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Comparison of cutting speed variations in the laser cutting process on the results of SS400 steel plate products

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ABSTRACT

Computer Numerical Control (CNC) laser cutting as a manufacturing tool for plate cutting, where industrial players are encouraged to get maximum results. Laser cutting is one of the tools used by the industrial world to maximize cutting results. The aim of this research is to determine the results of differences using cutting speed parameters on SS400 steel plate with a thickness of 1 mm using CNC fiber laser cutting on the surface roughness of the material. The method used in this research is a real experimental research method and data analysis to analyze the parameters of cutting plates using laser cutting on surface roughness with the number of experiments being replicated 2 times for the research process by testing surface roughness using Surface Roughness.

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1. INTRODUCTION

The development of manufacturing technology is experiencing rapid acceleration, with laser cutting emerging as a pivotal technique in modern industrial applications due to its precision, efficiency, and versatility (Lamikiz et al., 2005; Mohammad Rudi Romadhoni & Samsul Hadi, 2024; Nugroho, 2015; Yilbas, 2004). While traditional cutting relied on manual methods like hand sawing, contemporary laser systems offer superior speed and material handling capabilities (Carpene et al., 2010.; Singh & Melkote, 2008). This technology is particularly valuable at PT Tranalab Manufaktur Indonesia, where it is extensively used for fabricating critical components like LCD covers and fume hood body covers for laboratory equipment (Hidayat et al., 2021; Venkata Rao & Kalyankar, 2013).

Laser cutting machines comprise three core subsystems: the main engine, laser source, and electrical components (Alsaadawy et al., 2024; Pradana et al., 2023; Soori et al., 2024). The laser beam (typically infrared, invisible to humans) is precisely guided to achieve accurate cutting paths (Buj-Corral et al., 2021; Der & Başar, 2025; Ghozali & Pangaribawa, 2024; Nurwahyudin et al., 2025),with parameter settings (speed, power, frequency) critically influencing surface quality and structural integrity (Sun & Brandt, 2013; Ghoreishi et al., 2002; Kučera et al., 2014; Riveiro et al., 2019). Recent work by (Purba et al., 2023) confirms that laser parameter variations significantly alter material responses in metal processing, necessitating systematic optimization for industrial applications.

Prior studies by Riyadi-Pratama (gas cutting) and Sabotova-Demec (laser marking) demonstrate that speed and frequency adjustments directly impact surface characteristics (Riyadi & Pratama, 2019; Sobotova & Demec, 2015). Extending this foundation—and building on Purba's parameter optimization framework (Purba et al., 2023)—this research specifically investigates speed variations in SS400 steel laser cutting at PT Tranalab. The study employs visual inspection and surface roughness analysis to address operational gaps in component fabrication (De Graaf & Meijer, 2000; Fajar Adi Nugroho & Deni Hidayat, 2025).

2. RESEARCH METHOD

The following is a flowchart that describes the process of completing this final assignment as shown in the diagram below.

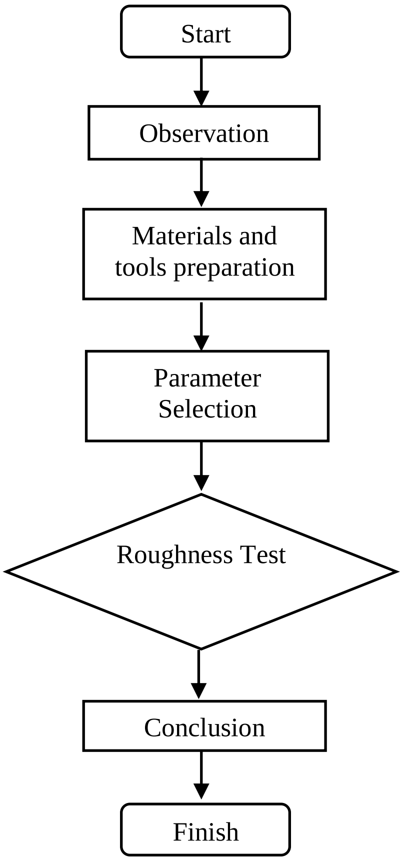


Figure 1. Flow chart

Start

Initial problem identification focused on inconsistent cut quality and efficiency at PT Tranalab's laser facility.

