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THE EFFECT OF THE LATE WOOD SHARE IN THE ANNUAL RING GROWTH ON THE CUTTING POWER

Kazimierz A. Orlowski – Daniel Chuchala

Abstract

In the paper the variations of cutting power required in the sawing process of Polish pine (Pinus sylvestris L.) in a function of the late wood share in the annual growth with regard to the wood origin are presented. Empirical values of the cutting power were determined on the narrow-kerf frame sawing machine. Nevertheless, measurements of the late wood share in the annual growth had been carried out directly earlier the sample have been sawn according to own methodology which based on the classical method described in the work by Krzysik. The comparison was made for pine from natural forests derived from four different regions of Poland.

Key words: *cutting power, sawing, annual ring growth, late wood share*

INTRODUCTION

The wood derived from various ecosystems which has grown in different local conditions, affected by such factors as weather (wind, sunlight, rainfall, length of growing season), terrain (lowland, mountainous areas), soil type etc. Those conditions highly affect the annual growth of trees as well as the share of late wood (summer wood) in the annual growth [3, 5]. Krzosek [2] prooved that there is a close relationship between selected mechanical properties of wood and a place of origin, as demonstrated both in sorting construction lumber with vision methods and machine methods [2]. It was assumed that depending on the size of the percentage share of the late wood in an annual growth ring the values of power in the process of sawing wood can significantly change. The paper presents results of experimental studies in this field for Polish pine wood from four different regions of origin.

MATERIAL AND METHODS

In order to understand the effect of the share of late wood on the cutting power demand in the process of sawing of Polish pine (*Pinus sylvestris* L.) empirical studies of cutting power determination on the frame sawing machine PRW15M [4, 5] were carried out. Pine wood samples (of dimensions mainly 60×60×550 mm), at moisture content MC 8.5–12%, which were used in the tests, originated from four Natural Forest Regions in Poland (Fig. 1): Region A - the Baltic Natural Forest Region, Region B – the Carpathian Natural Forest

Gdansk University of Technology, Narutowicza 11/12, 80-233 Gdansk, Poland
e-mail: korlowsk@pg.gda.pl; daniel.chuchala@gmail.com

Region, Region C - the Little Poland Natural Forest Region and Region D – the Great Poland-Pomeranian Natural Forest Region [1]. During cutting tests stellite tipped saw blades with a kerf equal to $S_t = 2$ mm were applied.

Fig. 1. Locations of Polish Natural-Forest Regions of pine wood origins

The sawing experiments of the cutting power determination, in which the samples are destroyed (sawn), were preceded by a measurement of the share of late wood in annual growth rings, according to the method thoroughly described in the paper by Chuchala et al. [1]. The mentioned measurements were based on the classical method of determining annual growth of wood [3]. The average share of late wood *SWL* is calculated with a formula as follows:

$$SWL = \frac{WLW}{AG} 100\% \qquad (1)$$

where: *SWL* is share of late wood [%], *WLW* is the width of late wood (Fig. 2) and *AG* is an average annual growth ring.

RESULTS AND ANALYSES

In the wood of Polish pine wood, differences of structural properties of wood such as: an average annual growth (number of rings) *S* (Fig. 3a) and the average share of late wood in annual growth *SLW* (Fig. 3b) can be observed depending on the Region of the wood origin. Except average values of analysed features their ranges are also preformed in Fig. 3.
The late wood (summer wood) has a higher hardness than early wood (spring wood) [3, 7], hence it is likely that an increase in the share of the late wood in an annual growth ring might mean an increase in cutting power required for wood sawing. However, the intensity of this effect could be different accordingly to the wood derivation.

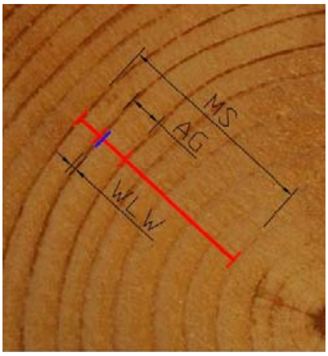
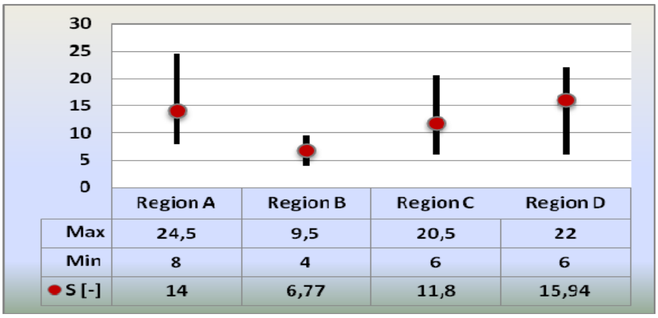


