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Influence of saw blade clearance over the workpiece on tool-wear

Utjecaj ispona lista kružne pile iznad obratka na trošenje oštrica alata

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ABSTRACT • *This paper presents the results of experimental measurement of tool-wear in the cutting process with circular saw of oak wood depending on the upper clearance of 5 mm and 50 mm, respectively. The circular saw blade made of HSS by Pilana was used for the experiment. The measurement was carried out by the experimental equipment designed by the Department of Woodworking, Technical University of Zvolen and DMMA–36 circular saw made by Reszelski Zaklad Przemyslu Leśnictwa in Reszel.*
The tool-wear was evaluated by two parameters and namely by the radius of the cutting edge r_n and by the cutting edge recession SV.
The results of tool-wear are presented in dependence on the indicated chip length and cutting material length. With the change of the clearance from 5 mm to 50 mm and with the thickness of the test specimen h = 30 mm almost double amount of sawn wood is required to attain the same chip length. The results have shown that in dependence on the length of the cutting material, the tool wear is smaller at a higher clearance of saw blade over the workpiece.

Key words: *circular saw, tool-wear, clearance, saw blade*

SAŽETAK • *U radu su izneseni rezultati eksperimentalnih mjerenja trošenja alata u procesu piljenja hrastovih uzoraka kružnom pilom u ovisnosti o visini ispona lista pile iznad obratka. Piljeno je s isponom pila 5 i 50 mm. Za eksperimentalno piljenje upotrijebljene su kružne pile izrađene od alatnog čelika proizvođača Pilana. Mjerenja su provedena u Zavodu za obradu drva Tehničkog sveučilišta u Zvolenu, na stroju tipa DMMA-36, proizvedenome u tvrki Reszelski Zaklad Przemyslu Leśnictwa u Reszelu. Trošenje alata izmjereno je uz pomoć dvaju parametara; mjeren je radijus zaobljenosti oštrice r_n i parametar istrošenosti oštrice SV.*
Rezultati trošenja alata prikazani su u ovisnosti o ukupnoj duljini odvojenih čestica te o ukupnoj duljini propiljenih uzoraka. Promjenom ispona kružne pile od 5 mm na 50 mm i pri visini piljenja 30 mm potrebno je ispiliti gotovo dva puta veću duljinu uzoraka da bi se postigla jednaka ukupna duljina odvojenih čestica. Rezultati mjerenja pokazali su da je u ovisnosti o ukupnoj duljini ispiljenih uzoraka istrošenost rezne oštrice manja ako se pili s većim isponom alata kružne pile iznad obratka.

Ključne riječi: *kružna pila, trošenje alata, ispon lista pile*

1 INTRODUCTION
1. UVOD

The wear can be defined as a gradual change of micro-geometry of wedge in the course of cutting, when the tool is loosing its ability to cut. This is caused by the fact that particles of metal are separated from the wedge. A tool is worn when the wedge has come into a critical state, which is accompanied by an intolerable degradation in quality of the work-piece surface, unde-

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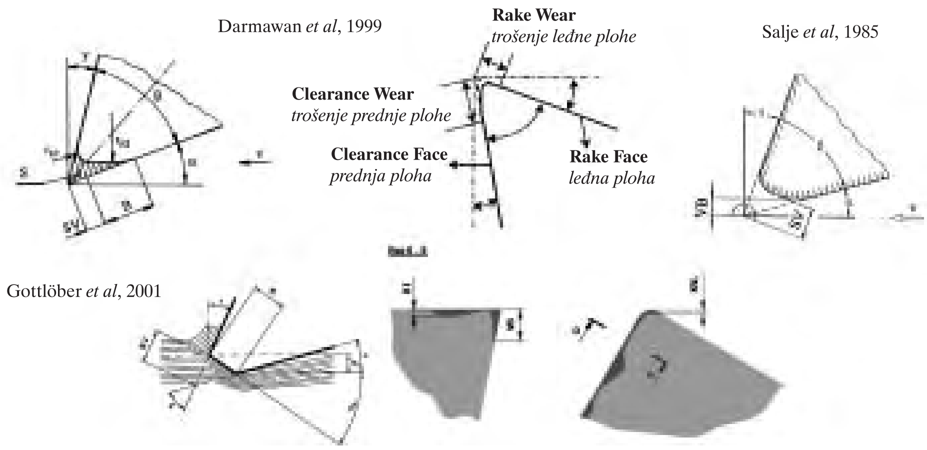


Figure 1 Methods of measurement of the cutting wedge tool-wear (Darmawan *et al*, 1999; Gottlöber *et al*, 2001; Salje *et al*, 1985)
Slika 1. Metode mjerenja trošenja rezne oštrice (Darmawan *et al*, 1999; Gottlöber *et al*, 2001; Salje *et al*, 1985)

sirable increasing of cutting power, burning, and dimensional inaccuracy of the work-piece (saw blade snaking), Prokeš (1980).

