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Performance Testing of The CNC Laser Engraver Machine on Plywood Media

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Abstract

This work aims to test and analyze the performance of the CNC Laser Engraver Machine on plywood media by using the grbl settings. The engraving process was conducted by using three filling methods in the grbl setting, i.e., reversed diagonal filling, horizontal filling and no filling. In the reversed diagonal filling method is tested a gears image input, in the horizontal filling method is tested a rumah gadang image input and in the no-filling method is tested a piston image input. The machine performance was assessed by comparing the CAD-based images input with the engraved images output that are carved on plywood media by a laser speed setting of 1000 mm/min, a laser power scale of 60% and a distance of laser from the media of 5 cm. From this assessment it can be concluded that the CNC Laser Engraver Machine is capable to create the shape and size of the images output that is the same as the shape and size of the images input. Here, the images size is obtained by a vernier caliper that has an accuracy of 0.05 mm.

Keywords: laser engraver, plywood media, CAD-based images input, engraved images output, performance

1. Introduction

The engraving is the practice of incising a design onto a hard, usually flat surface by cutting grooves into it with a burin. Based on this understanding, engraving is also an image made by humans on a surface that is done in such a way with certain tools so that the surface that was originally flat becomes uneven, but still looks beautiful and aesthetic [1].

The process of engraving and its tools have been developed very rapidly. In the industrial world, engraver machines have taken the form of CNC (Computer Numerical Control) machines. The CNC machine is a system that basically converts the program language (G-Code) into axis movements on the machine. In the CNC system circuit, there is a computer that functions to convert G-Code characters into machine language which is then processed and sent to each motor driver in the form of signals, both analog and digital signals [2]. Various types of CNC machies are seen from the media used, namely: CNC Router (cutter or drill), CNC Plasma (laser or fire), CNC Water, CNC Air and others. CNC machines have been very widely used in large industries and is a tool that must exist in the manufacturing industry either for reasons of precision or for production efficiency [3-8].

The CNC machine in the modern industrial world have been developed with the performance or capabilities of machines that are continuously increasing with simple and neat machine shapes with increasingly complex and sophisticated design features, and also using the latest technology so that they can work more efficiently and practically. These CNC machines components can be controlled (start, accelerate, decelerate and stop) called the machine axis [9-11].

The engineering aspect requires a machine with a precise level of work such as a CNC machine, but the price of this CNC machine on the market is quite high. This is of course a serious problem in production units in the middle to lower industries and also in newly developing private educational institutions [12]. In modern industry, CNC machines are widely used to produce high quality products. Meanwhile, in the middle to lower industries, this is often an obstacle. Likewise, in the practice of learning in developing private educational institutions [13]. However, along with the development of CNC machines with integrated new features, it has become a challenge for educational institutions. This is also a challenge to prepare graduates who have competence in CNC machines that suit industry needs in addition to preparing adequate facilities and infrastructure [14-15]. Based on this description, the Research Team from the Mechanical Construction Laboratory of the Padang Institute of Technology (Lab. LKM-ITP) has produced an innovative design for a CNC Laser Engraver Machine with dimensions of 585 mm x 533 mm x 350 mm, with a total weight of 22 kg and a work area of 310 mm x 390 mm. This machine is intended for CNC Laser Engraver Machines that can move the laser head in the direction of the X-Axis, Y-Axis and Z-Axis, where the laser head can be moved 10-60 mm in the Z-axis direction, 0-310 mm in the X-axis direction and 0-390 mm along the Y-axis on the engraving table [16]. Analysis of the machine structure has also been carried out. Where from the analysis the largest deformation is obtained and the value of safety factor (SF) on the main unit, namely the X-Axis and Y-Axis units, respectively, is 5.63 μm and 4.65 μm with SF at value around 15.

Referring to the design and structural analysis of the CNC Laser Engraver machine above, the Research Team of Lab. LKM-ITP continues the design of the CNC Laser Engraver machine manufacturing system. The design of the manufacturing system is intended to produce a CNC Laser Engraver machine which consists of five main parts, namely the Laser Engraver Module unit, the Z-Axis unit, the X-Axis unit, and the Y-Axis unit and the Box Controller [17].

Based on the design and structural analysis of the CNC Laser Engraver Machine in reference [16] which was then followed by the manufacturing system design in reference [17], the the Research Team of Lab. LKM-ITP carries out the production stages to produce a CNC Laser Engraver Machine as shown in Figure 1. Furthermore, in this work will describe the performance analysis of this CNC Laser Engraver Machine for the engraving process on plywood with the grbl setting on the machine.