Fig. 2. The determination method of the width of annual growth and the width of late wood, where: MS – measuring section, WLW – width of late wood, AG – annual growth [1]

a)



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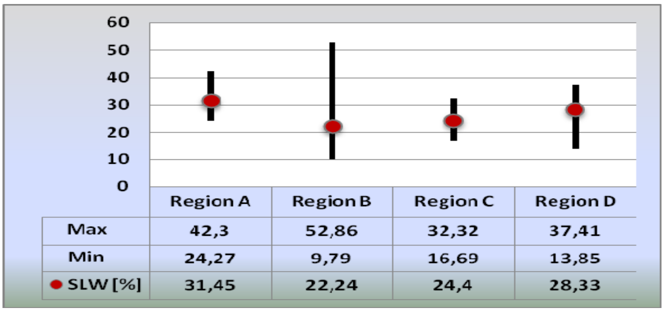

Fig. 3. Average annual growth (ring number) S over a 30 mm measuring section (a) and average share of late wood SLW [%] (b) with ranges for examined four Natural-Forest Regions in Poland

In Figure 4 (data for feed per tooth equal to f_z = 0.04 mm) and 5 (f_z = 0.13 mm) results of cutting power per one saw blade while sawing on the sash gang saw PRW15M for four examined Natural-Forest Regions in Poland in a function of the share of the late wood are shown. Except individual points of results additionally linear trends for each Natural-Forest Region are presented. For the majority of Regions there are generally observed ascending trends, however, this phenomenon does not concern results for the region B, for which decreasing tendency is noticed. In further analyses Pearson's *r* correlation coefficients were determind for each Region and their values together with interpretation of the size of a correlation [6], and their significance at the level $\alpha = 0.05$ [8], are given in Table 1.

Table 1. Pearson's r correlation coefficients between a share of a late wood and cutting power per one saw while pine sawing with their meaning and significance

Region	f_z [mm]	Pearson's r	Correlation	Significance
A (Sample size n = 21)	0.04	0.709	strong	Yes
	0.13	0.447	medium	Yes
B (Sample size n = 39)	0.04	-0.277	small	No
	0.13	-0.289	small	No
C (Sample size n = 24)	0.04	0.337	medium	No
	0.13	-0.188	small	No
D (Sample size n = 24)	0.04	0.578	strong	Yes
	0.13	0.685	strong	Yes
POLAND (Sample size n = 108)	0.04	0.222	small	Yes
	0.13	0.261	small	Yes

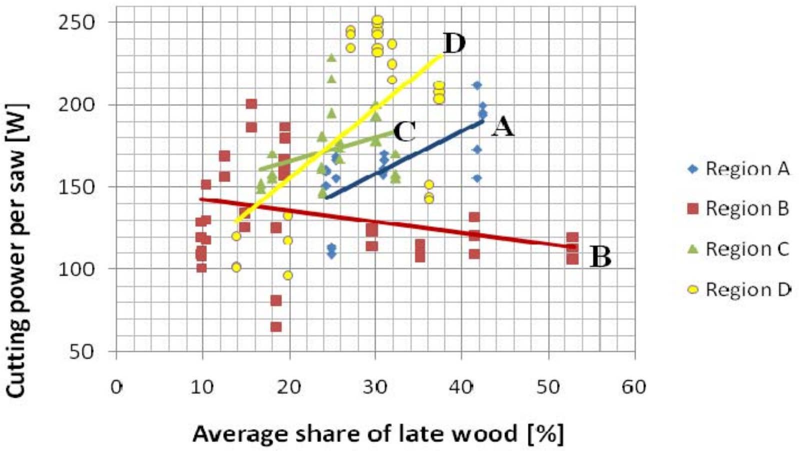

Fig. 4. The effect of the late wood share in the annual ring growth on the cutting power for feed per tooth 0.04 mm

In case of Region B (Fig. 4 and 5), in which plots decreasing tendencies are noticed, a size of correlation is rather small and it could be an effect of an inaccuracy in the share of late wood measurements because in the analysed cross section the uniform wood structure was affected by different kinds of defects (Fig. 6). Similar distortions in the results of measurements were observed by Krzosek in the study of the mechanical properties of wood derived from the Carpathian Natural Forest Region (Region B) while the dynamic methods were used [2]. The largest correlation between a share of a late wood and cutting power per one saw while pine sawing is observed for pine wood originated from Regions A and D.
For Regions B and C at feed per tooth of 0.13 mm (Fig. 5), the trends is decreasing with increasing *SLW* due to greater share in the cross-section of the cut (undeformed chip) while sawing the early wood because of a low share of the late wood in annual growth (Fig. 3).

