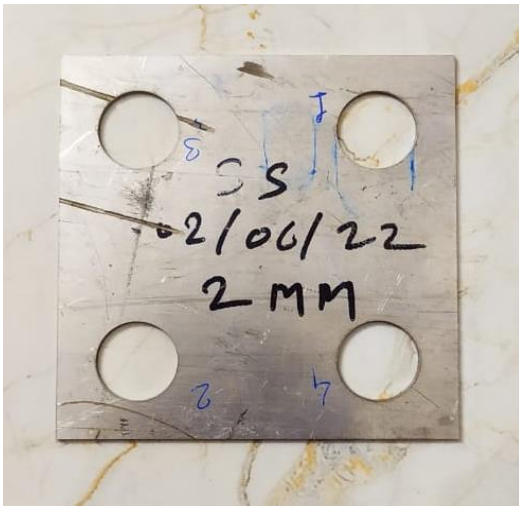


**Fig.5 Stainless Steel with Thickness 2mm.**

TABLE III. RESULTS FOR STAINLESS STEEL WITH 5MM THICKNESS.

| Hole no. | Diameter | Time | Volume | MRR | Cutting Speed | Surface Roughness |
|---|---|---|---|---|---|---|
| 1 | 20 | 40.12 | 628 | 15.65 | 0.1 | 1.36 |
| 2 | 20 | 14.97 | 628 | 41.95 | 0.3 | 1.4 |
| 3 | 20 | 9.83 | 628 | 63.89 | 0.5 | 1.38 |
| 4 | 20 | 7.21 | 628 | 87.10 | 0.7 | 1.11 |


**Fig.6 Stainless Steel with Thickness 2mm.**

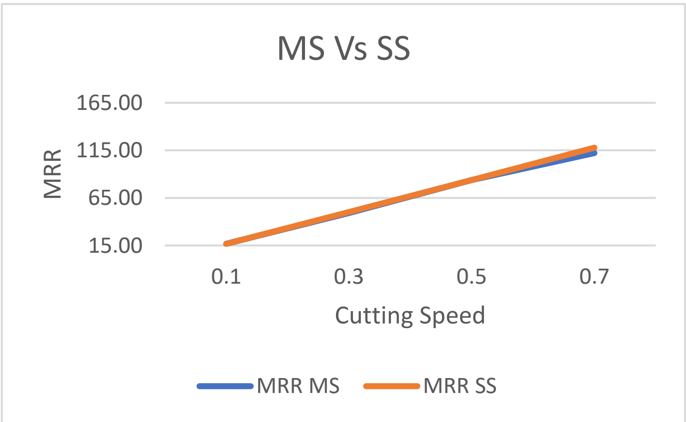


**Fig.7 MRR for MS Vs. SS.**

The proportion of material removal rate for Mild Steel and Stainless-Steel plates having a thickness of 2mm respectively is depicted in the above graph Fig.7. The blue line indicates the MRR for Mild Steel and the orange line indicates the material removal rate for Stainless Steel. The X-axis shows the cutting speed and the Y-axis indicates the MRR. From the above graph, we can conclude that the MRR of MS and SS is nearly the same up to the cutting speed of 0.5 m/min, and beyond that MRR of SS slightly increases.

