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Investigations of cutting power versus clearance of a circular saw blade over the workpiece and feed speed*

Istraživanje ovisnosti snage rezanja o isponu lista kružne pile i posmičnoj brzini

Original scientific paper • Izvorni znanstveni rad
Received - prispjelo: 13. 10. 2005.
Accepted - prihvaćeno: 14. 7. 2006.
*UDK: 630*822.02; 630*822.332.4*

ABSTRACT • *This paper presents the results of experimental measurement of cutting power in sawing spruce wood (soft wood) by circular saw as a function of clearance and feed speed. Two kinds of circular saw blades made by the company Pilana (CZ) were used for the experiment. The measurement was carried out on the test stand designed at the Department of Woodworking of the Technical University in Zvolen. The results have shown that the feed speed proved to be the most significant factor having impact on energy demand in the process of cutting, the second most significant factor was the clearance of circular saw over the workpiece, while the saw blade type (with the same geometry) had the lowest impact on the cutting power.*

Key words: *circular saw, power cutting, clearance, feed speed*

SAŽETAK • *Rad donosi rezultate eksperimentalnih mjerenja snage rezanja u procesu piljenja obične smreke (mekog drva) kružnom pilom uz promjenjivi ispon lista pile iznad obratka te uz različitu posmičnu brzinu. Za eksperiment su upotrebljavane dvije vrste kružnih pila proizvedenih u tvrtki Pilana (CZ). Mjerenje je obavljeno na stroju za provođenje eksperimenata konstruiranom u Odjelu za obradu drva na Tehničkom sveučilištu u Zvolenu. Rezultati su pokazali da se posmična brzina pokazala kao najutjecajniji činitelj na energetske zahtjeve u procesu rezanja, a drugi po redu utjecajni činitelj bio je ispon kružne pile iznad obratka. Vrsta kružne pile (s istom geometrijom) imala je najmanji utjecaj na snagu rezanja.*

Ključne riječi: *kružna pila, snaga rezanja, ispon, posmična brzina*

1 INTRODUCTION
1. UVOD

The use of circular blades in developing wood-working industry is very frequent and important. It is mainly the question of carrying out the operations of wood processing: shortening, sawing up, trimming to size, edging, re-sawing, mortise tenoning, grooving etc. (Lisičan, 1996). All these operations are realized by means of mechanical machinery, whose cutting tool is a

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* Rad je pripremljen za sastanak Interkatedra 2005 „Woodworking technique”.
* The paper was prepared for meeting Interkatedra 2005 „Woodworking technique”.

circular blade. In practice the statement of G. Schlesingera comes true: "Rentability of production process is hidden in the tool cutting edge". The decisive factors for the quality and economy of the process of mechanical working of material are precision, effectiveness, and durability of the used tools. The reason for an unsatisfactory machine performance can be the incorrect preparation of the tool in the grinding room, its incorrect installation into machine or the wrong working regime. Using circular blade with unsuitable technical and technological parameters in given conditions of work manifests itself simultaneously in several imperfections, and namely in fast wear of teeth with the effect of bad quality of cutting, increasing energy demand, and increased consumption of raw material with respect to the scheduled volume of production, as large allowances are required for machining. This paper deals with the influence of selected cutting parameters (feed speed v_f, size clearance and type of circular blade) on the energy demand (cutting power P_c) of machinery.

These problems have not been thorougly studied in the scientific area yet. The influence of clearance of circular blade and the resulting changes of fibre cutting angle on cutting process was studied by Lisičan and Goglia (Lisičan, 1996; Goglia et al, 2003).

2 MATERIAL AND METHOD
2. MATERIJAL I METODA

The measurement was carried out on the experimental test stand designed at the Department of Woodworking (Siklienka, 1999; Hájnik, 2005).

Experimental test stand consisted of four independent parts:

- joiner circular saw
- feeding device
- test stand
- data acquisition DAQ system.

Test stand consisted of the main switch, converter and potential transformers.

Data acquisition DAQ system consisted of the complete personal computer and card with AD converter.

Experimental tests were carried out on spruce test samples (*Picea abies*). The samples were handled so as to contain the least possible number of knots, resin canals, and have approximately the same structure of wood (annual rings). The sawn wood was dried and seasoned to 12 ± 1 % of moisture content. After drying, the species with dimensions 20 mm x 150 mm x 1000 mm were handled out and thus they were prepared for the experimental process of cutting.

