FACTORS INFLUENCING SOUND EMISSION DURING CIRCULAR SAWING OF OAK-WOOD (*QUERCUS ROBUR* L.)

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Abstract

This paper presents the results of research on sound emission during conventional sawing of oak-wood (Quercus Robur L.). The machining process was carried out on a circular saw for rip-sawing. The concerned variables in our research were: wood moisture content, cutting depth and feed rate. The cutting speed and tool parameters were constant. Also, directions of cutting with regard to grain directions in the whole experiment were approximately the same for each cutting depth.

Sound emission was measured for a specific condition of wood and machine parameters. At the same time the power requirements were measured, too.

The results obtained are summarized as follows:

(1) Sound level is higher during sawing of dried wood than green wood under the same sawing conditions.

(2) Sound level increases with the increase of feed speed for dried and for green wood but decreases for frozen wood.

(3) Sound level increases with the increase of cutting depth for dried wood but noise emission decreases with increased cutting depth for green wood.

(4) Cutting power reaches higher values during sawing of kiln dried wood and frozen wood than during sawing of green wood.

(5) Sound level for dried wood is in good correlation with cutting power, meaning that more work produces more noise; this statement, however, does not apply to sawing green wood.

Key words: *circular saw, wood moisture content, sound level, cutting power*

INTRODUCTION

For achieving efficient wood machining with circular saws, it is essential to understand thoroughly the interaction between raw materials, end products, machinery and the sawing process itself. Adequate knowledge of correct bite, feed speeds, tooth speeds, side clearances, depths of cut, cutting forces and power requirements is essential for a good saw operation.

We have a good understanding of the influence of most wood and machinery parameters on cutting forces and power requirements. Also, the influence of sawing conditions on sawing quality is a frequent object of research (Steward, 1984; Williston, 1989; Goglia, 1994; Aquilera and Martin, 2001).

Sound emission is an important parameter of sawing. Exposure of workers to noise is a health risk. There is sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension and ischemic heart disease, annoyance and sleep disturbance. Any subsequent harm depends on the level of exposure (Passchier-Vermeer and Passchier, 2000). The circular saws noise usually increases with the increase of the rotation frequency so that at higher cutting speeds it becomes a true health risk. Circular saw noise can be generally classified as idling noise and noise during cutting. The idling noise is induced by the interaction between the circular saw and the surrounding air. The noise during cutting originates primarily from the contact between the circular saw and the workpiece. Circular saws often reach higher noise levels at idling (because of the so called whistling noise) than in sawing and that is why the noise emission of idling circular saw is more frequently researched than noise emission during sawing. Many researches (Cho and Mote, 1977; Beljo-Lučić and Goglia, 2001; Leu and Mote, 1979; Dugdale, 1977; Hattori at al., 1999) deal with the problem of whistling noise.

The type and parameters of saw blade, rotation speed and clamping ratio are the most important factors affecting noise emission of idling circular saw (Cheng at al.,1998; Yanagimoto at al.,1995; Yokochi at al., 1994).

In order to establish the influence on the noise level during machining of wood, the right parameters should be chosen for each wood species or wood based materials. Effects of cutting conditions on the generation of sound were researched by Nagatomi et al (1993). Recognition of wood cutting conditions through cutting sounds was conducted in the research of relations between tool wear and cutting sound (Banshoya et al, 1994; Kitayama and Uekusa, 1985) and relations between surface-finish qualities and acoustic emission (Zhao et al, 1991). Researches have dealt with the effects of cutting velocities, feed speeds and cutting depth on sound emission, and however the influence of material properties, especially wood species and wood moisture content, were not thoroughly researched.

The purpose of our investigation was to measure sound level of the circular saw in cutting kiln dried, green and frozen wood and to determine the effect of feed speed and cutting depth on sound level. The secondary objective was to investigate the correlation between sound level and cutting power during circular sawing of solid oak-wood.

MATERIAL AND METHODS

This study researches the sawing process of the most important and most valuable wood species in Croatia: the oak wood (*Quercus Robur* L.). The machining process was carried out on a circular saw for resawing “Bratstvo”, type AC-3. The cutting speed was 53 m/s. Tool parameters are given in Table 1.

Table 1: Characteristics of used circular saw

Properties	Value
Saw diameter, mm	340
Number of teeth	24
Pitch, mm	43
Gullet area, mm^2	210
Blade thickness, mm	2.5
Kerf width, mm	3.3
Clearance angle, °	10
Hook angle, °	17

Cutting tests were performed on green (40-70 % of moisture content) and kiln dried wood pieces (8-12 % of moisture content), at three cutting depths (24 mm, 40 mm and 52 mm) and four feed speeds (15, 23, 30 and 46 m/min) keeping cutting speed constant. The measurement was also performed on a wood piece (cutting depth 52 mm) that was frozen. The directions of cutting with regard to grain directions in the whole experiment were approximately the same for each cutting depth (see Fig. 1). The moisture content was determined by use of electrical resistant wood moisture meter according to EN 175-13.01-2.

