Original scientific paper
Received:14.08.2025
Accepted:19.11.2025
UDC: [674.023:621.934]:[674.031/.032:620.191.35]

IMPACT OF FEED RATE ON ROUGHNESS OF THE CUT SURFACE DURING CUTTING DRY BEECH AND SPRUCE WOOD WITH A CIRCULAR SAW

Anastasija Temelkova[1], Zoran Trposki[1], Vladimir Koljozov[1], Ana Marija Stamenkoska[1]

Ss. Cyril and Methodius University in Skopje,
Faculty of Design and Technologies of Furniture and Interior-Skopje
email: temelkova@gmail.com; trposki@fdtme.ukim.edu.mk;
koljozov@fdtme.ukim.edu.mk;stamenkoska@fdtme.ukim.edu.mk

ABSTRACT

he precision of wood processing and the quality of the machined surface are critical factors in achieving the desired processing outcomes. These factors are influenced by a variety of parameters, among which the feed rate during mechanical processing plays a significant role in determining the surface roughness of the cut. Surface roughness, often caused by tool marks, affects subsequent hydrothermal treatments and other mechanical processes, ultimately reducing the efficiency of wood usage when it is too high.

For this purpose, in this paper, the dependence of the feed rate on the roughness of beech and spruce wood during the cutting of dry wood with a circular saw is investigated, with the intention of determining the optimal cutting conditions for obtaining lower values of the roughness.

In this research, three different feed rates were applied ($U_1 = 12$ m·min^{-1}, $U_2 = 16$ m·min^{-1} and $U_3 = 20$ m·min^{-1}) for a constant cutting height of 15 mm in dry beech and spruce wood with moisture content W = 10 ± 1%. The measurements were made with a circular saw with a diameter of cutting tool D = 250 mm, a number of teeth Z = 40 and a width of the cut b = 3.2 mm. The number of rounds was n = 5500 min^{-1}.

Roughness measurements were taken with a digital comparator, according to the R_{max} criterion. The obtained results showed a pronounced significance and a directly proportional dependence of the roughness of the cut surface on the feed rate.

Keywords: beech wood, spruce wood, circular saw, roughness, feed rate.

1. INTRODUCTION

Wood, as a material, is highly suitable for both interior and exterior decoration. It can be shaped easily with relatively low energy consumption. It possesses low acoustic, thermal, and electrical conductivity, along with high resistance to chemical agents (Stanojević, 2016).

Circular saws are among the most widely used tools in the mechanical processing of wood, covering all stages of production. Manufacturers on the market offer various types of saws with different diameters and numbers of teeth. Circular saws are also used for cutting other materials such as plastics, metals, ceramics, and various construction materials (Đurković et al., 2017). In addition to the physical, mechanical, and anatomical properties of wood, the surface quality of components and final products is influenced by numerous factors — such as the cutting direction, the geometry of the tooth and its cutting edge, the thickness of the removed segment, inaccuracies in tool sharpening, and technological parameters (cutting speed, feed speed, etc.) (Richter et al., 1995). The contact surfaces of tools during machining are subjected to high pressures and friction, which leads to tool wear. Tool wear is an important factor in the mechanical processing of wood because it directly affects surface quality, cutting forces, cutting power, and energy consumption (Đurković et al., 2019).

The main criteria that characterise the quality of the processed surface are surface roughness, machining accuracy, and durability. Marks left by vibrations of the machine and the cutting tool, as well as the structure and density of the processed material, are among the causes of surface roughness. In the mechanical processing of wood, feed speed is one of the factors that has a strong influence on the roughness of the sawn surface.

2. RESEARCH OBJECTIVES

The aim of this research is to determine the dependence of feed speed on the roughness of the cut surface in beech and fir/spruce wood when sawing dry wood with a circular saw in order to define optimal cutting conditions that achieve minimal surface roughness.

3. MATERIAL AND METHODS

3.1. Material

The tests were carried out on defect-free sawn timber of beech (*Fagus sylvatica* L.) and fir/spruce (*Picea abies* Karst., *Abies alba*), with dimensions 1500 × 150 × 15 mm. All samples were kiln-dried and conditioned before testing. The measured average moisture content of beech was 9.32%, and of fir/spruce 10.26%. From these planks, specimens were cut with a constant cutting height of 15 mm.

