ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 11 N° 2 2015
pp. 21-30

COMPARATIVE STUDY ON THE TECHNICAL PERFORMANCES OF TWO THICKNESSING MACHINES

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Abstract:
The paper presents a series of experimental researches on two operating parameters – the energy consumption and the generated noise level – for two thicknessing machines of different generations: MRG8 (production year: 1972) and Felder D963 (production year: 2013). The aim was to highlight some of the developments registered over four decades by this type of woodworking machines. The results show that, in similar operating conditions, the new machine consume less energy and produce lower noise level.

Key words: *thicknessing machines; evolution; energy consumption; noise level.*

INTRODUCTION

The idea of this comparative study has arisen when the lab of woodworking machine-tools of the Wood Engineering Faculty has been equipped with new machines. Thus, the obvious question for any professional "Is it really better the new machine?" was able to quickly find the answer. For comparison two thicknessing machines were chosen, MRG8, Romanian construction, production year 1972 (Fig. 1a), respectively Felder D963, production year 2013 (Fig. 1b). The next question was: "But what mean ***to be better***?", in other words, how can we quantify this ***better***? Leaving aside the obvious differences in design and control/adjustment systems, more advanced in terms of precision and ergonomics of the newer machine, the authors decided an evaluation in terms of energy consumption, generated noise and quality of the machined surface. This paper focuses on the first two aspects. The results regarding the quality of processed surfaces will be presented in a forthcoming paper.

a. ***b.***

Fig. 1.
The two thicknessing machines used for experimentations:
a – MRG 8; b – Felder D963.

The energy consumption (the consumed active electric power) is an important criterion considered in the analysis of various factors which influences woodworking and also the wear level of a woodworking machine tool. Therefore Budău G, in his doctoral thesis, studied the processing power consumption in order to realize an adaptive control system and its integration into a MRG8 thicknessing machine (Budău 1988).

Darmawan W (2011) studied wood planing using a milling cutter with solid helical edge compared to a conventional edge milling cutter. The results showed that the helical edge milling cutter generates slightly larger cutting power, but the sound pressure level generated is considerably lower than the sound pressure made by the conventional edge, up to 5dB(A). Regarding the wear resistence the helical edge milling cutter are better, these suffer less edge fractures and the quality of the wood surface is better than the one generated by planning with conventional edge cutter.

Minami T and Nishio S studied the planning with a unique planer head that they developed – a U-formed planer head - with a ultra-thin HSS hard coated knife curved into a U-form. They found that the coated thin knife had a 5 time longer cutting life, and the cutting noise lower than a uncoated steel knife (Minami 2011, Minami 2013).

The energy consumption on milling was studied by several researchers. Lee H. W. studied power consumption on peripheral milling for twelve Korean domestic species. The results showed that average power consumption increased as cutting depth increased (Lee 2005). Power consumption, cutting forces and surface roughness were studied by Aguilera A. on milling in two different ways: conventional and climb cutting (Aguilera 2001). Also Barcik S made a study about the power consumption for cutting at plain milling. Were used different parmeters for cutting and feed speed while milling beech wood (Barcik 2010).

More studies regarding the energy consumption in wood processing were made with the development of wood composite panels technologies when the canter chipping process was studied. Various studies were made, like: a theoretical model for power consumption during chipper canter process (Lusth 2013), the variation of energy consumption depending on the cutting angles (Lusth 2012), the effects of chipping length and wood properties on direct power consumption (Di Fulvio 2015) or the energy effiency of drum and disk chippers (Spinelli 2013).

Ţăran N and Godan N (Ţăran 1992, Godan 2009), analyze the noise spectrum measured on a MRG8 thicknessing machine in different positions, at idle running and under load, with and without the exhaust system functioning, to the processing of various species (fir, oak, beech). The results indicated that the noise generated during thicknessing, in all test conditions were above the maximum alowed level.

Heisel U found the distribution of noise intensity at a thicknessing machine and the sound pressure level generated at processing by changing the feed rate and depth of cut (Heisel and Groβ 2007). There was observed the trend of increasing the sound pressure level with the increase of the feed speed.