It can be concluded from the survey of direct methods of measurement of the cutting wedge tool-wear (Fig.1), that individual authors (Darmawan *et al*, 1999; Gottlöber *et al*, 2001; Salje *et al*, 1985) have tried to do their best in recording the rate of the cutting wedge tool-wear, and made use of various characteristics for its determination. The same characteristics are measured by individual authors in different directions and the acquired values are not mutually comparable. One characteristic does not always express the total rate of the cutting wedge tool wear and it is necessary to measure more characteristics, or give the graphic description of the cutting wedge point prior and after the tool wear. A great disadvantage of individual characteristics of the tool wear lies in their very small values, unclear transition from round to straight form, etc. The survey implies that there are no uniform methods of measurement of the cutting wedge tool wear in wood working, which is a problem from the viewpoint of comparison of experimental results.

The aim of this paper is to investigate the change of the cutting wedge profile in dependence on the saw blade clearance over the cut. The relational quantity is a very substantial factor regarding the degree of tool wear. The rate of tool wear (the individual ways of measurements are presented in Figure 1) can be evaluated with respect to the cut area or with respect to the indicated chip length (trajectory of saw tooth in the test sample). The saw blade clearance has a great influence on the length of chip, whereas in the cut area there is no change. Previous research has given poor information about the effects of saw blade clearance over the cut on the cutting wedge wear.

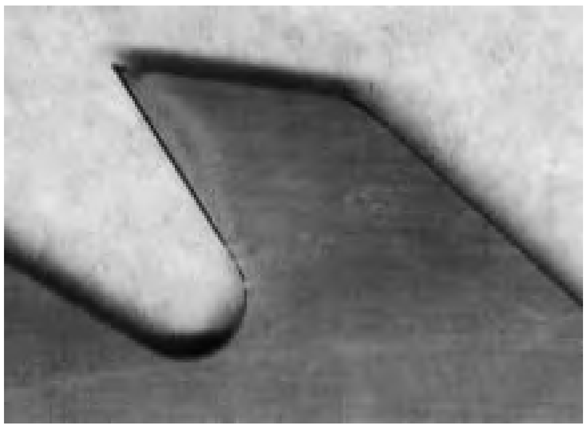
The main task of this paper was to show the effect of technological parameter, mainly the clearance of the saw blade over the work-piece, on the tool wear of the cutting wedge.

At present there are many authors dealing with tool wear in dependence on the sawn running metres or on the quantity of the cut area. However, these indices do not belong to the most accurate criteria for the evaluation of the tool wear. This is due to the fact that the cutting conditions are changing (indicated length of chip, feed per tooth,…) at different technological parameters of cutting, and consequently our results cannot be mutually compared. Therefore we want to point out the significance of the effects of clearance on the tool wear of the cutting wedges.

2 MATERIALS AND METHODS
2. MATERIJAL I METODE

The measurement was carried out in the experimental test stand designed by the Department of Woodworking (Siklienka *et al*, 1999). It is a joiner circular saw. The cutting process was carried out with a circular saw blade made of high-speed steel. The saw blade had the following parameters:

Parameters of the circular saw blade HSS / *Parametri lista kružne pile*



Diameter / *promjer*:	400 mm
Saw blade thickness / *debljina lista pile*:	2.5 mm
Number of teeth / *broj zubi*:	32
Width of cut / *širina propiljka*:	3.6 mm
Permissible rotational speed / *dopuštena frekvencija vrtnje*:	3800 min^{-1}
Producer / *proizvođač*:	Pilana (CZ)

Angles /*kutovi*: clearance angle / *prsni kut* $\gamma = 15°$, wedge angle / *kut oštrice* $\beta = 50°$, rake angle / *leđni kut* $\alpha = 25°$