Observation

Field reviews documented: a) Inconsistent edge quality in LCD/fume hood components; b) Suboptimal speed settings causing rework *(Industrial context aligns with Purba's applied research approach* (Purba et al., 2023)*.*

Materials & Equipment

1. Material: SS400 low-carbon steel (30×30 mm plates, ASTM A36/JIS G3101) *Selected due to its prevalence in structural applications and validated response to laser processing* (Purba et al., 2023; JIS G 3010, 2016).
2. Equipment: a) Laser Max Series Flat Laser Cutting (<1000W, 220V 50Hz); b) Nanosecond Pulsed Fiber Laser (beam width <0.15 mm); c) Computer-controlled parameter adjustment *(Machine specifications mirror those used in Purba's engraving study* (Purba et al., 2023)*)*

Figure 2. Max Series Flat Laser Cutting Machine

Figure 3. Test Material Dimensions

Preparation of the test material was carried out by marking the material with dimensions of 18 mm x 20 mm on a 30 mm x 30 mm SS400 plate as shown in Figure 3. The marking motif is square in shape with a line space of 0.05 mm and 0 degrees with the position of the pulse optic laser machine to the material at a distance of 2 mm vertically as shown in Figure 4. *Following geometric standardization from* (Kučera et al., 2014; Purba et al., 2023)

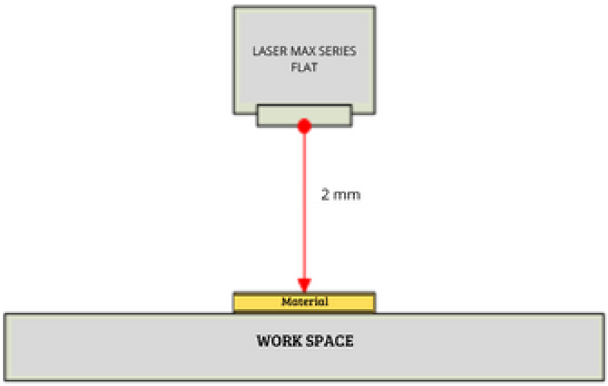


Figure 4. Material Location and Marking Process with Optical Laser

In the research conducted, the parameters that were varied were speed while power and frequency were fixed parameters as shown in Table 1. Speed variation was carried out with 1 repetition. The surface roughness measurement process was carried out at 4 measurement points using a surface roughness tester ISO 4287 (ISO/IEC-27002, 2022).

Table 1. Variation of research parameters

Cutting Speed (m/min)	Nozzle Height (mm)	Gas Pressure (bar)	Power (Watt)
0.2	2	3	1000
0.4	2	3	1000
0.6	2	3	1000
0.8	2	3	1000
1.0	2	3	1000
1.2	2	3	1000

3. RESULTS AND DISCUSSIONS

Laser cutting with cutting method is a laser cutting activity by utilizing high-pressure gas to cut material by shooting a laser beam that will heat and melt the material with high power. The speed of the laser machine is the pulse power or laser shooting power provided by the machine with its respective capabilities, a machine that has a speed capability of up to 40 m / min which is suitable for the cutting process on metal materials. Therefore, the research was conducted on plate material with a size of 30 mm x 30mm with a thickness of 3 mm.

Testing was carried out using speed variations of 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 with a frequency of 20 kHz, a speed rate of 220 mm/s with the number of test samples at each speed variation of 2 plate samples. On each sample plate, roughness testing will be carried out using a surface roughness tester repeatedly to determine the depth of ingestion on the marking following the Open Engineering journal reference on Laser Marking as Environment Technology. Measurements are made by placing the needle and arm of the surface roughness tester perpendicular to the direction of the marking line.

The implementation of marking with different parameters without changing other parameters produces different products. The difference in each marked product will be tested for surface roughness using a surface roughness tester, in addition, testing will be carried out repeatedly 2 times from each sample sheet that has been marked. Visual observation of samples and test results with roughness testers from each product are shown in table 2. The average calculation results of the roughness value will be entered into the roughness class according to ISO or DIN 4763: 1981 where N1 to N12 have different roughness numbers as in table 2 below.