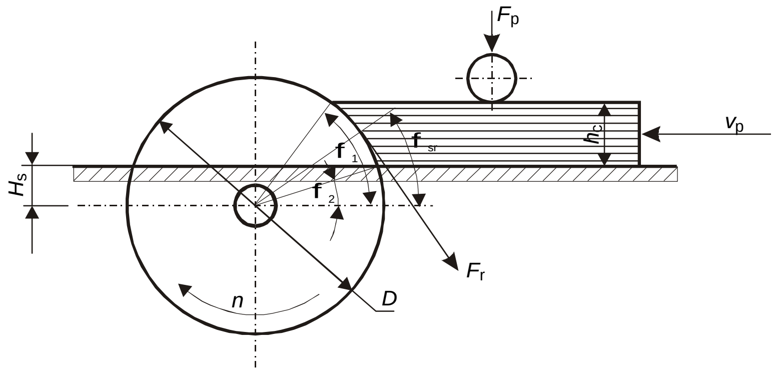

Figure 1 – Sawing condition

Electrical power was measured by the power converter Iskra MI 400 and sound level was measured by Bruel & Kaer Sound Level Meter, Type 2209. Electrical signals of this equipment were acquired with NI DaqPad 6070E for later post processing.

Cutting power P_c was derived as the difference between measured total power requirements and idling power requirements:

$$P_c = P_t - P_o \qquad (3)$$

Where: P_t – arithmetic mean of measured total power in 0.2 s intervals (the sampling frequency was 80 kHz); P_o - arithmetic mean of measured power during machine idling.
The measurement data were analysed by use of: LabVIEW, EXCEL and STATISTICA 6.0.

RESULTS AND DISCUSSION

Figure 2 shows the results of sound level in relation to feed speed for green, frozen and dried wood pieces and for three different cutting depths. In the range of the experiment feed speed it is obvious that the dependence of the sound level on feed speed could be expressed as linear.
For all cutting depths, measurement results have shown that higher sound level is generated during sawing dried wood than green or frozen wood. Sound level increases with the increase of feed speed for all cutting experiments except when sawing frozen wood. The linear trend line is better fitted for the data of sound level in relation to feed speed for green wood than for kiln dried wood. The difference between sound level during sawing of kiln dried and green wood is larger with higher cutting heights.
Figure 3 shows the data of sound level in relation to feed speed for different cutting depths. It is obvious that the sound level is higher when the cutting height is higher for kiln dried wood, but the results are quite opposite for green wood. This means that in case of sawing

green wood, wood moisture shows its sound damping effect, especially with higher cutting heights.

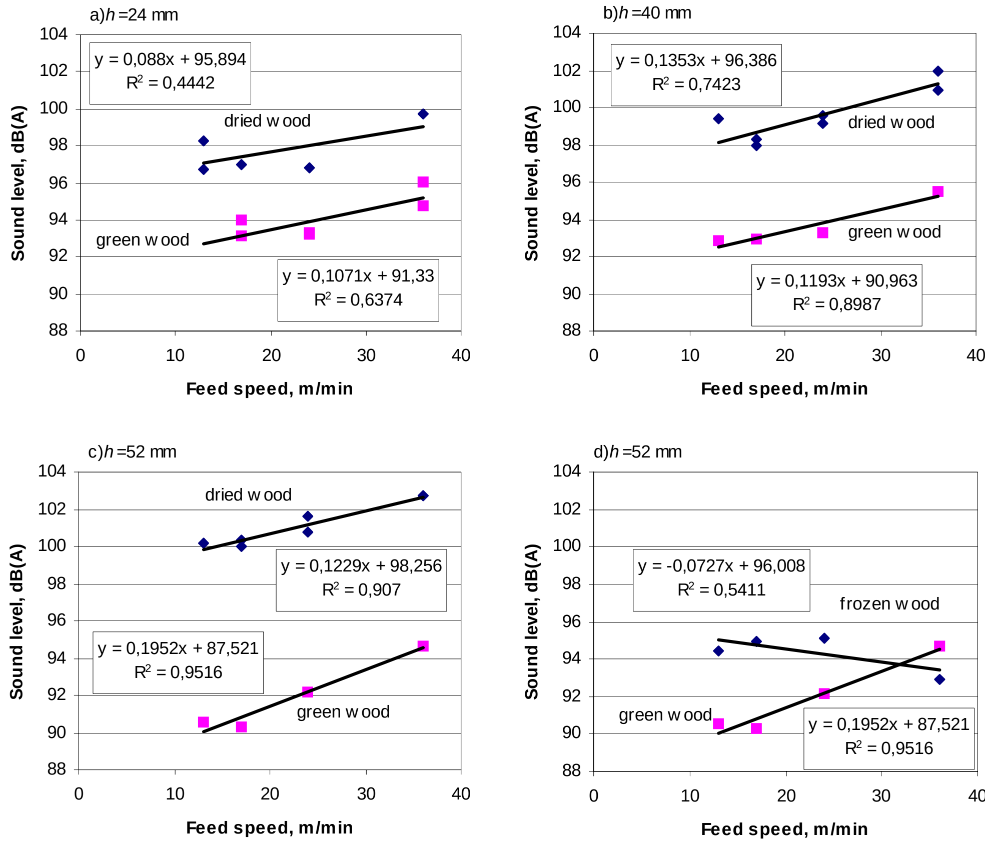

Figure 2 – Sound level in relation to feed speed for green, frozen and dried wood