Table 1 Re-calculation of the indicated length of chip l_t to common metres L at clearance p = 5 mm
Tablica 1. Preračunane vrijednosti ukupne duljine odvojenih čestica l_t u metre ispiljenih uzoraka L pri isponu lista kružne pile p = 5 mm

l_t, m	0	1000	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000
L, m	0	45	91	182	274	365	457	548	640	731	822	913	1004	1096
l_t, m	26000	28000	30000	32000	34000	36000	38000	40000	42000	44000	46000	48000	50000	
L, m	1187	1278	1370	1461	1552	1644	1735	1826	1918	2009	2100	2192	2283	

Table 2 Re-calculation of the indicated chip length l_t to common metres L at clearance p = 50 mm
Tablica 2. Preračunane vrijednosti ukupne duljine odvojenih čestica l_t u metre ispiljenih uzoraka L pri isponu lista kružne pile p = 50 mm

l_t, m	0	1000	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000
L, m	0	84	168	336	504	672	840	1008	1177	1345	1513	1681	1849	2017
l_t, m	26000	28000	30000	32000	34000	36000	38000	40000	42000	44000	46000	48000	50000	
L, m	2185	2353	2521	2689	2857	3025	3193	3362	3530	3698	3866	4034	4202	

Experimental tests were carried out on oak test samples (*Quercus Robur*). 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 wood was sawn tangentially. The sawn wood was dried and seasoned to 12 ± 1 % of moisture content. After drying, the samples with dimensions of 30 mm x 150 - 250 mm x 1000 mm were handled out.

In the cutting process the following saw blade clearances were used p_1 = 5 mm and p_2 = 50 mm and feed speed v_f= 10 m·min^{-1}. Cutting height was 30 mm. Individual samples were cut longitudinally on a circular saw at the given changed cutting conditions. The rate of tool-wear was monitored in dependence on the indicated length of chip (length of tooth path in the test samples). Recording of the tooth profile was carried out by the laboratory equipment shown in Fig. 2, which consists of digital camera, microscope and personal computer.

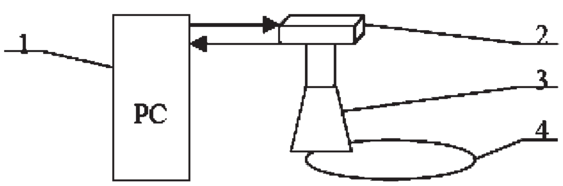


Figure 2 Laboratory equipment for scanning the cutting wedge tool-wear (1- personal computer, 2 - digital camera, 3 - microscope, 4 – saw blade)
Slika 2. Oprema za određivanje veličine trošenja oštrice kružne pile (1 – računalo, 2 – digitalna kamera, 3 – mikroskop, 4 – list kružne pile)

Saw blade was divided into 4 zones and two cutting wedges were chosen in each zone. Cutting wedges were chosen according to the initial condition of tool-wear (identical). The snapshots of the cutting wedge profile were recorded in the following working points of the indicated length of chip l_t = 0 m, 1000 m, 2000 m and then graded in 2000 m up to 50 000 m during experimental sawing with both clearances (5 and 50 mm). For better orientation, the indicated chip length l_t is re-calculated to common metres L at clearance p = 5 mm and 50 mm in Tables 1 and 2. Common metres L represent the required running metres of material for attaining the indicated chip length and they were calculated according to Lisičan (1996).

Table 1 and Table 2 show that the increase of clearance from 5 to 50 mm cause the decrease of the length of cutting wedge passing through material and an increase of required running metres of material for attaining the same length of indicated chip up to nearly double.

The tool-wear was evaluated by means of two parameters i.e. by the radius of the cutting edge r_n and by recession of the cutting edge SV. These characteristics are shown in Fig. 3.

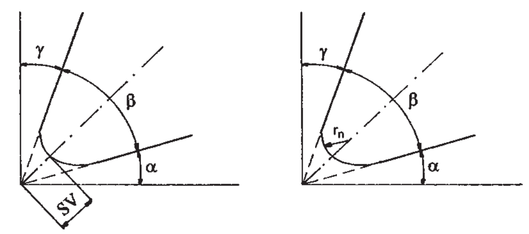


Figure 3 Parameters of measurement of the cutting wedge tool-wear (SV – recession, r_n – radius)
Slika 3. Parametri mjerenja trošenja rezne oštrice (SV – istrošenost oštrica, r_n – radijus oštrica)

As already mentioned the snapshots were performed by means of laboratory equipment and subsequently elaborated in the Impor 5 professional software. This software was also used for interleaving individual snapshots of cutting wedge during the cutting test.

