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Design of circular saws in view of noise emission

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Abstract: *Design of circular saws in view of noise* emission. The paper presents an analysis of selected carbide tipped circular saws in terms of the characteristics and location of design solutions reducing noise emission. Analyses of emitted sound spectrum, during sawing and idling, were conducted on 5 saws with comparable characteristics in terms of their design and basic dimensions. The greatest noise dampening efficiency was provided by the use of a damping foil in the design of saws. It was observed that the highest sound levels during saw operation are found at frequencies of 2 – 8 kHz. Saws with no special antinoise solutions had the greatest values of emitted noise over the entire investigated range. The use of an irregular tooth pitch resulted in the elimination of impulse sound level changes.

Keywords: circular saws, noise emission, noise dampening incisions, irregular tooth pitch

INTRODUCTION

Noise is the most frequent health hazards observed in workplaces connected with wood working and processing of wood-based materials. Particularly adverse effects in this respect are observed in the course of sawing operations with the use of circular saws. Circular saws have relatively few solutions protecting against noise emission. Commonly used circular saws, most typically carbide tipped circular saws, generally have large diameters at the simultaneous limited body thickness, ensuring lower saw kerf widths. The cutting motion of a circular saw causes vibrations during its operation and the saw, acting as a membrane, emits sound waves. Problems connected with noise emission levels in wood machining plants as well as noise hazard, mainly during sawing operations, are presented in (***Kowal 1993***, ***Kowal et al. 2013, Puzyna 1985, Rybarczyk 1999, Rybarczyk 2007***).

During its operation the saw blade is exposed to tangential and radial tensile stresses as well as stresses generated by thermal fields and cutting forces. Tangential and radial stresses as a result of centrifugal forces provide dynamic stiffness to the rotating saw. An increase in temperature during cutting causes disturbances in the distribution of stresses.

According to (***Wasielewski 2011***), saw stiffness prevents elastic deformations of the saw under the influence of these forces.

Studies on the form of vibrations and the mechanical and mathematical models of torsional vibrations in circular saws are presented in papers (***Kaczmarek et al 2014, VUKOV et al. 2013***).

At present manufacturers of circular saws focus on the elements of saw design connected with a reduction of noise emission, both in standard saws and saws labelled as reduced-noise saws. Operation of saws generating low noise emissions is an essential factor both in the occupational safety within the work environment and in environmental protection.

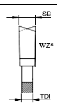
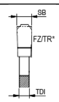
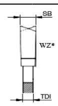
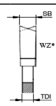
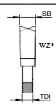
Papers (***Kopecký et al. 2011, Kopecký et al. 2010***) presented studies and analyses concerning the effect of design modification in circular saws, mainly in terms of varied pitch, on the quality of worked surface and the level of noise generated by saws. According to (***Kopecký et al. 2010***), a positive effect of composite toothing and antiresonance incisions may be found on noise reduction of selected saws.

This paper presents studies and analyses of selected design solutions of circular saws, connected with the reduction of noise emission and their effect on saw silencing effects.

RESEARCH METHODOLOGY

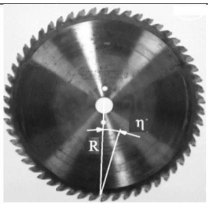
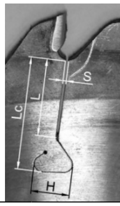
Tests were conducted on five carbide tipped circular saws, denoted with nos. 3, 4, 5, 8 and 10, selected from a larger group of saws. All saws had identical main dimensions (table 1).

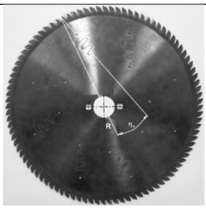
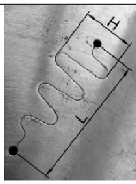
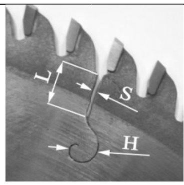
Tab. 1 Characteristics of tested carbide tipped circular saws

Circular saw	No. 3	No. 4	No. 5	No. 8	No. 10
Outside diameter D [mm]	350	350	350	350	350
Kerf width SB [mm]	3,2	3,2	3,2	3,5	3,2
Body thickness TDI [mm]	2,2	2,2	2,2	2,5	2,2
Number of tooth z [pcs.]	54	96	54	54	54
Pitch t [mm]	20,36	11,45	17,1 – 24,43 irregular	20,36	20,36
Manufacturer (name)	*Leitz*		*Leitz*	*Leitz*	*Leitz*
Toothing type ***WZ – alternately oblique from the flank face** ***FZ/TR – alternately simple and trapezoid**					

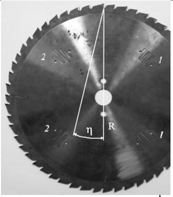
Characteristics of design solutions of tested circular saws (nos. 3, 4, 5, 8) in terms of noise emission reduction, are presented in Table 2. Circular saw no. 10 had no special antinoise solutions applied.