3.2. Experimental methods

The experimental tests were performed on a format circular saw machine type NIKOLAIDIS TEMA 3800. Three feed speeds were applied: $U_1 = 12\ m\cdot min^{-1}$, $U_2 = 16\ m\cdot min^{-1}$, and $U_3 = 20\ m\cdot min^{-1}$. The circular saw blade had a diameter of D = 250 mm, a number of teeth of Z = 40, and a kerf width of b = 3.2 mm (Figure 1). The spindle rotational speed was $n = 5500\ min^{-1}$. The cutting length for each specimen was 1.2 m.

The surface roughness data were measured using a digital comparator, type SHAHE, according to the R_{max} criterion. For each specimen, 100 measurements were taken over a length of 1.0 m (Figure 2).

Figure 1*. Circular saw with diameter D = 250 mm, number of teeth Z = 40 and kerf width b = 3.2 mm.*

Figure 2*. Digital comparator type SHAHE.*

4. RESULTS AND DISCUSSION

4.1. Measured surface roughness values for beech specimens

Table 1. *Results of the surface roughness measurements for beech specimens at various feed speeds (U_1 = 12 m·min⁻¹, U_2 = 16 m·min⁻¹, U_3 = 20 m·min⁻¹), according to the R_{max} criterion.*

Feed speed (U) for number of teeth Z = 40 and diameter D = 250 mm					
U_1 = 12 m·min^{-1}		U_2 = 16 m·min^{-1}		U_3 = 20 m·min^{-1}	
Cutting height [mm]		Cutting height [mm]		Cutting height [mm]	
h = 15mm		h = 15mm		h = 15mm	
Surface roughness	[mm]	Surface roughness	[mm]	Surface roughness	[mm]
Mean value	0.0320	Mean value	0.0491	Mean value	0.0618
Standard deviation	0.0067	Standard deviation	0.0093	Standard deviation	0.0112
Coefficient of variation	20.80	Coefficient of variation	19.05	Coefficient of variation	18.06
Minimum	0.020	Minimum	0.032	Minimum	0.037
Maximum	0.054	Maximum	0.072	Maximum	0.084

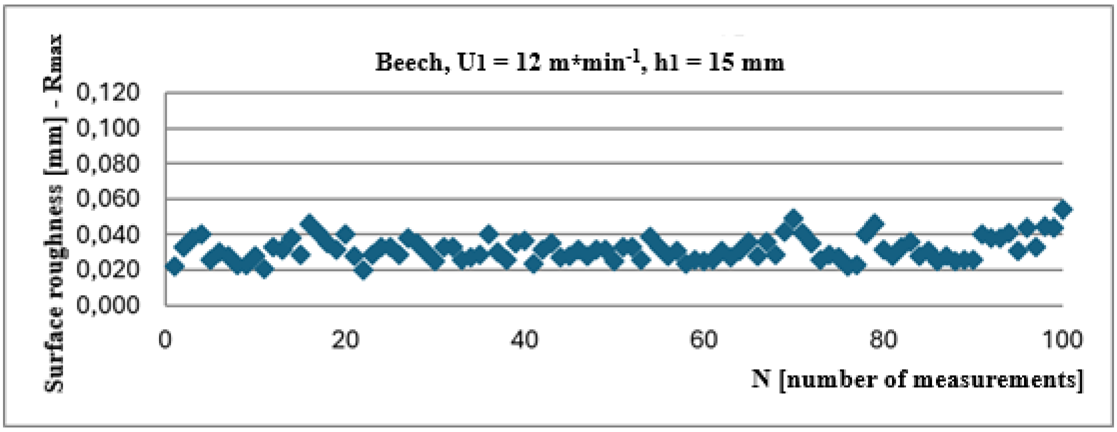

Figure 3. *Beech specimens' surface roughness for feed speed U_1 = 12 m·min^{-1}.*