Technical parameters of joiner circular saw - *Tehnički parametri stolarske kružne pile*

Type – *Tip*	lateral – longitudinal circular saw (joiner) *Lateralna – longitudinalna kružna pila (stolarska)*
Main motor power – S*naga glavnog motora*	5 kW,
Voltage – *Napon*	380 / 220 V,
Frequency – *Frekvencija*	50 Hz,
Rotational speed of spindle – *Frekvencija vrtnje vratila*	2800 rpm
Made in – *Proizvedeno*	1989
Producer – *Proizvođač*	Rema SA Woodworking Machinery in Reszel (PL) *Rema SA strojevi za obradu drva – Reszel (PL)*

Parameters of circular saw blade of tool steel - *Parametri kružne pile od alatnog čelika*

Diameter –*Promjer*	400 mm
Saw blade thickness – *Debljina kružne pile*	2,0 mm
Tooth number – *Broj zubi*	36
Width of cut – *Širina propiljka*	3,6 mm
Permissible rotational speed – *Dopuštena frekvencija vrtnje*	4800 rpm
Producer – *Proizvođač*	Pilana (CZ)

Clearance angle (*leđni kut*), α = 14°, wedge angle (*kut oštrice*), β = 40°, rake angle (*prednji kut*), γ = 36°

Parameters of circular saw blade with carbide - *Parametri kružne pile s tvrdim metalom*

Diameter – *Promjer*	400 mm
Saw blade thickness – *Debljina kružne pile*	2,5 mm
Number tooth – *Broj zubi*	36
Width of cut – *Širina propiljka*	3,6 mm
Permissible rotational speed – *Dopuštena frekvencija vrtnje*	2800 rpm
Made in – *Proizvedeno*	1989
Producer – *Proizvođač*	Pilana (CZ)

Clearance angle (*leđni kut*), α = 14°, wedge angle (*kut oštrice*), β = 40°, rake angle (*prednji kut*), γ = 36°

Technical parameters of feeding equipment Frommia –*Tehnički parametri posmične opreme Frommia*

Type – *Tip*	850 ZMD 252 / 137
Voltage – *Napon*	380 V
Feed range – *Raspon brzina*	0.5 / 1 / 2 / 5 / 10 / 15 / 20 / 30 [$m \cdot min^{-1}$]
Main motor power – *Snaga glavnog motora*	0.55 kW
Nominal rotational motor speed – *Nominalna frekvencija vrtnje*	2 800 rpm
Made in – *Proizvedeno*	1972
Producer – *Proizvođač*	Maschinenfabrik Ferdinand Fromm

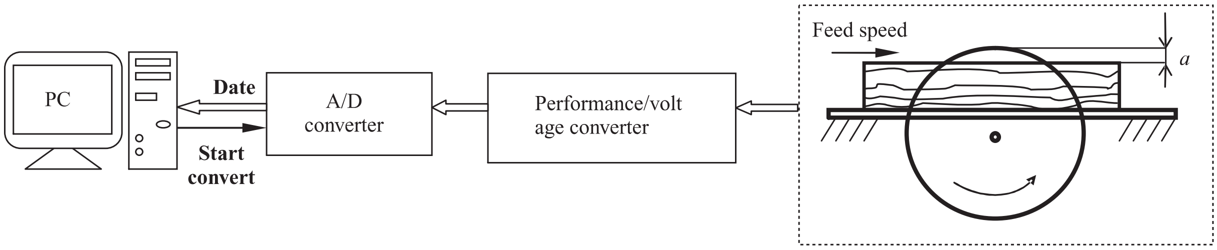

Figure 1 Block diagram of the experimental test stand
Slika 1. Blok–dijagram opreme za provođenje eksperimenta

In the cutting process the following clearances of saw blades were used a = 20, 35, 50, 65 and 80 mm and feed speed v_f = 5, 10, 15, 20 and 30 m·min^{-1}. Two kinds of saw blades (the saw blade from tool steel and the saw blade with carbide) were used for the cutting process.