The variation of the sound pressure level was studied by Stehle (cited by Godan 2009). He analyzed the influence of the working shaft length, of the motor power and its rotational speed. He observed an downward trend in the sound pressure level with the increase of the main shaft length, but a small variation with the increase of the rotational speed in the range 4000-5000rpm.

OBJECTIVES

The main objective of this study was to analyze the evolution over time (over 40 years) of thicknessing machines by comparing the performance of two such machines in terms of energy consumption and operating noise levels generated, the first machine (MRG8) being manufactured in 1972, and the second one (Felder D963) in 2013.

METHOD AND MATERIALS

The technical characteristics of the two thicknessing machines used in the study, MRG8 (Fig. 1a) respectively Felder D963 (Fig. 1b), are presented in Table 1.

Table 1

Main technical characteristics of MRG8 and Felder D963 thicknessing machines

Technical characteristic	MRG 8	FELDER D963
Width of working table	800mm	630mm
Vertical stroke of working table	200mm	300mm
The positioning accuracy of the working table	0.05mm	0.1mm
The working shaft diameter	140mm	120mm
Number of knives of the working shaft	4 plane din OSC	2 elicoidale, segmentate din CMS (Silent-POWER spiral cutterblock)
The rotational speed of the working shaft	5580rpm;	4566rpm
Cutting speed	40.9m/s	28.7m/s
Feed speed	1-40m/min	4-16m/min
Puterea motorului electric:	5.5kW	7.5kW
The rotational speed of the electric motor	2850rpm	2850rpm

The samples used within the present research (Fig. 2) were cut from 25mm thickness semiradial beech timber. They were processed by planing and thicknessing in order to reach the final dimensions as in Fig. 2.

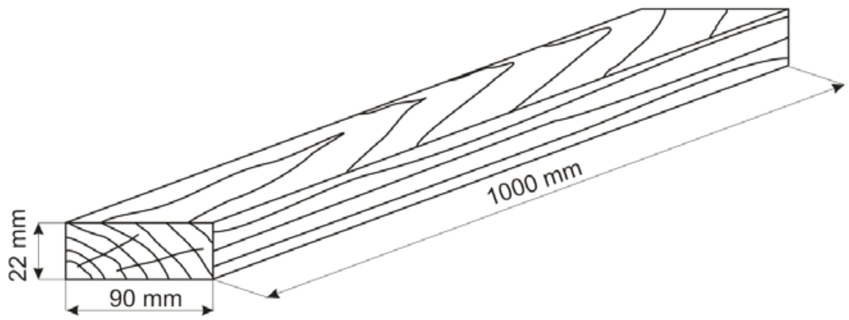


Fig. 2.
Shape and size of samples used within the experiments.

The experiments were conducted having as variables the cutting depth h, the tooth bite u_z, and the machine type (Table 2).

Table 2

Working parameters

Parameter	MRG 8	FELDER D963
Cutterblock diameter, *Ds*	140mm	120mm
Number of cutting edges, *z*	4	2
Rotation speed of cutter-block, *n*	5580rpm	4566rpm
Cutting depth, *h*	1mm; 2mm	
Tooth bite, u_z	0.88 / 1.33 / 1.75mm	
Feed speed, *u*	20 / 29.5 / 39m/min	8 / 12 / 16m/min

The values of the tooth bite were calculated using the known formula:

$$u_z = \frac{1000 \cdot u}{n \cdot z}, \text{ (mm)} \qquad (1)$$

where:

n – rotational speed of the working shaft, rpm;
u – feed speed, m/min;
z – number of knives.

Energy consumption

An objective of the study was to measure the energy consumption (power consumption or active power) in planing of beech wood. The comparative experiments were carried out in identical working conditions in terms of processed material, of the cutting depth h and tooth bite u_z.

For a better representativity of the results, each working schedule was repeated for three times, the final results representing the average of the individual measurements. Thus 36 measurements were performed (2 thicknessing machines x 2 cutting depths x 3 tooth bites x 3 measurements for each schedule). Measurements of consumed active electric power were carried out in idle running and during processing.