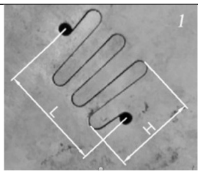
Tab. 2 Characteristics of design solutions of tested circular saws

Saw no. 3			
	Three long, straigth dampening dilatation grooves, made at every 120º, triangular-shaped end; each groove set at angle η ≅ 10° in relation to the direction of radius (R)		L ≅ 23,5 mm L_c ≅ 33,5 mm S = 0,8 mm H ≅ 11,0 mm

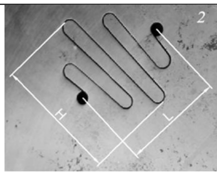
Saw no. 4				
	Eight noise dampening incisions in saw body, arranged at angle η_u ≅ 15° in relation to direction of radius (R)	 L = 50,0 mm H ≅ 19,5 mm	 L ≅ 10,5 mm, H ≅ 6,0 mm S = 0,8 mm	Four dilatation grooves, short, spiral-like ends, arranged at angle η ≅ 10° in relation to direction of radius (R)

Saw no. 5

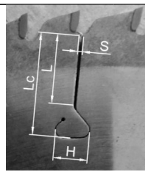




L ≅ 30,5 mm
H ≅ 23,0 mm



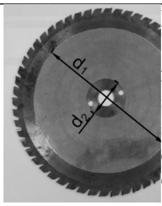
L ≅ 30,5 mm
H ≅ 38,0 mm



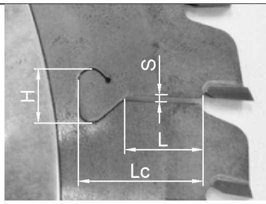
L ≅ 23,5 mm
L_c ≅ 33,5 mm
S = 0,8 mm
H ≅ 11,0 mm

- irregular pitch of saw tooting,
- four dampening dilatation grooves, straight, triangular-shaped end, between noise dampening incisions, arranged at angle η ≅ 10° in relation to direction of radius,
- two shape types of noise dampening incisions (*1* and *2*), arranged at the circumference, in saw body:
  1. two regular incisions of identical height, ended with openings arranged at different diameters,
  2. two incisions of irregular height, ended with openings arranged at different diameters with.

Saw no. 8



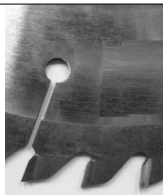
Damping foil (right-side) mounted in specially prepared seat, in saw body
d_1 = 270 mm
d_2 = 72 mm



Three dilatation grooves, arranged at every 120º, triangular-shaped end
L ≅ 15,0 mm
L_c ≅ 24,5 mm
S = 1,2 mm
H ≅ 11,0 mm

Saw no. 10

Three wide dilatation grooves, arranged at every 120º



Noise levels were measured in a closed shop floor. All measurements at identical ambient conditions at a temperature of 18^{o}C. The main element of the testing station (Fig. 1) was a circular saw by Robland, model Z3200, adequately prepared for the tests condenser microphone by Tbone SC440, with sound transfer band of 30 Hz-20 kHz, was mounted on the right of the saw (Fig. 1). For each saw 3 series each were performed, comprising measurements of sound spectrum, at 30 s intervals on idle and during sawing. Rotational velocity of the saw spindle during tests was 4000 min^{-1}. Recordings were taken using a digital audio editor Audacity. Sound spectrum was measured during the sawing operation on a three-layer laminated particleboard by Egger, of 18 mm in thickness.

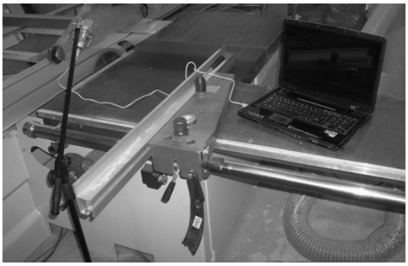
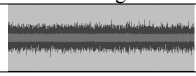
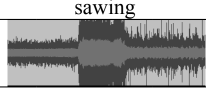
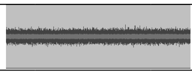
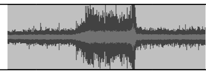
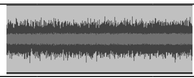
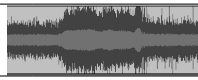


Fig. 1. The testing station

Tab. 3 Images of sound spectrum for selected saws, recorded during test

Idling	sawing
	
Saw no. 3	
	
Saw no. 4	
	
Saw no. 10	

RESULTS AND DISCUSSION

Recorded sound spectrum images for selected saws, when idling and during sawing, are presented in Table 3.

Figure 2 presents values averaged for the whole range of tested frequencies, recorded for sound emitted by tested saws when idling and during sawing, while Fig. 3 presents the graph for sound levels, emitted by saws during sawing over the range of tested frequencies.

