OPTIMIZATION OF PARAMETERS FOR LASER MARKING AND ENGRAVING ON PLYWOOD AND PINE WOOD MATERIALS

PARAMETRU OPTIMIZĀCIJA LĀZER MARĶĒŠANAI UN GRAVĒŠANAI UZ FINIERA UN PRIEDES KOKMATERIĀLIEM

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Abstract. *This publication shows the results of CO_2 laser marking and engraving on plywood and pine materials at different speeds and powers. Plywood and pine materials were marked and engraved with four different speed and seven different power ratios. Marked and engraved line depth was measured for these materials. In this publication used SUNTOP CC-9060 CO_2 laser machine and OLYMPUS OLS5000 laser microscope.*

Keywords: CO_2 *laser, laser marking, laser engraving, plywood, pine.*

Introduction

In 2018, global wood-based panel production reached 408 million m³, a 1 percent increase over the previous year (404 million m³) and a 9 percent increase over the observed period. Wood-based panels were the product category that saw fast growth in production, owing to the rapid and consistent growth in the Asia-Pacific region until 2016. In later years, global production has stabilized. [1]

In 2018, global sawn wood production totaled 493 million m³, which was 2.2 percent higher than in 2017 (482 million m³) and 13 percent higher than in 2014 (435 million m³). The latest regional production figures for 2018 are as follows: Europe – 170 million m³ (35 percent); Asia–Pacific – 151 million m³ (31 percent); Northern America – 129 million m³ (26 percent); Latin America and the Caribbean – 32 million m³ (6 percent); and Africa – 11 million m³ (2 percent). [1]

Application of birch veneer and pine wood: Industrial production and mechanical engineering, transport engineering, shipbuilding aircraft construction. Furniture production: production of upholstered furniture, manufacture of chests of drawers and cabinets, cabinet furniture, shelves, and scaffolding (racks), interior items, decorative decoration of the premises. Package, production of boxes, pallets, and cable reels. Construction: roofing works, cladding works (for concrete formwork), floor covering, wall finishing and cladding using panels. [2], [3], [4].

Wood marking and engraving are two of the popular laser processing types because they can encompass so many different projects, ideas: different images, logos, decorations, details etc. [5]

Publication objective: study, measure, obtain results on plywood (veneer) and pine materials, with various laser marking and engraving parameters: laser marking and engraving speed, laser power.

Publication problem: Changing the parameters of the marking and engraving laser also changes the depth and width of the line.

During the research, various literature and other sources of publication were studied, gaining an idea of the significance of the publication topic and problem-solving methods, as well as to find out the results obtained by other authors in this or a similar field.

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Equipment

In the experiment uses a CO_2 laser system SUNTOP ST-CC9060. (See in Fig. 1)

Fig.1. Laser machine SUNTOP ST-CC9060

Table 1. **Laser machine SUNTOP ST-CC9060 technical specifications**

Laser type	CO2 laser, CW mode
Wavelength	10640 nm
Maximum power	100W
Workspace (Cutting area)	900 x 600 mm
Scanning speed	0 – 1000 mm/s
Precision	0,02 mm
Laser Safety Class	4
Cooling system	Water cooling

For measuring line depth *h* OLYMPUS OLS5000 was used. Microscope is shown in Fig.2.

Fig.2. OLYMPUS OLS5000 laser microscope

Technical parameters for OLYMPUS OLS5000 laser microscope:

- Max magnification 100x,
- Z measurement pitch: 2μm,
- X and Y axis resolution: +/- 1.5%

Methodology

Before the experiment, the laser output power was measured. The power *P* adjustment curve is shown in the graph in Fig.3. This relation is logarithmic.

In this experiment, series were engraved with an SUNTOP ST-CC9060 CO_2 laser system. Two series of experiments were made.

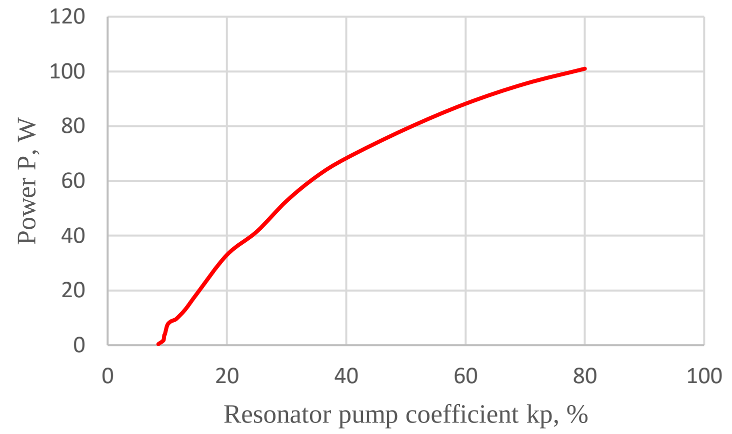


Fig.3 Dependence of the radiation power P on the resonator pump coefficient k_P %