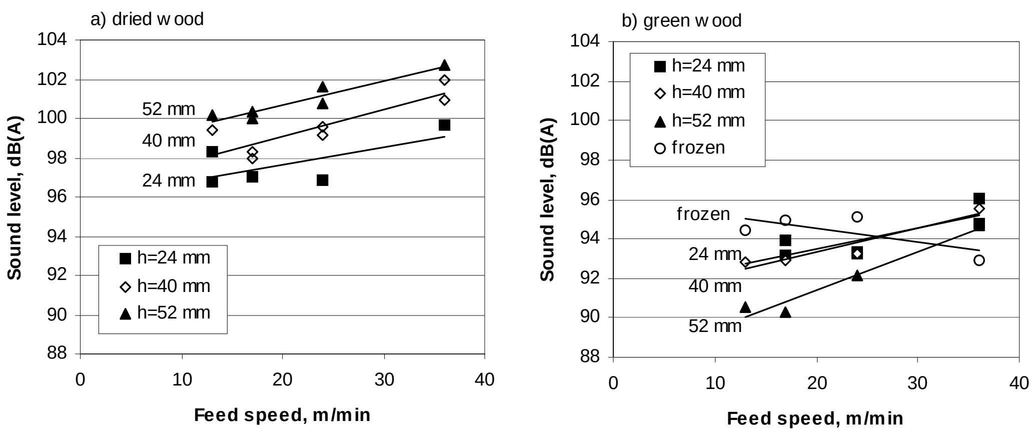

Figure 3 – Sound level in relation to feed speed for different cutting depths: a) dried wood, b) green wood

Figure 4 shows clearly that the relationship between sound level and cutting power could be expressed as linear with satisfying correlation coefficient only for kiln dried wood. So the possibility of recognition of cutting power variation by microphone, which could be used as part of an adaptive control optimization system, could possibly be implemented for dried wood.

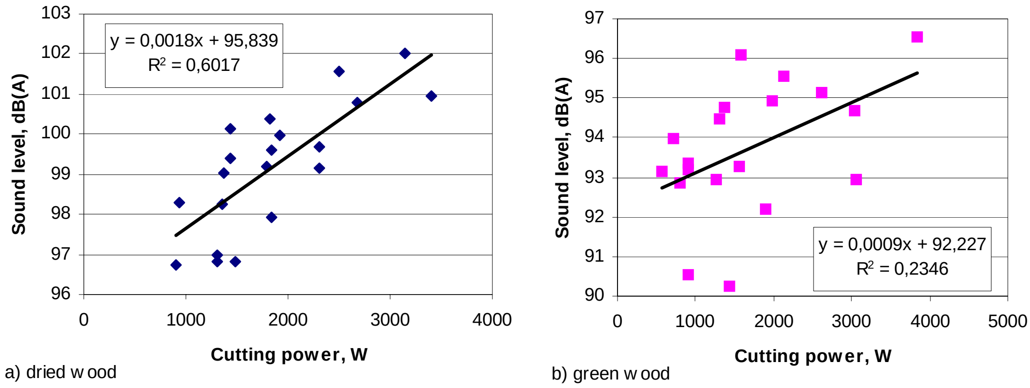

Figure 4 – Correlation between sound level and cutting power during circular sawing

It should be noted, however, that further research should be carried out of other machining parameters, sawing quality parameters and other wood species so as to make a comprehensive comparison between sawing of dried and green lumber and estimating the possible correlation between sound level and cutting power.

CONCLUSION

The results obtained are summarized as follows:

(1) Sound level is higher during sawing of dried wood than green wood under the same sawing conditions. Sound level increases with the increase of feed speed for dried and for green wood but decreases for frozen wood.

(2) Sound level increases with the increase of cutting depth for dried wood but noise emission decreases with increased cutting depth for green wood.

(3) Cutting power reaches greater values during sawing of kiln dried wood and frozen wood than during sawing of green wood.

(4) Sound level for dried wood is in good correlation with cutting power, meaning that more work produces more noise; this statement, however does not apply to sawing green wood.

These results could be useful in optimizing the process of wood machining, when it should be decided whether to saw green or dried lumber. Advantages of machining green lumber are definitely lower power requirements and lower level of sound emission than is the case with machining dried wood.

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