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

Figure 4 and Figure 5 present the actual contours of the cutting wedge at the determined measuring points. The gradual change of the cutting wedge during sawing at the clearance of 5mm over the cut is shown in Figure 4, and at the clearance of 50 mm in Figure 5.

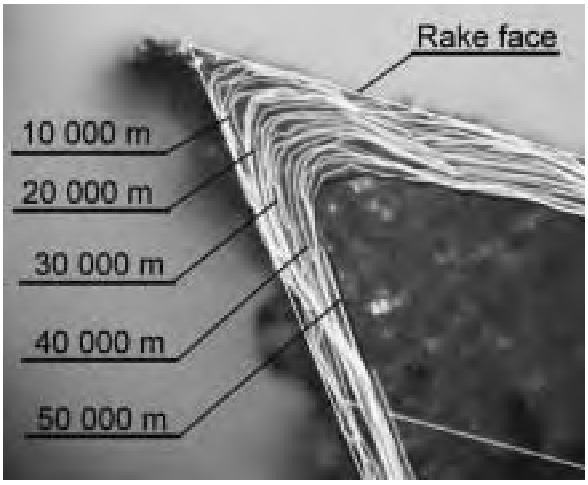


Figure 4 Tool wear of the cutting wedge at the clearance p = 5 mm
Slika 4. Trošenje oštrice pri isponu lista pile p = 5 mm

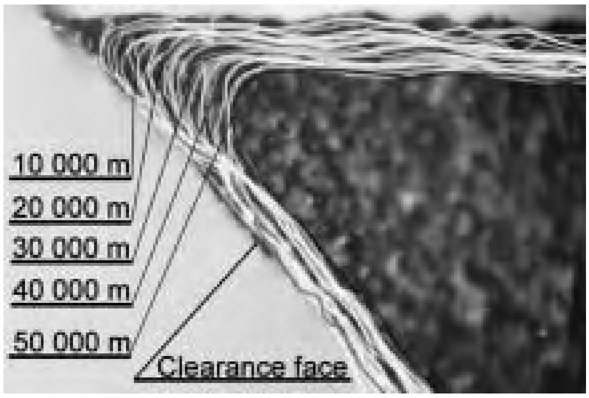


Figure 5 Tool wear of the cutting wedge at the clearance p = 50 mm
Slika 5. Trošenje oštrice pri isponu lista pile p = 50 mm

It can be concluded from these Figures that the tool wear (recession *SV*) of the cutting wedge is nearly the same at both clearances. At the higher clearance, p = 50 mm, greater tool wear was recorded of the round cutting edge (measured as radius of the cutting edge r_n) than at the clearance p = 5 mm. It should be emphasized that the change of clearance causes the change of indicated chip length. With increasing clearance, the contact angle decreases, and so also does the indicated chip length. Figure 6 and Figure 7 present the dependencies of tool wear on indicated chip length.

With the change of clearance from 5 mm to 50 mm and with the test specimen thickness h = 30 mm almost double amount of sawn wood is required to attain the same indicated chip length. It means that at a higher clearance, the tool wear is smaller in dependence on the cutting length (Fig. 8).

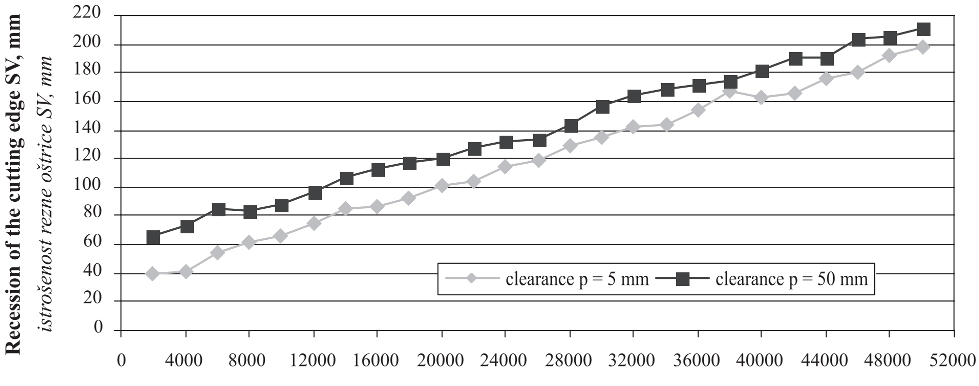


Figure 6 The affect of indicated chip length on the recession of the cutting edge *SV*
Slika 6. Utjecaj ukupne duljine odvojenih čestica na parametar *SV* istrošenosti rezne oštrice