Individual species were longitudinally cut on circular saw in the given changing cutting conditions. At major cutting edge, perpendicular-longitudinal cutting model was carried out and at minor cutting edge transverse-longitudinal cutting conditions prevailed. The cutting power P_c (after subtraction of an idle-run output) was recorded by personal computer with the use of converter and Suchomel software. At each clearance and feed speed 50 values of the cutting power P_c were registered. The principle of measurement is based on the change of electric current drawn by electromotor of the circular saw from electric network. This change is the converter of real power (converter performance/voltage) scanning the fluctuation of current φ, voltage and power factor converted on the output current, which is transformed by AD converter into digital models. Values of the cutting power were recorded each half second. The measured data of the cutting power were saved in the data files and adapted (filtered) from values, which were extremely high or low. Measured data were further processed by the Microsoft Excel software.

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

Based on the changing input factors in the cutting process (feed speed v_f, clearance of circular saw a, type of saw blade) we can conclude as follows:

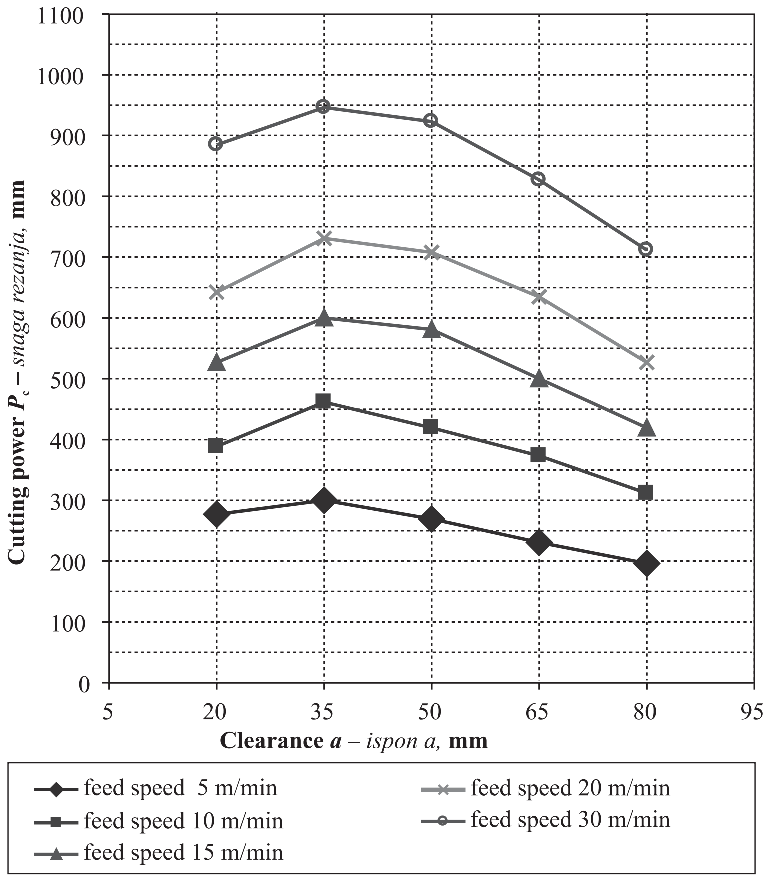

Figure 2 The influence of the clearance of saw blade over the workpiece on the cutting power with individual feed speed for saw blade with carbide
Slika 2. Utjecaj ispona kružne pile iznad obratka na snagu rezanja pri različitim posmičnim brzinama za kružnu pilu s tvrdim metalom