The energy consumption measurements have been carried out by means of a data aquisitioning system (DAQ), comprising: a three-phase transducer for active power type Sineax P530/Q531, a Velleman Instruments DAQ board type Velleman PCS10 and a PC. The main technical characteristics of the Sineax P530/Q531 transducer are:

- nominal input voltage: 220/380 V;
- nominal input current: 5 A;
- input frequencies: 45 ... 55 Hz;
- output voltage: 0 ... 10 V;
- output current: 0 ... 20 mA;
- precision: 1%.

The apparatus has been connected into the electric circuit of the machine motor, according to the scheme presented in Fig. 3. The DAQ software was Velleman Pc-Lab 2000. The DAQ was made with a frequency of 100Hz.

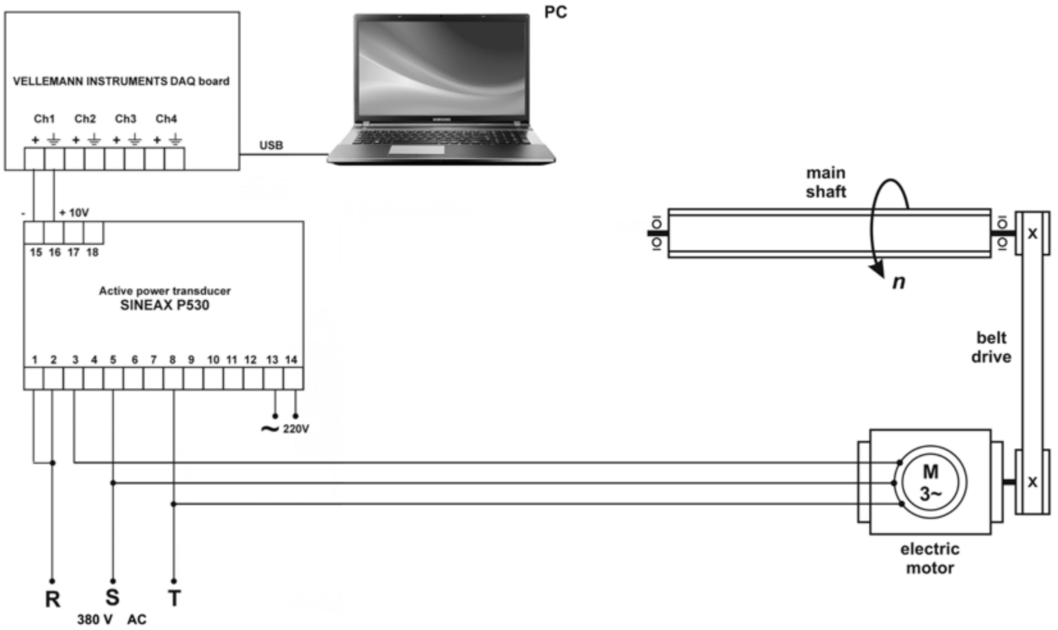


Fig. 3.
Connection scheme of the aparatus used for power consumption measurements.

Sound level

The second objective was to measure the level of the noise generated during thicknessing. These measurements were made simultaneously with the active power consumption measurements by using a sound level meter Bruel-Kjaer type 2250, a modular measurement platform with many optional application modules such as frequency analysis, FFT, advanced logging (profiling), sound recording and building acoustics, with the main technical characteristics:

- 4.2Hz - 22.4kHz broadband linear frequency range, with supplied microphone Type 4189;
- 16.6 - 140dB A-weighted dynamic range, with supplied microphone Type 4189.

Data were recorded according to Romanian standard STAS 8857-87. Thus, the sound level meter was placed at 1.5m height above the floor, in the machine operator position (Fig. 4).