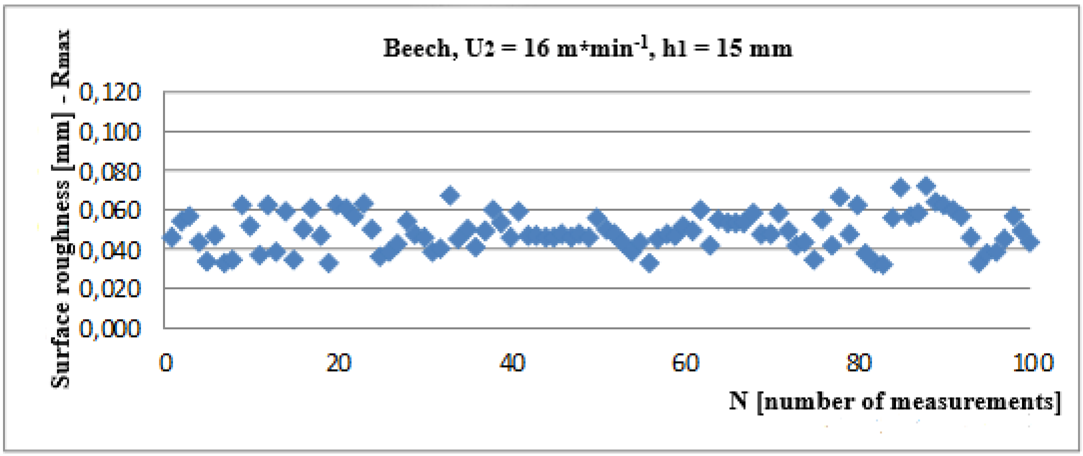

Figure 4. *Beech specimens' surface roughness for feed speed U_2 = 16 m·min^{-1}.*

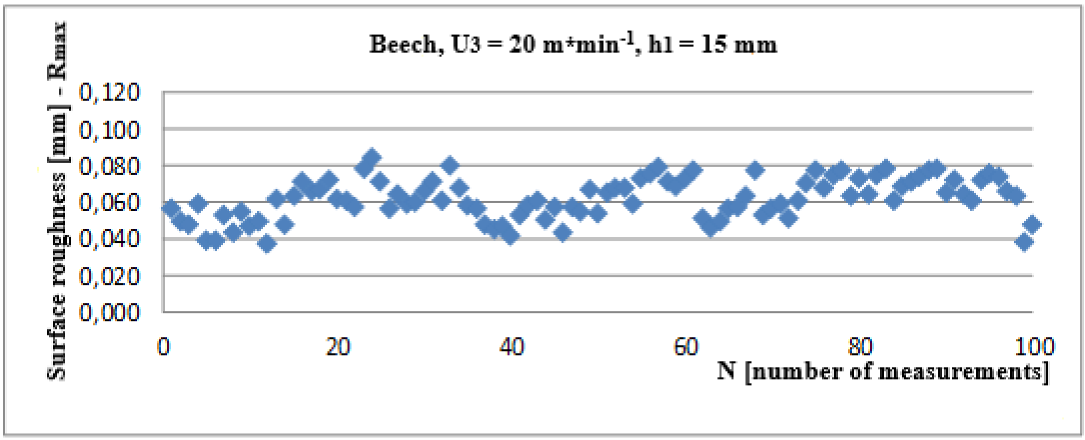

Figure 5. *Beech specimens' surface roughness for feed speed U_3 = 20 m·min^{-1}.*

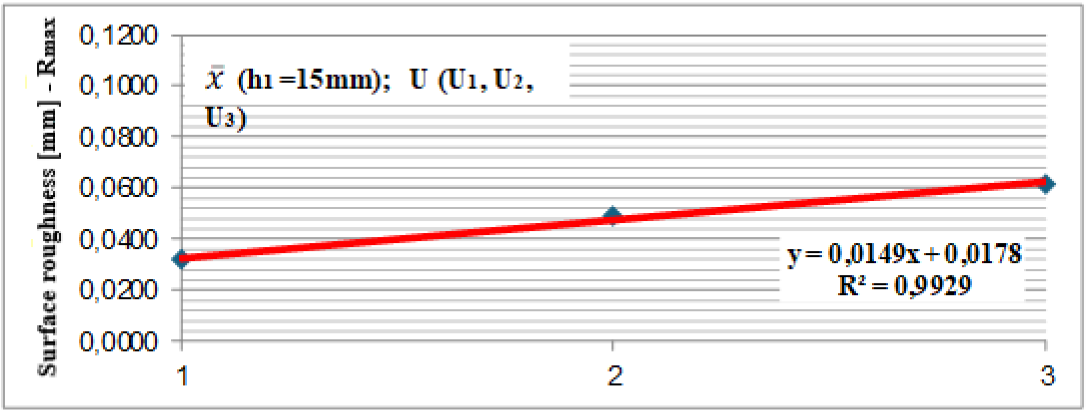

Figure 6. *Regression analysis for mean values of the beech specimens' surface roughness with all three feed speeds (U_1=12m·min-1, U_2=16m·min^{-1} and U_3=20m·min^{-1}).*