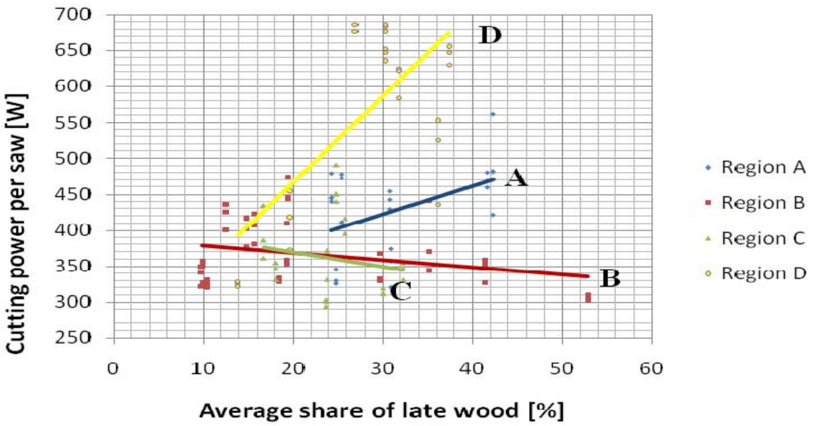

Fig. 5. The effect of the late wood share in the annual ring growth on the cutting power for feed per tooth 0.13 mm

Fig. 6. Example of the cross section of pine wood sample from the Region B with an irregular annual growth

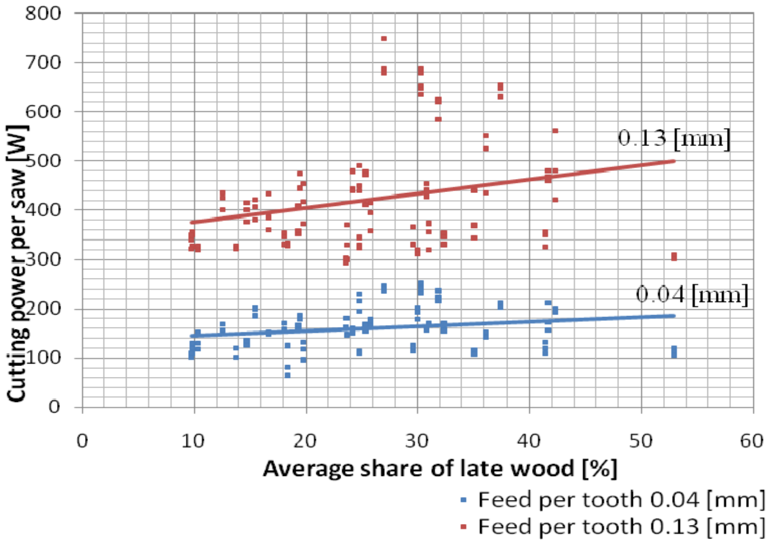

Fig. 7. The effect of the late wood share in the annual ring growth on the cutting power for Polish pine wood for feeds per tooth 0.04 mm (lower trend line) and 0.13 mm (upper trend line) – as a global approach

Similar analyses of the effect of the share of the late wood on cutting power while sawing Polish pine wood could be carried out for the territory of Poland as a plot of every points from Regions A–D (Fig. 7). Also in this case Pearson's *r* correlation coefficients were determined for both values of feed per tooth, and Pearson's *r* together with the interpretation of the size of a correlation [6], at the significance level α = 0.05 [8], are presented in Table 1. For both values of feed per tooth the correlation coefficients between a share of a late wood and cutting power per one saw are small, nevertheless, in both cases they are statistically significant. The presence of low values of Pearson's *r* coefficients could be explained by the properties of wood derived from Regions B and C (see Fig. 4 and 5, and Table 1).

CONCLUSIONS

Based on the results of this study the followig conclusions can be drawn:

- The effect of the share of the late wood on the cutting power demand while sawnig Polish pine wood is observed. However, Pearson's *r* correlation coefficient values depend strongly on the examined wood origins.
- The largest correlation between a share of a late wood and cutting power per one saw while pine sawing has been observed for pine wood originated from Regions D (the Great Poland-Pomeranian Natural Forest Region) and Region A (the Baltic Natural Forest Region).
- The global analyses of those phenomena are not recommended because the results might be affected by the results of wood for which either small Pearson's *r* coeffitients or simultanously insignificance of correlation coefficient are present.

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