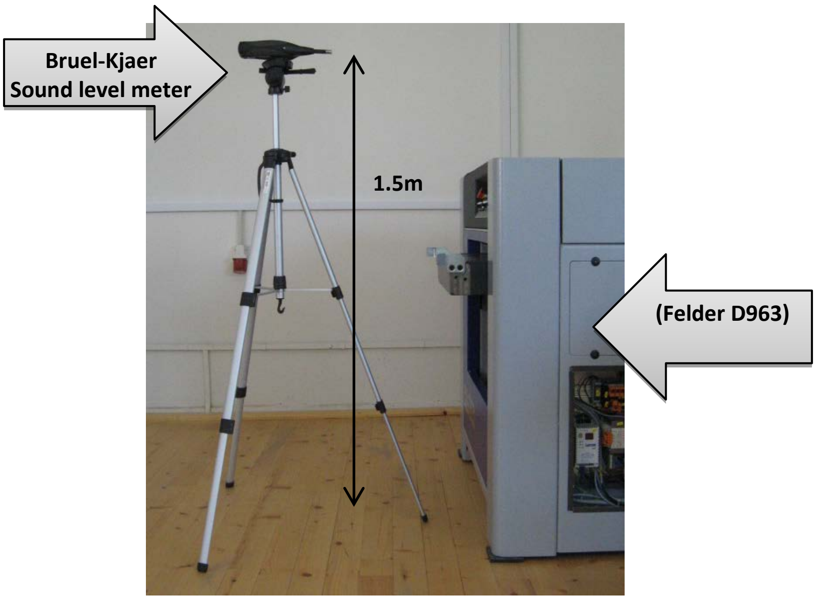


Fig. 4.
The positon of sound level meter for data recording.

RESULTS AND DISCUSSIONS

Energy consumption

The obtained data were recorded and saved using the DAQ software Velleman Pc-Lab 2000. These represent the values of the total electrical active power consumed (P_T) by the motors which drives the working shafts during processing. The total consumed power includes both the power consumption for moving the machine organs (at idle running) P_0 and the power consumption for effective processing (the cutting power) P_a:

$$P_T = P_0 + P_a \text{, (kW)} \quad (2)$$

where:

P_T – the total electrical active power consumed;
P_0 – the consumed power at idle running;
P_a – the cutting power.

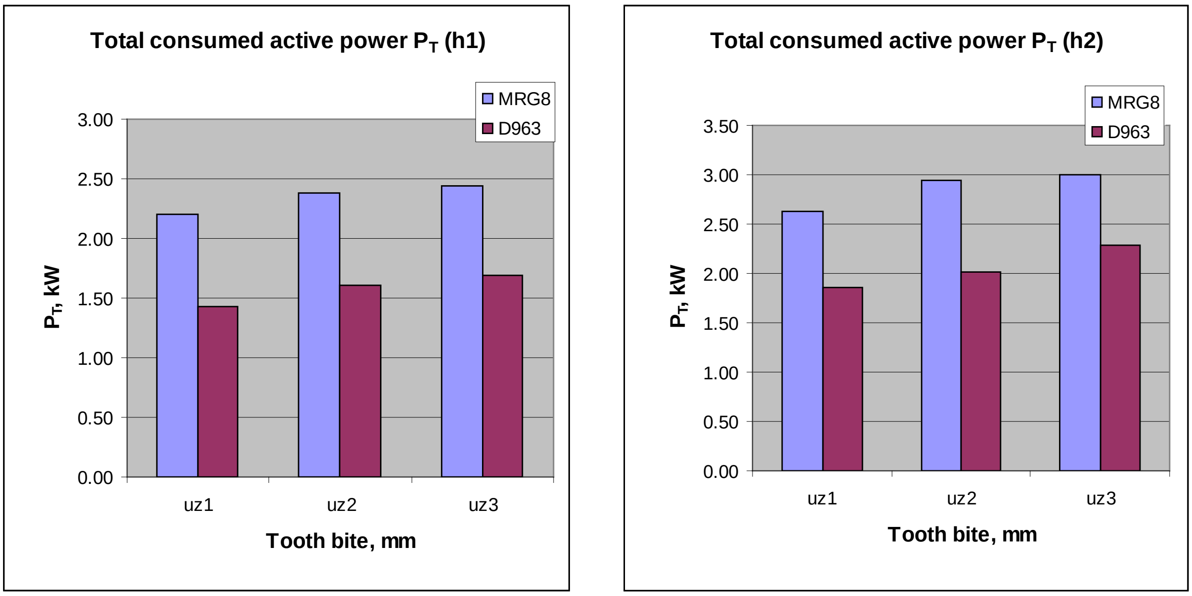
Data processing has been performed by means of the MICROSOFT EXCEL 2010 programme and the main results are presented in Table 3 and Fig. 5.