From the presented results (Table 1, Figures 3, 4, 5, and 6), it can be concluded that with an increase in feed speed, the roughness of the cut surface increases in direct proportion. The dependence is mathematically expressed by the regression line y = 0.0149x + 0.0178 and the coefficient of determination R^2 = 0.9929. Regression analysis showed that the measurements are best fitted by a linear equation. The correlation coefficient indicates a strong dependence.

4.2. Measured surface roughness values for fir/spruce specimens

T***able 2.*** *Results of the surface roughness measurements for fir/spruce specimens at various feed speeds (U_1 = 12 m·min^{-1}, U_2 = 16 m·min^{-1}, U_3 = 20 m·min^{-1}), according to the R_{max} criterion.*

Feed speed (U) for number of teeth Z = 40 and diameter D = 250 mm					
U_1 = 12 m·min^{-1}		U_2 = 16 m·min^{-1}		U_3 = 20 m·min^{-1}	
Cutting height [mm]		Cutting height [mm]		Cutting height [mm]	
h = 15mm		h = 15mm		h = 15mm	
Surface roughness	[mm]	Surface roughness	[mm]	Surface roughness	[mm]
Mean value	0.0865	Mean value	0.1127	Mean value	0.1733
Standard deviation	0.0077	Standard deviation	0.0095	Standard deviation	0.0123
Coefficient of variation	8.93	Coefficient of variation	8.43	Coefficient of variation	7.09
Minimum	0.040	Minimum	0.099	Minimum	0.131
Maximum	0.115	Maximum	0.139	Maximum	0.201

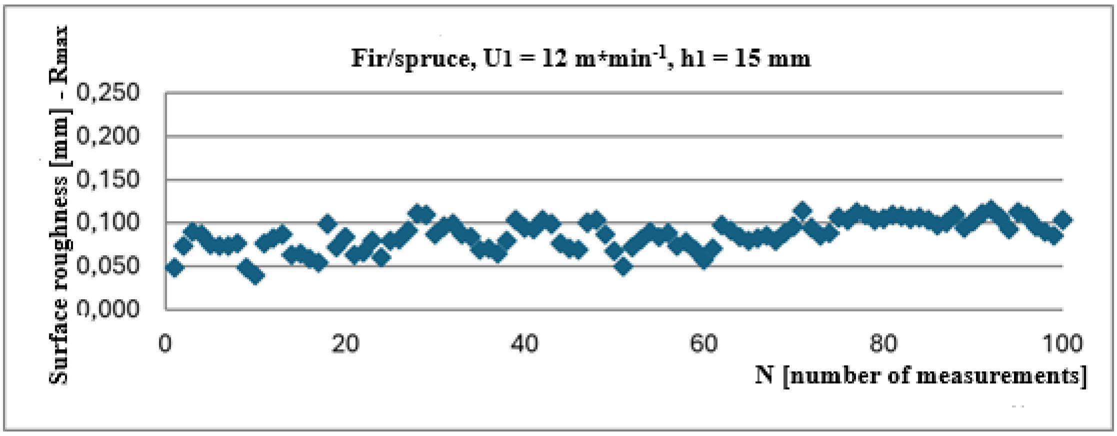

Figure 7. *Fir/spruce specimens' surface roughness for feed speed U_1 = 12 m·min^{-1}.*