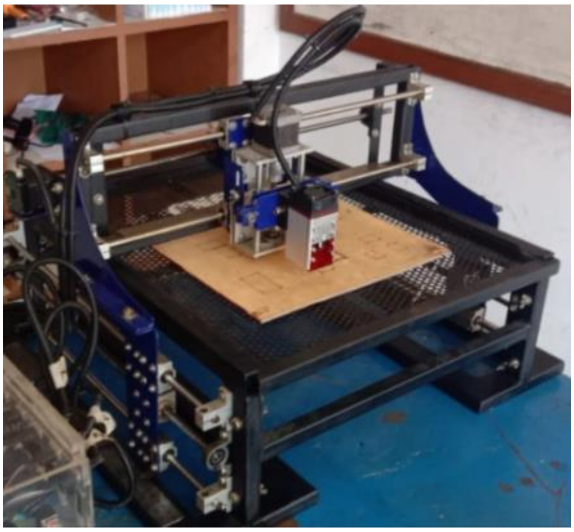


Figure 1. The CNC Laser Engraver Machine produced by the Research Team of Lab. LKM-ITP

2. Method

In this work, the performance testing of the CNC Laser Engraver Machine was carried out on the engraving process on Plywood Media with grbl settings. The testing has been conducted in the Lab. LKM-ITP. This performance testing setup is shown in Figure 2.

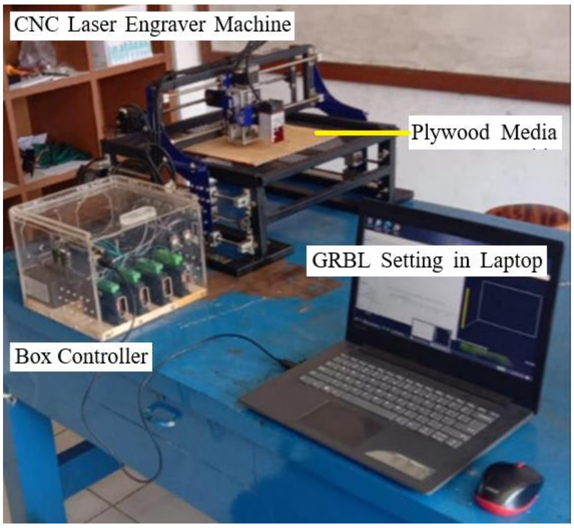


Figure 2. The perfomance testing setup of the CNC Laser Engraver Machine in Lab. LKM-ITP

The engraving process is carried out using three methods, i.e, reversed diagonal filling method, horizontal filling method and no-filling method. In the reversed diagonal filling method, a CAD-based image input is used in the form of gears image as shown in Figure 3. In the horizontal filling method, a CAD-based image input is used in the form of a *Rumah Gadang* image as shown in Figure 4, and in the no-filling method, a CAD-based image input is used in the form of a piston image as shown in Figure 5. At the grbl setting, the laser speed is 1000 mm/min and the laser power scale is 60%. Laser head distance is set as far as 5 cm above the plywood media.

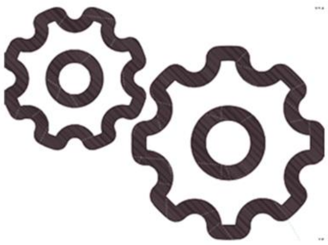


Figure 3. A gears image as input in reversed diagonal filling method

Figure 4. A *Rumah Gadang* image as input in horizontal filling method

Figure 5. A Piston image as input in no-filling method

The test procedure is carried out in the following stages: (1) Prepare the CNC Laser Engraver Machine, (2) Connect the X Motor (X-axis actuator), Y1 and Y2 Motors (Y-axis actuator) and Z Motor (Z-axis actuator) and laser to the controller, (3) Connect the arduino on the controller to the Laptop, (4) Connect the PLN power to the controller by pressing the switch on the controller so that the fan and motors are ON, (5) Do grbl setting in the laptop: the laser speed is 1000 mm/min and the laser power scale is 60%, (6) Prepare the plywood media, (7) Set laser head distance as far as 5 cm above the plywood media, (8) Set zeros position of machine for XY Plane, (9) Prepare a CAD-based gears image (Figure-3), prepare a CAD-based Rumah Gadang image (Figure-4), and prepare a CAD-based piston image (Figure-5), (10) Create G-Code to engraving process of Figure-3 by using reversed diagonal filling method, create G-Code to engraving process of Figure-4 by using horizontal filling method and create G-Code to engraving process of Figure-5 by using no-filling method, (11) Send G-Code to the CNC Laser Engraver Machine: Do this for each image input, (12) Measure the main dimensions of the engraving results with vernier caliper.