Table 3

Active power consumed on thicknessing for MRG8 and Felder D963 (averages)

Total electrical active power consumed P_T, [kW]	MRG 8			FELDER D963		
	Cutting depth h1	Cutting depth h2	Idle running (P_0, kW)	Cutting depth h1	Cutting depth h2	Idle running (P_0, kW)
Tooth bite u_{z1}	2.21	2.63		1.42	1.85	
Tooth bite u_{z2}	2.39	2.94	1.90	1.61	2.02	0.82
Tooth bite u_{z3}	2.45	3.00		1.70	2.29	

As expected, an increase of the consumed active power with the feed speed is observed (namely the tooth bite u_z), but also with the increase of the cutting depth h. It is also observed the value of the idle running power P_0, much higher for MRG8 than for D963 (2.3 times higher!). This can be explained both by the much larger masses put in motion by the electric motor of the MRG8 machine and the lower transmission efficiency with conventional wide belt (at MRG8) compared with the efficiency of the Poly-V belt transmission (at D963), but also by the higher friction in bearings and the more intense aerodynamic phenomena generated by the working shaft of MRG8.



a. ***b.***

Fig. 5.
The total active power consumed on thicknessing:
a – cutting depth 1mm; b – cutting depth 2mm.

Sound level

The sound pressure level was recorded and processed using BZ-5503 Measurement partner suite software (Fig. 6), which allowed the analysis of noise frequency bands. The A-weighted sound pressure level equivalent continuous LAeq, was determined, this being a descriptor of noise emission and noise exposure (ISO 11690-1: 1996, Godan 2009).

For most industrial noise measurements an A weighted Leq or LAeq is used. In many countries the maximum permissible noise levels (continuous or intermittent noise) from a factory Leq = 85dB(A) for eight hours duration daily (http://www.bksv.com/doc/bo0051.pdf). Leq is the preferred method to describe sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest.

It is common practice to measure noise levels using the A-weighting (LAeq) setting built into all sound level meters. In which case the term is properly known as LAeq. (http://www.gracey.co.uk/basics/leq-b1.htm)

In order to rate the noises it is recommended to use the family of curves which correspond to the noise criteria Cz (Godan 2009). In the woodworking industry, maximum sound pressure level is expressed using the Cz85 curve. Thus, if the noises spectrum generated in the workplace exceed the Cz85 curve at one or more frequencies this does not comply with the allowed limits, and it is harmful for human (Ţăran 2005, Ţăran and Godan 2006). Hearing loss is prevented if the sound pressure level of a noise, which operates continuously for more than 5 hours per day, does not exceed the noise criterion Cz85 at the frequencies of 500, 1000 and 2000Hz (Darabonţ 1983, Godan 2009).

The final data processing has been performed by means of the MICROSOFT EXCEL 2010 programme.