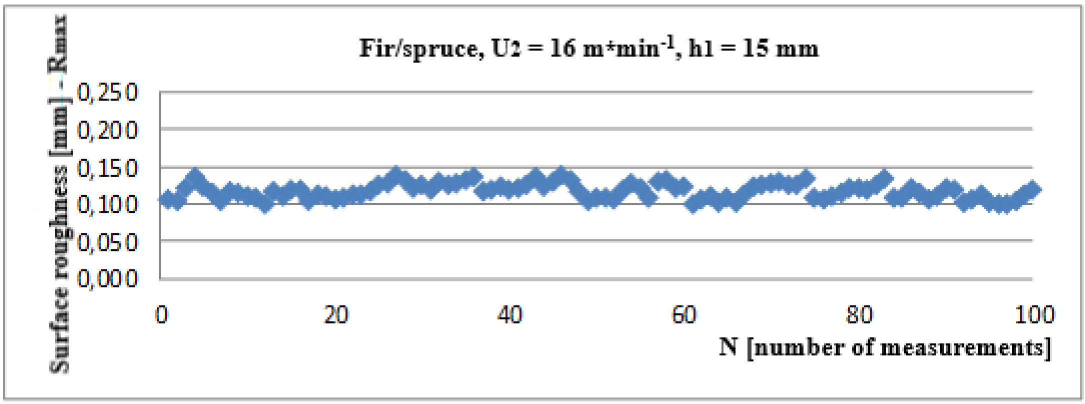

Figure 8. *Fir/spruce specimens' surface roughness for feed speed U_2 = 16 m·min^{-1}.*

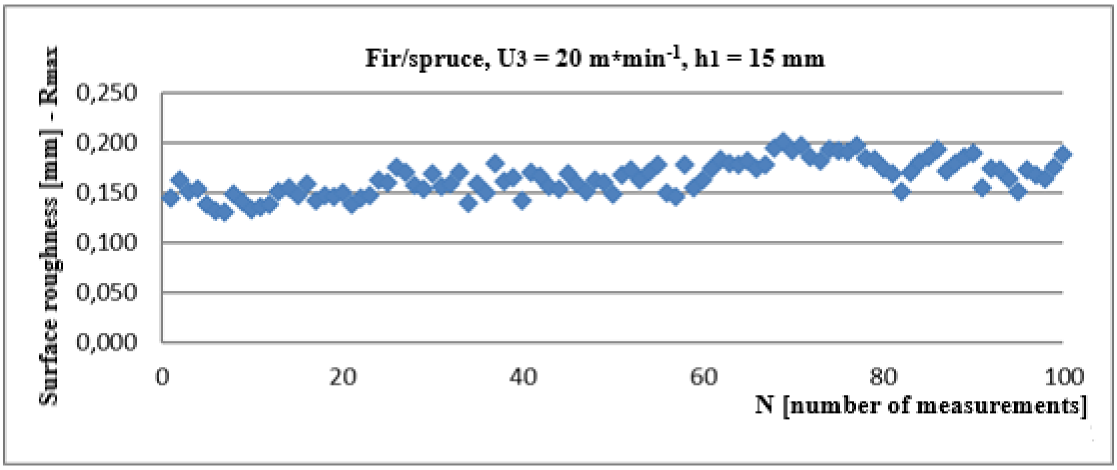

Figure 9. *Fir/spruce specimens' surface roughness for feed speed U_3 = 20 m·min^{-1}.*