Table 2. ISO atau DIN 4763:1981

Roughness Ra (µm)	Roughness Class	Sample Length (µm)
50	N12	8
25	N11	
12,5	N10	2,5
6,3	N9	
3,2	N8	0,8
1,6	N7	
0,8	N6	
0,4	N5	
0,2	N4	0,25
0,1	N3	
0,05	N2	
0,0025	N1	0,08

Table 3. Test results with surface roughness

Speed Parameter (m/min)	Visual Product	Avg. Surface Roughness Test (Ra) µm	Roughness Class
		5,694 µm	

0.2		5,729 µm	N9
0.4	 	4,797 µm 4,215 µm	N8
0.6	 	4,639 µm 4,744 µm	N8
0.8	 	4,505 µm 2,730 µm	N8
1.0	 	5,332 µm 5,820 µm	N9

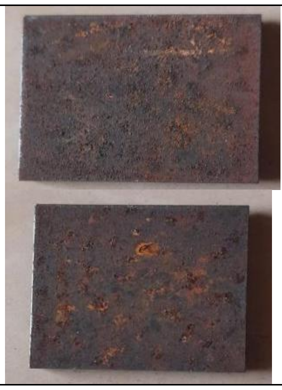
1.2		4,943 µm 4,759 µm	N9

Table 3 is the result of repeated sample testing using a surface roughness tester to obtain the arithmetic mean (Ra) as a parameter of the test. The average result of the test will be categorized into the roughness class according to the roughness class according to ISO or DIN 4763:1981.

The test results of sample 1 at a speed of 0.2 m/min obtained an average value of the tested sample of 5.694 µm to 5.729 µm and entered the roughness class N9. At a speed of 0.4 m/min the roughness value obtained after testing the sample roughness was 4.797 µm to 4.215 µm on average the results of observations of 2 products that entered the roughness class N8. The results of the test sample with a speed of 0.6 m/min are very clearly different, the test results found have a roughness value of 4.639 µm to 4.744 µm, from these results a difference in roughness of ±0.5 µm is seen. The roughness value of the product is 0.6 m/min, it falls into the N8 class. The results of the test samples with a speed variation of 0.8 m/min have a roughness value of 4.505 µm and 2.750 µm and fall into the N8 roughness class. The results of the test samples with a speed variation of 1.2 m/min have a color change in the marking area. This is due to the large power supply to the pulse of 1000 Watts, which results in serrated plate cuts on the material. The roughness results of the product also look much different from the previous results, which are 5.332 µm to 5.820 µm with a difference of 9 µm. The marking value falls into the N9 roughness class. The speed variation of 1.4 m/min has a very large change when compared to 1.2 m/min, with measurement results of 4.943 µm to 4.759 µm which has a difference of 2 µm. Apart from the results of roughness value measurements, the product sample at a speed variation of 1.4 m/min showed changes in the laser cutting results which made the cutting results smoother and less jagged.

4. CONCLUSION

In the non-conventional non-marking process, there is a process that uses a laser as a medium for removing or forming patterns. The depth and neatness of the marking results can be adjusted by determining the parameters. Parameters are important to understand and observe in the laser marking process. Changes made to the parameters will affect the final result of the product. Making a product by varying the speed parameters and without changing any other parameters, later visual observations and surface roughness testing will be carried out using a surface roughness tester to see the differences that will be produced from these variations.

The parameters used are speed parameters with variations of 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2, while the frequency parameters used are 20 kHz, speed rate of 220 mm/s on SS400 steel material. The standard reference used in measuring the surface roughness level is ISO or DIN 4763:1981. The results obtained at the lowest speed parameter, namely 0.8 m/min, have a roughness value of 4.505 µm and 2.750 µm and are included in the roughness class N8, a speed of 0.4 m/min has a roughness value of 4.797 µm - 4.215 µm, a speed of 0.6 m/min has a roughness value of 4.639 µm - 4.744 µm and is included in the N8 class, a speed of 1.4 m/min has a roughness value of 4.943 µm - 4.759 µm and is included in the N8 class, a speed of 1.2 m/min has a roughness value of 5.332 µm - 5.820 µm and is included in the N9 class, a speed of 0.2 m/min has a roughness value of 5.694 µm - 5.729 µm and enters the N9 class. Based on the results obtained, it was found that the higher the speed given to the engraving process, the higher the level of roughness.

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