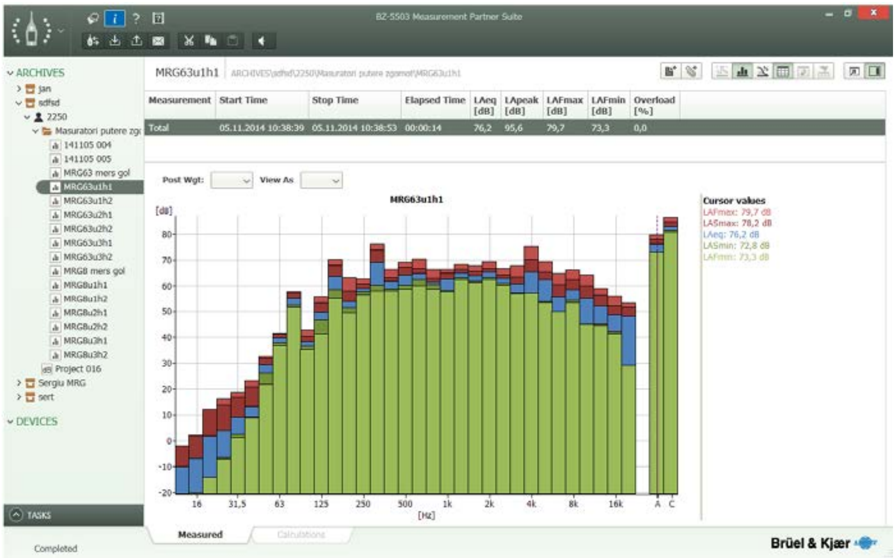
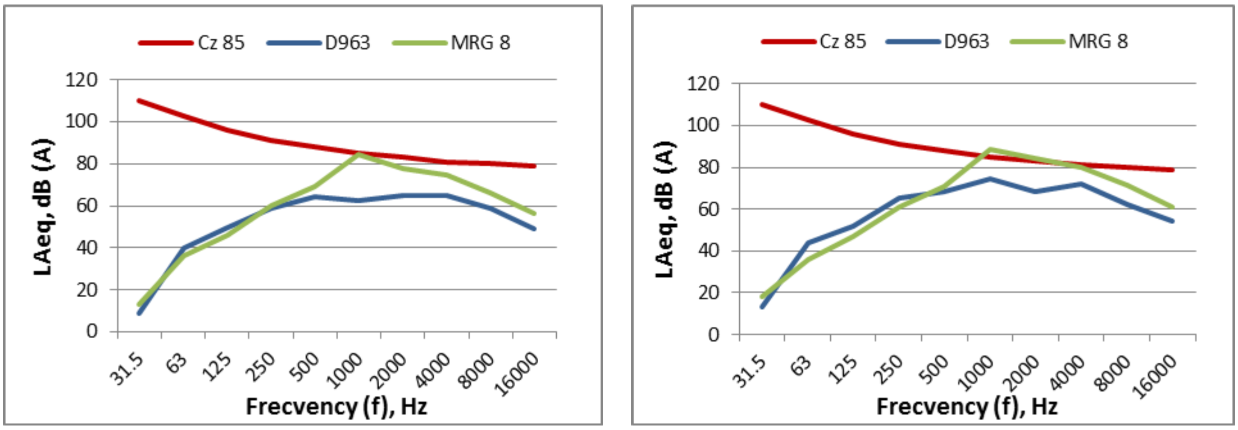


Fig. 6.
Window of the software used for processing the sound level data.

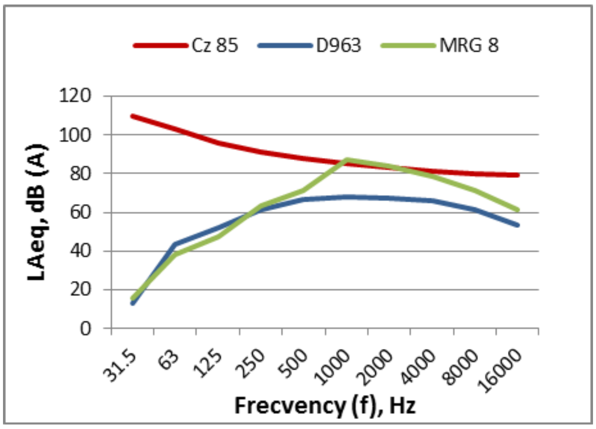
It can be seen a trend of increasing sound pressure level LAeq with the increase of the feed speed, namely of the tooth bite u_z (Fig. 7, 8 and 9). The increase of the sound pressure level is also observed with the increase of the cutting depth h.

In Fig. 10 is presented the chart of the sound pressure level LAeq at idle running for both thicknessing machines.

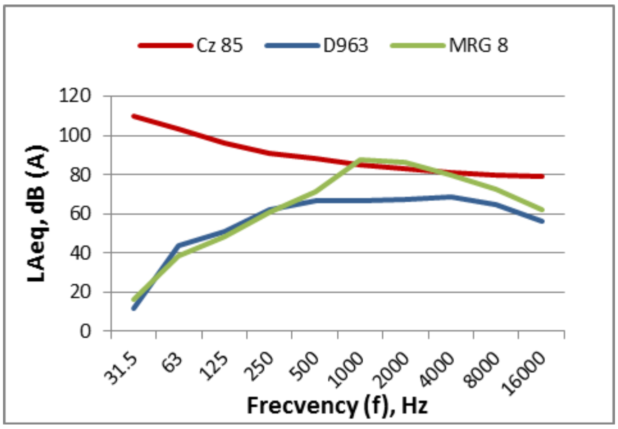


a. ***b.***

Fig. 7.
The sound pressure level LAeq:
a - for u_z1 and h1; b - for u_z1 and h2.