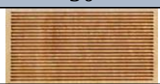
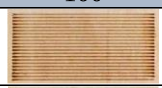
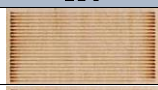
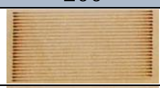
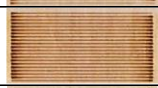
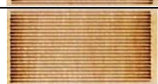
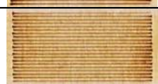
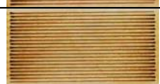
1) In the first series of experiment, made the dependence on plywood plate the marking and engraving parameter (depth *h*) depending on the output power *P* and speed *v*. The length of each line is 40 mm.

2) In the second series of experiment, made the dependence on pine wood plate the marking and engraving parameter (also depth *h*) depending on the output power *P* and speed *v*. The length of each line is 40 mm.

These experiments were made where power *P* is these values: 10 W, 15 W, 20 W 25, 30 W, 35 W and 40 W. Also, the speed *v* had a constant value of 50 mm/s, 100 mm/s, 150 mm/s, 200 mm/s. The distance between lines Δx is 1 mm.

In this experiment, series were measured line depth *h* with an OLYMPUS OLS5000 [Fig.2.] laser microscope. 4 lines were marked with each parameter, depth of each line was measured and average line depth was calculated. It was measured in the middle of each marked and engraved lines because both sides of the lines are more burnt than the middle part of the lines.

Table.1. Summary of data for marked and engraved lines of plywood series. Distance between marked and engraved lines $\Delta x = 1$ mm.

	Speed v [mm/s]			
Power P [%]	50	100	150	200
10				
15				
20				
25				
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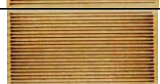
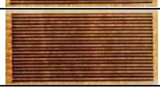
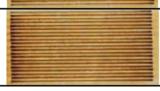
35				
40				

Table.2. Summary of data for marked and engraved lines of pine wood series. Distance between marked and engraved lines Δx = 1 mm.

	Speed v [mm/s]			
Power P [%]	50	100	150	200
10				
15				
20				
25				
30				
35				
40				

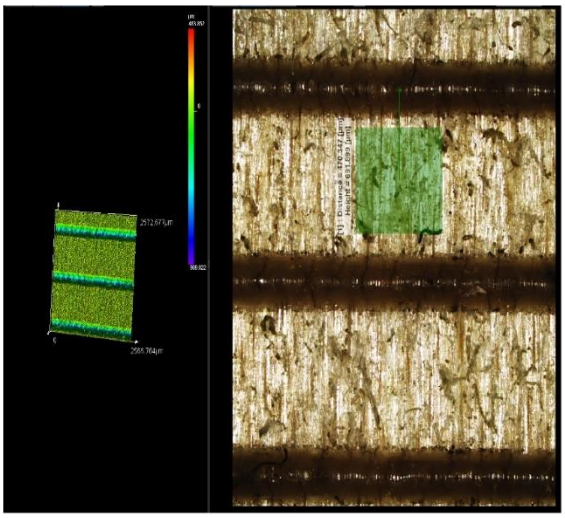


Fig.8. *Measured result under a microscope with a magnification 5x to engraved plywood material with power P = 20 % and speed v = 200 mm/s. Line depth is 470 µm.*

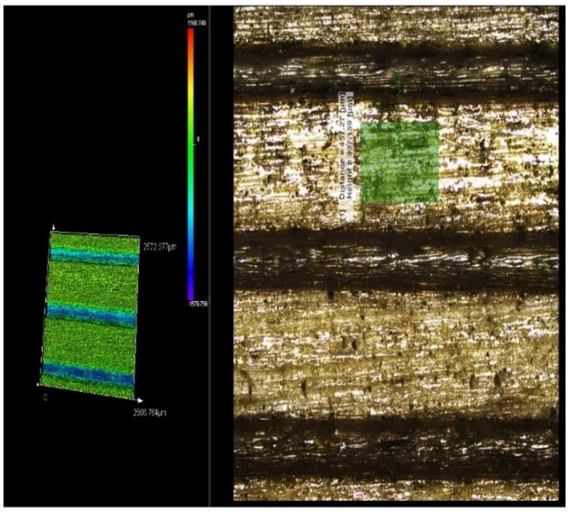


Fig.9. *Measured result under a microscope with a magnification 5x to engraved pine wood material with power P = 30 % and speed v = 50 mm/s. Line depth is 450 µm.*

Materials

In publication used two wood types of materials – plywood and pine.

Birch veneer (plywood) is a sheet material consisting of several glued veneer sheets, which are obtained by peeling a veneer block into a veneer chip. Plywood is usually made of several sheets of plywood, depending on the required thickness. The direction of the wood fibers in the adjacent sheets is usually perpendicular to each other. One-sided plywood is also produced, the veneer sheets of which are oriented in one direction. [9], [10].