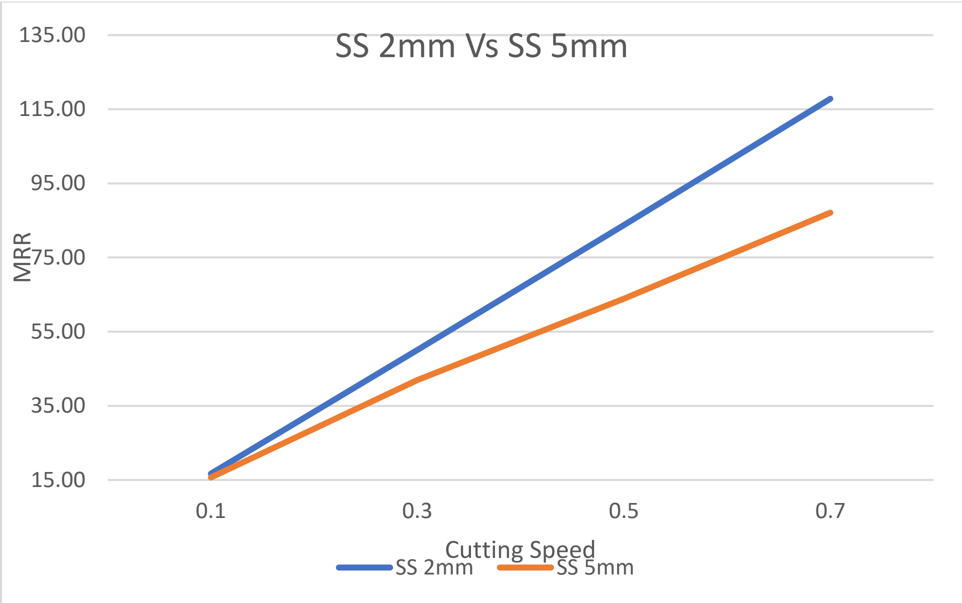


**Fig.8 MRR for SS 2mm Vs. SS 5mm.**

The proportion of material removal rate for Stainless Steel of 2mm and 5 mm respectively is depicted in the above graph Fig.8. The blue line indicates the MRR for SS 2mm and the orange line indicates the material removal rate for SS 5mm. The X-axis shows the cutting speed and the Y-axis indicates the MRR. From the above graph, we can conclude that the MRR of SS with a 2mm thickness is greater than that of SS with a 5mm thickness.

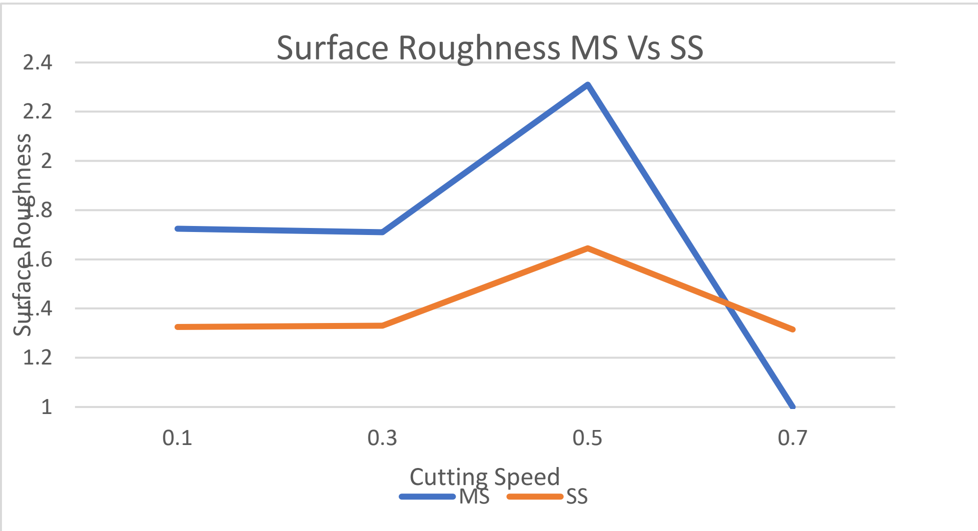


**Fig.9 Surface Roughness for MS Vs. SS 2mm.**

The proportion of Surface Roughness for Stainless Steel and Mild Steel respectively is depicted in the above graph Fig.9. The blue line indicates the Surface Roughness of MS and the orange line indicates the Surface Roughness of SS. The X-axis shows the cutting speed and the Y-axis indicates the Surface Roughness.

From the above graph, we come to the conclusion that up to the cutting speed of 0.3 m/min the value of Surface Roughness is nearly constant for both MS as well as SS. As the cutting speed reaches to 0.5 m/min the value of surface roughness suddenly increases. After making a peak as the cutting speed reaches to 0.7 m/min the surface roughness goes down.


**Fig.10 Surface Roughness for SS 2mm Vs. SS 5mm.**

The proportion of Surface Roughness for Stainless Steel and Mild Steel respectively is depicted in the above graph Fig.10. The blue line indicates the Surface Roughness of SS with 2mm thickness and the orange line indicates the Surface Roughness of SS with 5mm thickness. The X-axis shows the cutting speed and the Y-axis indicates the Surface Roughness.

The above graph suggests that the surface roughness of SS with 2mm thickness is constant up to the cutting speed of 0.3 m/min and after that it suddenly increases at 0.5m/min and then decreases with the cutting speed of 0.7m/min. Compared to that the SS with a thickness of 5mm slightly increases up to 0.3m/min and it gradually decreases as the cutting speed increases.

## VII. CONCLUSION.

The experiment we performed draws the conclusion that the Material Removal Rate varies for different materials according to their properties and the thickness of the material. As we can observe from the results, we obtained shows that Material Removal Rate for mild steel is slightly less as compared to that of Stainless Steel.

We also experimented the SS material with different thickness (i.e., 2mm and 5mm). here we observed that the material removal rate for the 2mm material is more as compared to the 5mm material. From here we can draw the conclusion that as the material thickness increases the material removal rate decreases.

In the case of surface roughness graph suggests that when the cutting speed is at lower side the surface roughness values remain constant and as the cutting speed increases more the surface roughness values also increase and reaches to a certain value and starts to drop.

## VIII. REFERENCES.

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