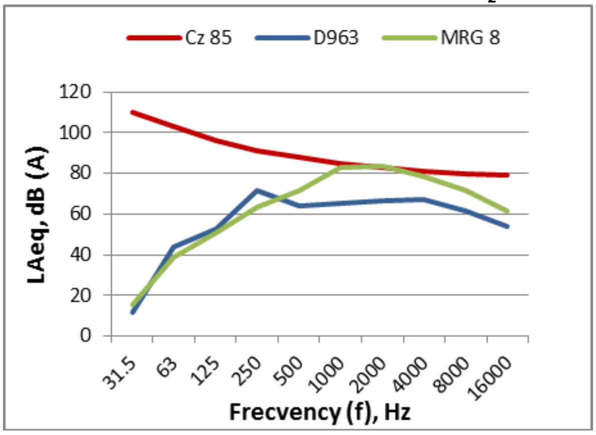


a.

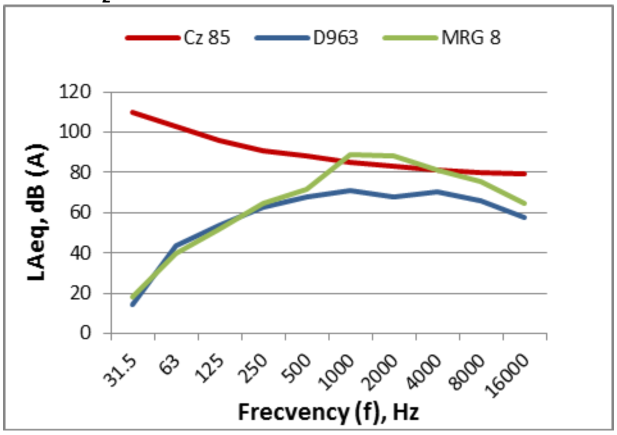


b.

Fig. 8.
The sound pressure level LAeq:
a - for u_z2 and h1; b - for u_z2 and h2.



a.



b.

Fig. 9.
The sound pressure level LAeq:
a - for u_z3 and h1; b - for u_z3 and h2.

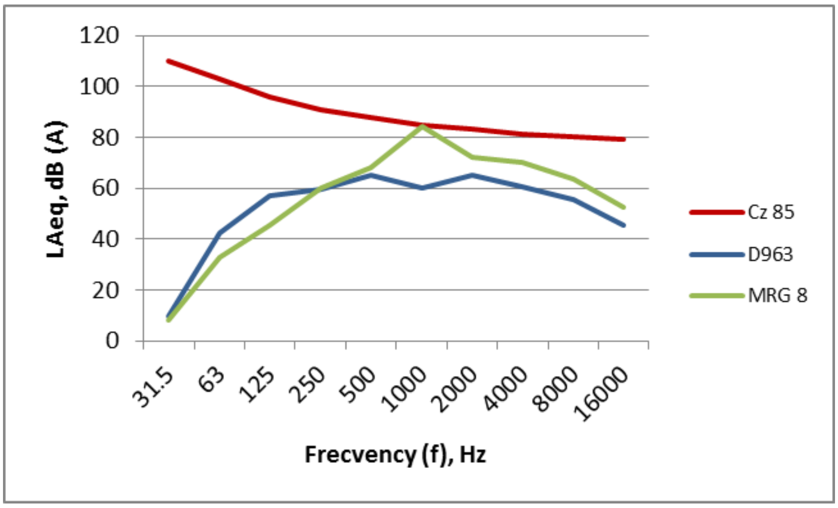


Fig. 10.
The sound pressure level LAeq at idle running.