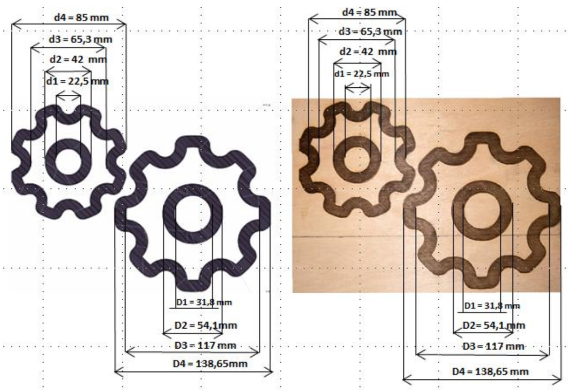
3. Results and Discussion

In the testing by using reversed diagonal filling method to engraving process, a CAD-based image input is gears image with main dimensions of first-gear are d_1, d_2, d_3 and d_4 and main dimensions of second-gear are D_1, D_2, D_3 and D_4. The measurement results for the engraved image on plywood media obtained the main dimension of the first-gear with d_1=22.50 mm, d_2=42.00 mm, d_3=65.30 mm and d_4=85.00 mm and the main dimensions of the second-gear with D_1=31.80 mm, D_2=54.10 mm, D_3= 117.00 mm and D_4=138.65 mm (Figure-6). From this result, it can be concluded that the CNC Laser Engraver Machine is capable of producing the shape and size of the gears image output that is the same as the shape and size of the CAD-based gears image input.

In the testing by using horizontal filling method to engraving process, a CAD-based image input is *Rumah Gadang* image with main dimensions are D_1, D_2, D_3 and D_4. The measurement results for the engraved image on plywood media obtained the main dimension are D_1=202.00 mm, D_2=208.50 mm, D_3= 222.20 mm and D_4=229.60 mm (Figure-7). From this result, it can be concluded that the

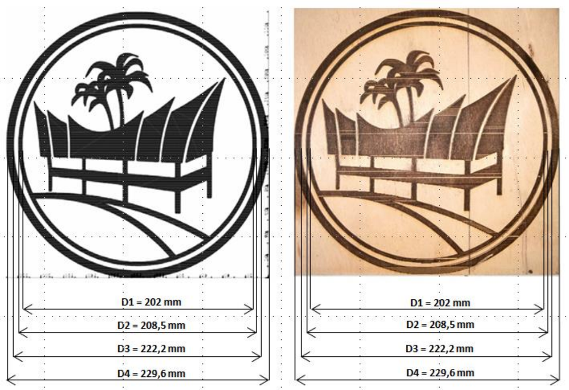
CNC Laser Engraver Machine is capable of producing the shape and size of the *Rumah Gadang* image output that is the same as the shape and size of the CAD-based *Rumah Gadang* image input.

In the testing by using no-filling method to engraving process, a CAD-based image input is piston image with main dimensions are A, B, C, D, E, F, G and H. The measurement results for the engraved image on plywood media obtained the main dimension are A=77.90 mm, B=25.90 mm, C=78.60 mm, D=209.00 mm, E=215.35 mm, F=55.40 mm, G=30.55 mm and H=71.00 mm (Figure-8). From this result, it can be concluded that the CNC Laser Engraver Machine is capable of producing the shape and size of the piston image output that is the same as the shape and size of the CAD-based piston image input.



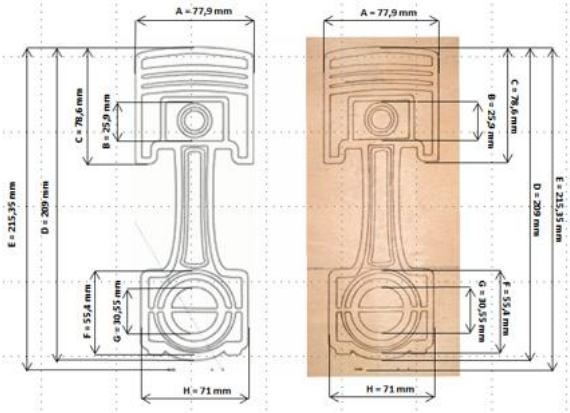
CAD-based image input Image output on the media

Figure 6. Comparison of the CAD-based gears image input with the gears image output on the plywood media



CAD-based image input Image output on the media

Figure 7. Comparison of the CAD-based *Rumah Gadang* image input with the *Rumah Gadang* image output on the plywood media



CAD-based image input Image output on the media

Figure 8. Comparison of the CAD-based piston image input with the piston image output on the plywood media

4. Conclusion

Based on the result and discussion have been done, it can be concluded that the CNC Laser Engraver Machine produced by the Research Team of Lab. LKM-ITP is able to produce the output in the shapes and sizes of engraving images on the plywood media as same as the input shapes and sizes in the form of CAD-based image. The image size (main dimensions of images) is obtained with a vernier caliper which has an accuracy of 0.05 mm. The measurement of main dimensions of images have been done in the testing by using engraving process methods (reversed diagonal filling, horizontal filling and no-filling).

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