Pine is softwood, natural wood material. Pine wood is medium-weight and relatively soft. Its strength and elasticity are good. As with other coniferous woods, the properties of the wood depend upon the density of the annual growth rings: The higher the proportion of summerwood, the heavier and harder the wood. [6], [8].

Results

The result charts are shown in Figures 4, 5, 6, 7.

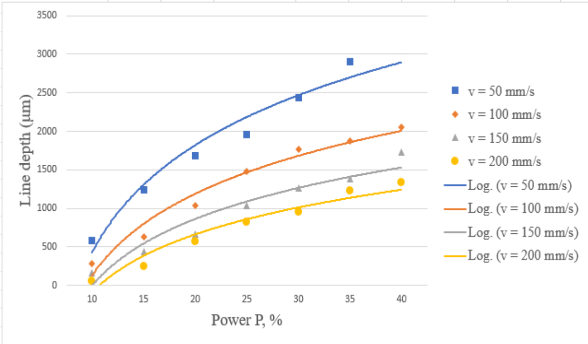


Fig.4. Graph of line depth values on plywood material depending as power change.

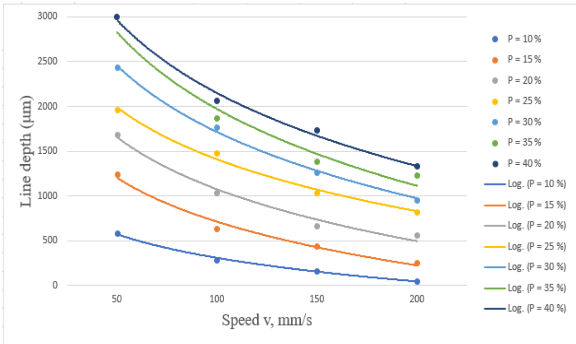


Fig.5. Graph of line depth values on plywood material depending as speed change.

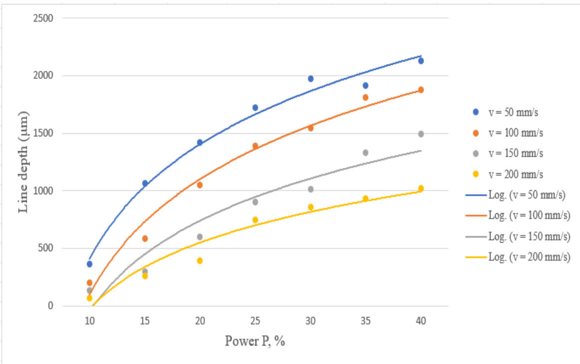


Fig.6. Graph of line depth values on pine wood depending as power change.

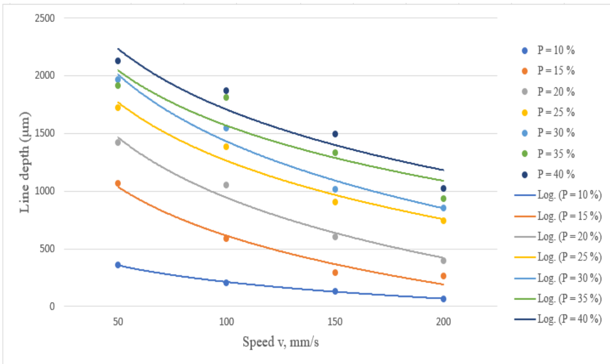


Fig.7. Graph of line depth values on pine wood depending as speed change.

The obtained results show that there is a regularity that increasing the laser power *P* increases the depth of the line, increasing the laser speed *v* decreases the line depth *h* and this regularity will appear in Figures 4, 5, 6, 7. in the charts. The line width was also measured experimentally on both plywood and pine materials, but due to the too uneven surface (Because of carbonization during marking process line surface was burnt) it is difficult to measure accurately. [2]. For plywood material at the following parameters v = 50 mm / s, power P = 35%, laser cutting begins, plywood material is 3 mm thick. In pine wood material has not been detected laser cutting process, marking, and engraving were observed.

Conclusions

1. *Analyzing the results of laser marking and engraving experiments for plywood and pine materials, the specific regularities are fulfilled. Graphics of line depth values of plywood and pine wood materials increase logarithmically, as power increases. But graph of line depth plywood and pine wood values decrease logarithmically, as speed increases.*
2. *When comparing plywood to pine material, it was found that the plywood material had a higher line depth than the pine material, which is because these materials have different mechanical and chemical properties, and that the pine board is a natural material, while the plywood is a manufactured material and consists from wood and glue layer.*
3. *The line width was also measured experimentally, but due to the uneven and burnt surface, the measurements were inaccurate and were not included in this article. Additional research is recommended to determine the dependence of the marked line width on speed and power.*

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