The processing operations performed on the MRG8 machine recorded a sound pressure level very close to the values of the Cz85 curve, even exceeding them in most cases, in frequency ranges of 1000, 2000 or 4000Hz. In the case of measurements recorded at the Felder D963 machine values were much lower, around 70dB, the maximum value, for u_z1 and h2, being 74.6dB(A) (the limit value on Cz85 curve being 85 dB(A)).

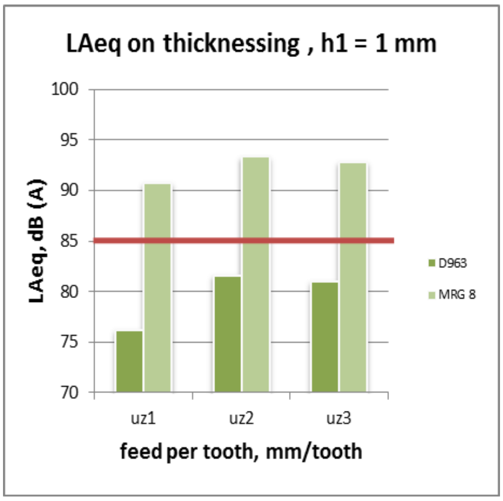
Table 5

Sound level for MRG8 and Felder D963 on idle running

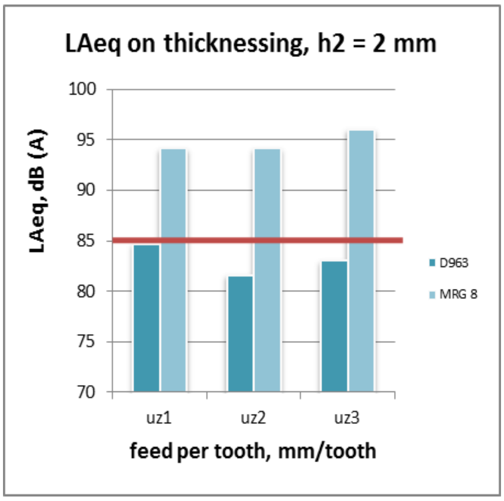
f, Hz	31.5	63	125	250	500	1000	2000	4000	8000	16000
Cz 85, dB	110	103	96	91	88	85	83	81	80	79
D963, dB	9.4	42.5	56.8	59.5	65.2	60.2	65	60.6	55.3	45.4
MRG 8, dB	8	32.7	45.4	60	68.1	84	71.9	70	63.7	52.6

So, the results show that the sound pressure level LAeq registered when processing on the MRG8 machine is higher than the maximum limit of 85dB(A) at all operating modes, but in the case of processing on the FELDER D963, it is under the maximum limit allowed at all operating modes (Fig. 11). It can also be observed the increasing trend of the sound pressure level LAeq with the increase of the feed speed, namely of the tooth bite u_z.

These results can be explained both by the increased intensity of the aerodynamic phenomena given by the working shaft of the MRG8 machine compared with the Silent-Power shaft of the machine D963, but also by the sound insulation of the D963 machine in the area of the working shaft.



a.



b.

Fig. 11.
LAeq on thicknessing:
a – cutting depth 1mm; b – cutting depth 2mm.

CONCLUSIONS

The results obtained by the present studies highlight the developments over four decades registered by this type of woodworking machines. Thus, operating under similar conditions, the new machine (Felder D963) consumes about 43% less energy (at idle running) than the old one (MRG8) and by 64% ... 76% less for the considered cutting regimes, the differences being greater with the increase of the cutting depth (69% - 76%).

Also, the newer machine generates a much lower noise level, not exceeding 75dB for any used cutting regime, while the oldest machine exceeds the limit of the Cz85 curve for all operating modes. Moreover, at idle running the Felder D963 machine does not exceed 65.2dB, while MRG8 almost touch the curve Cz 85 (84dB at 1000Hz).

The final conclusion is that in terms of energy consumption and noise emission during functioning, the newer machine (Felder D963) is clearly superior that the 1972 generation machine (MRG8).

Future research on the quality of processed surfaces on the two machines will be presented in a future issue of the PRO LIGNO journal.

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