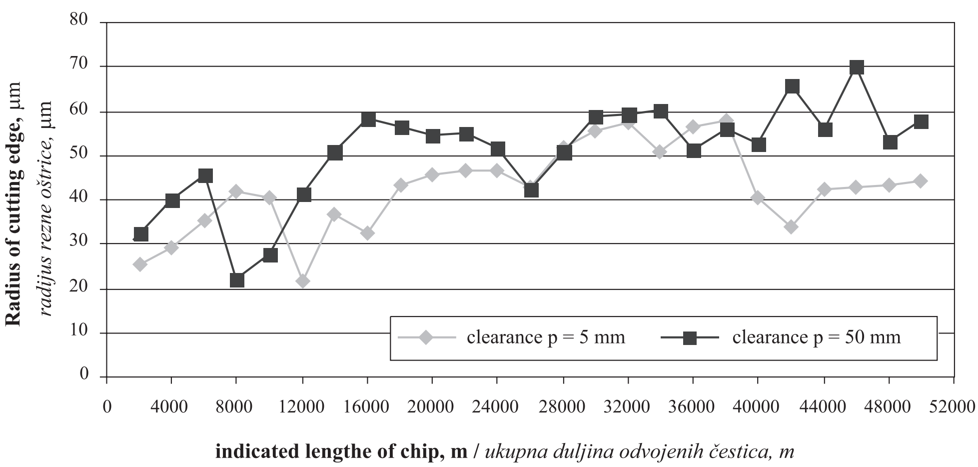


Figure 7 Effect of indicated chip length on radius of the cutting edge
Slika 7. Utjecaj ukupne duljine odvojenih čestica na radijus rezne oštrice

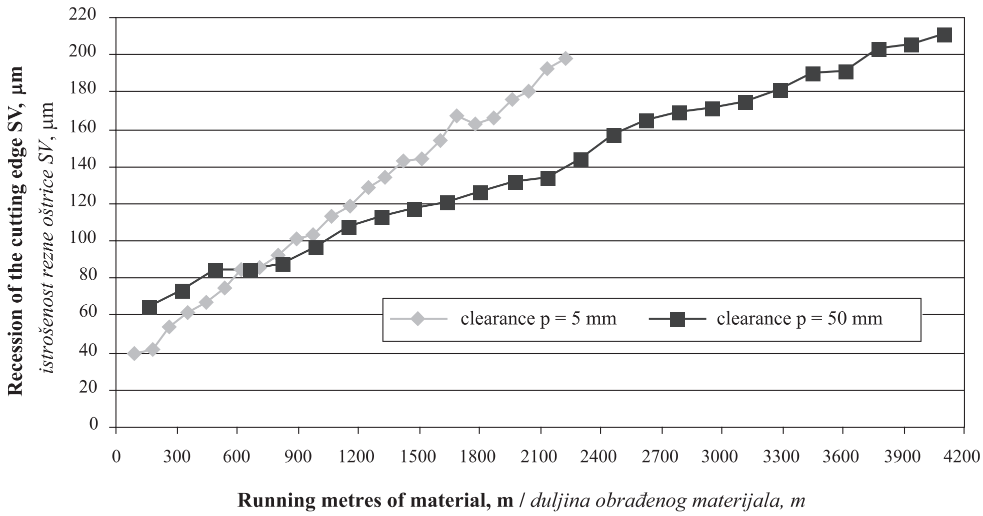


Figure 8 Effect of running metres of material on recession of the cutting edge *SV*
Slika 8. Utjecaj duljine obrađenog materijala na parametar *SV* istrošenosti rezne oštrice

4. CONCLUSION
4. ZAKLJUČAK

The aim of this paper was to point out the importance of clearance of saw blades.

With the change of clearance from 5 mm to 50 mm the tool wear is smaller in dependence on the cutting length. The choice of appropriate clearance is quite substantial. The change of clearance causes the change of parameters of the cutting process. However, it cannot be stated unambiguously that the greater the clearance, the better. Although the durability of cutting edge is longer, the increased clearance also affects other factors; at greater clearances the diameters of saw blades are greater as well as the thickness of the saw blades, which subsequently causes an increase in the amount of sawdust. Apart from this, with an increase of clearance, the stability of saw blade decreases. All these factors must be taken into account, and an optimum clearance of the saw blade over the cut must be found by a complex study of these factors.

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