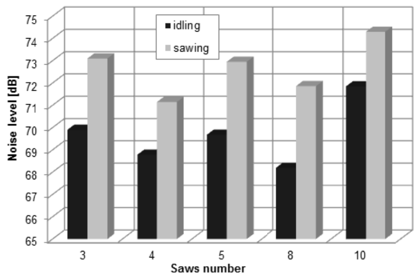


Fig. 2. Averaged values of sound emitted by tested saws

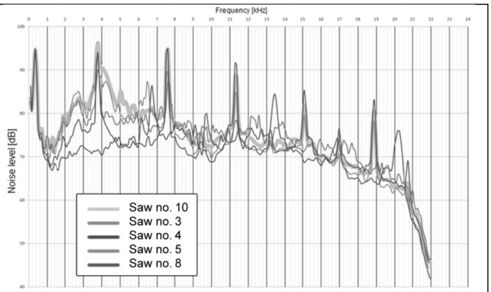


Fig. 3. A graph of sound, emitted during sawing over the range of tested frequencies

CONCLUSIONS

These tests showed that the highest values of sound emitted by saws during operations were recorded within the range of frequencies from 2 to 8 kHz. The design of the circular saw with a damping foil ensures the greatest efficiency of reduction for noise emitted when idling, while noise emitted during sawing was considered to be the least bothersome, within the detectable range. The application of an irregular tooth pitch resulted in the elimination of impulse sound level fluctuations. Saws with no special design solutions connected with the minimization of noise emission had the greatest values of the measured noise spectrum, both for idling and sawing.

It was concluded that advantageous effects resulting in lower noise emission in carbide tipped circular saws may be obtained thanks to the adequately selected design of dampening dilatation grooves.

It was stated that the level of sound emitted by circular saws is determined also by the number of teeth, as well as the application of a set of various design solutions reducing noise emission within one saw, which needs to be confirmed in the course of further research.

REFERENCE

1. KACZMAREK A., JAVOREK L., ORŁOWSKI K. 2014: Mode vibrations of plates – experimental analysis. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology 88: 97-101.
2. KOPECKÝ Z., ROUSEK M., HLÁSKOVÁ L., VESELÝ P., SVOBODA E. 2011: Quality of the workpiece surface at cutting by a circular-saw blade with the irregular tooth pitch. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology No 74: 192-198.
3. KOPECKÝ Z., ROUSEK M., VESELÝ P. 2010: The noise level of circular sawblades with the irregular tooth pitch. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology No 71: 360-366.
4. KOWAL E. 1993: Analiza zmian zagrożenia hałasem w wydziałach obróbki mechanicznej drewna i ich wpływ na wydajność pracy, Wydawnictwo Wyższej Szkoły Pedagogicznej im. Tadeusza Kotarbińskiego w Zielonej Górze.
5. KOWAL E., DUDARSKI G., CZĘSTOCHOWSKI C. 2013: Analysis of noise emission in wood bucking. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology 83: 78-81.
6. PUZYNA C. 1985: Podstawowe wiadomości o dźwiękach i ich oddziaływaniu na człowieka. Instytut Wydawniczy Związków Zawodowych, Warszawa.
7. RYBARCZYK W. 1999: Hałas w przemyśle i jego ograniczanie – ujęcie ekonomiczne – dla przedsiębiorców. Centrum zastosowania ergonomii, Zielona Góra.
8. RYBARCZYK W. 2007: O ograniczaniu hałasu na stanowiskach pracy realistycznie. Centrum zastosowania ergonomii, Zielona Góra.
9. VUKOV G., GOCHEV Z., SLAVOV V, WIELOCH G. 2013: Investigation of the forced torsional vibrations in the saw unit of a University of Life Sciences – SGGW. Forestry and Wood Technology No 81: 279 kind of circular saws. Part I: mechanic-mathematical model. Annals of Warsaw -285.
10. WASIELEWSKI R. 2011: Dokładne i oszczędne przecinanie drewna piłami tarczowymi. Wydawnictwo Politechniki Gdańskiej, Gdańsk.

Streszczenie: *Konstrukcje pił tarczowych w aspekcie emisji hałasu.* W pracy dokonano analizy wybranych pił tarczowych z nakładkami z węglików spiekanych, w zakresie charakterystyki i lokalizacji rozwiązań konstrukcyjnych zmniejszających emisję hałasu. Do badań widma dźwięku, w czasie piłowania i na biegu luzem, przyjęto 5 pił o zbliżonych charakterystykach, w zakresie budowy i głównych wymiarów. Największą efektywność tłumienia hałasu zapewniło zastosowanie w konstrukcji piły folii wygłuszającej. Zaobserwowano, że najwyższe wartości poziomu dźwięku podczas pracy pił występują w zakresie częstotliwości 2 – 8 kHz. Piła bez specjalnych rozwiązań antyszumowych wykazała największe wartości poziomu hałasu w całym zakresie badań. Zastosowanie nieregularnej podziałki uzębienia piły spowodowało wyeliminowanie impulsowych skoków poziomu dźwięku.

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