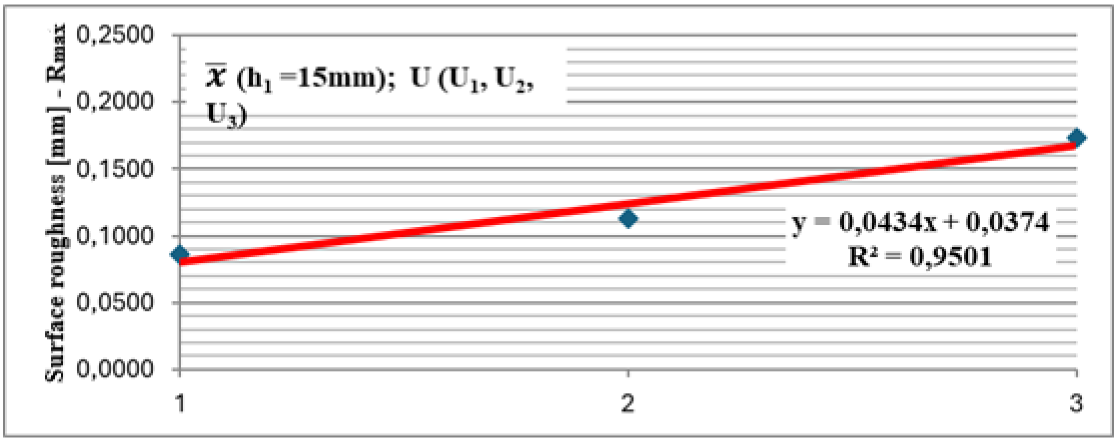

Figure 10. *Regression analysis for mean values of the fir/spruce specimens' surface roughness with all three feed speeds (U_1=12m·min-1, U_2=16m·min^{-1} and U_3=20m·min^{-1}).*

The data presented (Table 2, Figures 7, 8, 9, and 10) indicate that an increase in feed speed correlates directly with an increase in the roughness of the cut surface. The dependence is mathematically expressed by the regression line y = 0.0434x + 0.0374 and the coefficient of determination R^2 = 0.9501. The correlation coefficient indicates a strong dependence.

5. CONCLUSIONS

Regardless of the type of mechanical processing, every author in the professional and scientific literature we evaluated concurs that an increase in feed speed leads to an increase in the roughness of the cut surface. The authors Škaljić, Beljo Lučić, Čavlović, and Obućina (2009) examined the surface quality of beech, oak, and spruce wood. The experiment was conducted on a four-sided planer using a tool with two blades at different feed speeds. They came to the conclusion that surface roughness increased with feed speed based on the results. The lowest roughness was recorded in the oak specimens, and the highest in the spruce specimens. In the research conducted by Svrzić, Đurković, Danon, Furtula, and Stanojević (2021), the examination of surface roughness indicated a significant influence of feed speed on the increase of roughness. The results clearly show that the physical and mechanical properties, as well as the anatomical structure of the wood, affect surface roughness. In general, better results in mechanical wood processing are obtained with lower feed speeds. Considering the wood species used in this study as the processing material, beech and fir/spruce, it is possible to observe differences in the obtained values. Namely, lower values for the roughness of the cut surface were obtained for beech, while higher values for the roughness of the cut surface were obtained for spruce, which is due to the anatomical structure of the wood. It is of great importance to determine the optimal feed speed value in order to achieve favourable productivity and surface quality.

REFERENCES

1. Đurković, M., Danon, G., Svrzić, S., Trposki, Z., & Koljozov, V. (2017) A justification of the use of specialized circular saws for wood. *Proceedings of the 3rd International Scientific Conference "Wood Technology & Product Design"*, pp. 61–66.
2. Đurković, M., Milosavljević Mirić, M., Mihailović, V., & Danon, G. (2019). Tool wear impacts on cutting power and surface quality in peripheral wood milling. *Proceedings of the 4th International Scientific Conference "Wood Technology & Product Design"*, pp. 110–118.
3. Richter, K., Feist, W. C., & Knabe, M. T. (1995). The effect of surface roughness on the performance of finishes. Part 1: Roughness characterisation and strain performance. *Forest Products Journal*, *45*(7/8), pp. 91–97.
4. Škaljić, N., Beljo Lučić, R., Čavlović, A., & Obućina, M. (2009). Effect of feed speed and wood species on roughness of machined surface. *Drvna industrija*, *60*(4), pp. 229–234.

5. Stanojević, D. (2016). Basis of maximum qualitative utilized sawing in cutting beech. *Proceedings of the tenth International Scientific Conference "The Power of Knowledge"*, pp. 1205–1212.
6. Svrzić, S., Đurković, M., Danon, G., Furtula, M., & Stanojević, D. (2021). On acoustic emission analysis in circular saw cutting beech wood with respect to power consumption and surface roughness. *BioResources, 16*(4), pp. 8239–8257.

The Authors' Address:

Anastasija Temelkova, PhD, teaching assistant
Zoran Trposki, PhD, full professor
Vladimir Koljozov, PhD, full professor
Ana Marija Stamenkoska, MSc, teaching assistant
Ss. Cyril and Methodius University in Skopje, Faculty of Design and Technologies of Furniture and Interior-Skopje 16-ta Makedonska brigada 3, 1000 Skopje, Republic of North Macedonia.