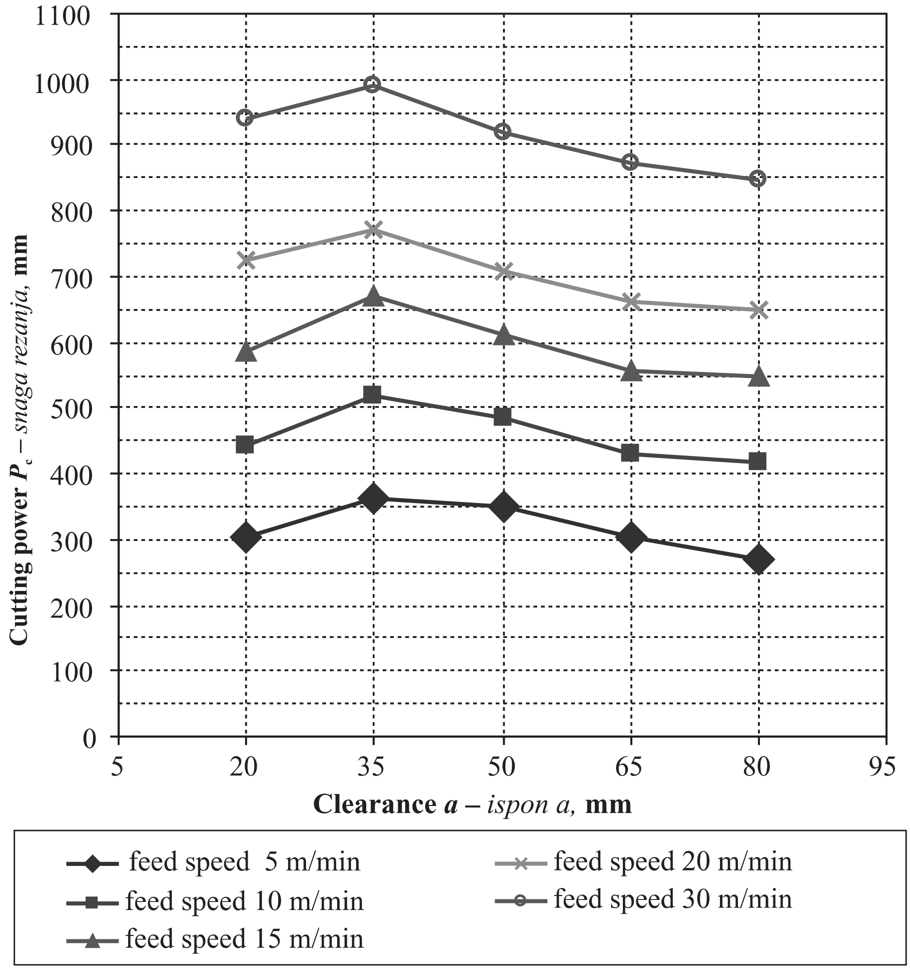

Figure 3 The influence of the clearance of saw blade over the workpiece on the cutting power at individual feed speed for the saw blade from steel tool
Slika 3. Utjecaj ispona kružne pile iznad obratka na snagu rezanja pri različitim posmičnim brzinama za kružnu pilu od alatnog čelika

- the feed speed v_f manifested itself as the most significant factor having impact on energy demand in the process of cutting, i.e. on the cutting power,
- the second most significant factor having impact on the cutting power P_c was clearance of the circular saw over the workpiece a,
- the change of the saw blade type (with the same geometry) had the lowest impact on the cutting power out of these three factors.

The influence of the clearance of saw blade over the workpiece and feed speed on the cutting power of the circular saw depending on the saw blade type is summarized into two graphs by Microsoft Excel software.

During the experiment, an increase of the cutting power was recorded with the rise of the feed speed. We cannot state the same with the changing clearance of the saw blade over the workpiece. As shown in the graph, the cutting power rises with increasing clearance of the saw blade from the value of 20 mm to 35 mm with the same feed speed. With rising clearance of the saw blade over the workpiece from 35 mm the cutting power decreases. This fact can be explained by anisotropy of wood and by the change of the cutting angle trough fibres i.e. the change of the cutting model from longitudinal to perpendicular one.

4 CONCLUSION
4. ZAKLJUČAK

The measurement was carried out on the test stand designed by the Department of Woodworking. The test stand consisted of four independent parts. During the cutting process the following clearances of saw blade over the workpiece were applied a = 20, 35, 50, 65 and 80 mm and feed speed v_f = 5, 10, 15, 20 and 30 $m \cdot min^{-1}$.

The cutting process was carried out with two types of saw blades (the saw blade from tool steel and the saw blade with carbide). The experimental tests were carried out on spruce wood samples.

Based on the changing input factors in the cutting process (feed speed v_f, clearance of circular saw a, type of saw blade) we can conclude as follows:

- the feed speed v_f manifested itself as the most significant factor having impact on energy demand in the process of cutting, i.e. on the cutting power,

- the second most significant factor having impact on the cutting power P_c was clearance of the circular saw over the workpiece *a*,
- the change of the saw blade type (with the same geometry) had the lowest impact on the cutting power out of these three factors.

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Acknowledgement

This paper was made within the grant project „Research influence of interaction phenomena in wood cutting process on contingency factors of the work environment“, number 1/1355/04, VEGA SR.

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