7th International DAAAM Baltic Conference
"INDUSTRIAL ENGINEERING
22-24 April 2010, Tallinn, Estonia

THE TOOL INFLUENCE ON THE QUALITY OF THE BIRCH WOOD STRAIGHT MILLED SURFACES

Fotin, A.; Cismaru, I; Cismaru, M. Cosereanu, C; Brenci, L.M. & Curtu, I.

Abstract: *The paper presents the results on the quantitative assessment of the quality of the straight edge surfaces when longitudinally and transversally milling the birch wood surfaces using two types of milling cutters of 80 mm diameter: one with removable metal inserts and one with brazable inserts. Variable parameters as processing direction, rotative speed, feed speed, cutting height and the milling width were considered. The results prove that a better quality of the surface is obtained when milling it with cutters with removable metal inserts. The final conclusion may contribute to the rehabilitation of the Betula pendula (birch wood) status, by changing the attitude of the specialists regarding the possibilities of using it on a large scale in industry.*

Key words: birch, surface quality, roughness, milling cutters.

1. INTRODUCTION

The actual tendency is to develop the international (and also national) basis of raw materials using the less representative species of wood for products or components, or in the structure of wooden composites. Thereby, more and more specialists in Romania are investigating the possibilities of processing and using the less representative species of wood, The birch wood is one of the species of wood that can by used on a large scale for furniture manufacturing, but for this purpose the producers must reach the necessary information regarding the optimum milling parameters of birch wood in order to obtain an appropriate quality of the surfaces recommended for furniture products.

The milling operation is considered to be, by the specialists, the most important one in the wood machining due to the fact that it has the role of defining the shape and dimensions of the wooden part or component. That is the reason why many national and international researchers focused on the study of wood machining [1], [2], [3], tools and equipment necessary for milling operation and of the optimum working process parameters in particular [4], [5], [6]. The final analyzed indicator of a good workability in case of milling operation is always the adequate quality of the surface [7], [8], [9], aiming permanently to the establishing of the optimum working parameters. The analysis of the surface obtained after milling operation is done by scanning the topography of the wood surface using various methods with contact or without contact on the surface and interpreting the results of the roughness parameters considered to be more representative for the wood surfaces, as: *Ra, Rz, Rk, Rpk, Rvk*.

Some researchers [10], [11], consider that *Rk* and *Rpk* are indicators appropriate to provide accurate information about the influence of the machining on the quality of the surface.

The main objective of the present paper is to conclude if the way of mounting the inserts into the milling tool has influence on the quality of the surface, in the conditions of variable parameters of the milling process of birch wood and to establish the optimum milling parameters when machining this species of wood.

a. b.

Fig. 1. Milling cutters with brazable metal inserts (a) and removable metal inserts (b)

2. SAMPLES AND METHOD

The samples made of birch wood (*Betula pendula*), had a moisture content of 8%, the length of 700 mm and a variable width for longitudinal milling and the width of 700 mm and a variable length for transversal milling. The sample edges were machined longitudinally and transversally by milling on MNF 10 - vertical milling machine with detachable mechanical feed device (Fig.2), using two types of milling cutters with sintered carbide inserts as follows: removable metal inserts and brazable inserts (Fig.1). The variable milling parameters in case of straight milling of the edges are shown in Table 1.
The principle of the tests were established according to PROGR software, based on the method of factorial experiment for three variables: feed speed (u), cutting height (h) and milling width (b).
The roughness of the processed surfaces was measured by a MicroProf FRT (Fries Research Technology) type, a German optical equipment for measuring the roughness without contact (Fig.3)

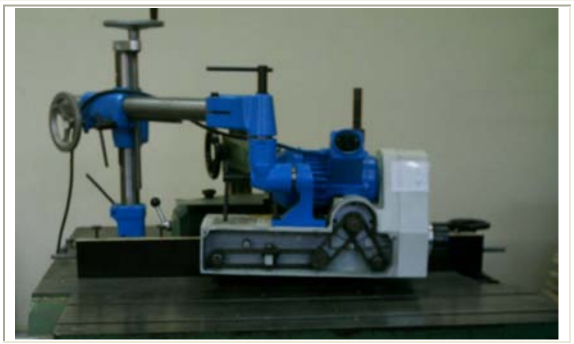


Fig. 2. Vertical milling machine type MNF10 with mechanical feed device.

Parameter name	Values
Rotation speed, (n) rpm	6620; 9732
Feed speed, (u) m/min	4.5; 9; 13.5; 18; 22.5
Cutting depth, (h) mm	1; 2; 3; 4; 5
Cutting width, (b) mm	20; 25; 30; 35; 40

Table 1. Milling parameters

The roughness was measured parallel to the milling direction, the samples being placed in a device when measured, so to keep the measuring position (Fig.3).
Two measurements were performed on each sample, on different areas and the final value of the roughness was calculated as the average of the two determinations. The scanning parameters of the MicroProf FRT roughness measuring equipment, of a high performance, are shown in Table 2.
The data acquisition was performed by ACQUIRE software, provided with the possibility of saving the results in. *frt* and *.txt* files, but also with the possibility of viewing the surface topography. The analysis of the roughness profile was done by MARK III software, which allowed to save files as *.log* files type.
The roughness profile was obtained after filtering the data with Gaussian filter. The *.txt* files resulted with ACQUIRE software were processed by a software of conversion into a DELPHI programe.

Fig. 3. MicroProf FRT optical equipment

Parameter name	Modul 2D
Scanning speed	750 µm/s
Number of points per lines	10.000 puncte
Number of measuring lines	1
Evaluation length	50 mm
Sampling length	2,5 mm
Resolution	5 µm
Direction of measurement	Along the processing direction

Table 2. The scanning parameters of the MicroProf FRT roughness measuring equipment

The DELPHY programme has used mathematical regression method with a nonlinear model degree II - for three variables, namely *u*, *h* and *b* [7], according to equation:

$$Y=a + bx_1 + cx_2 + dx_3 + ex_1x_2 + fx_1x_3 + gx_2x_3 + hx_1^2 + ix_2^2 + jx_3^2 \qquad (1)$$

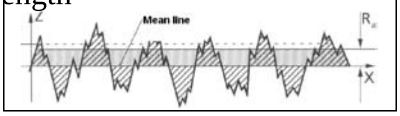
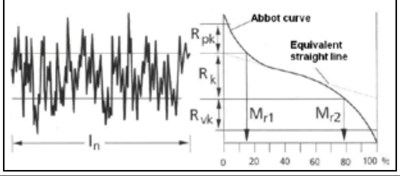
Parameter name	Description
Ra, µm	-The arithmetical mean leviation *Ra* is the arithmetic hean of the absolute ordinate ʼalues *Z* within a sampling ength 
Rk, µm Rpk, µm	-the central area, *Rk* - ›arameter for the processing oughness evaluation -the profile peaks area *Rpk* - ›arameter for the fuzzy grain valuation 

Table 3. Analyzed roughness parameters

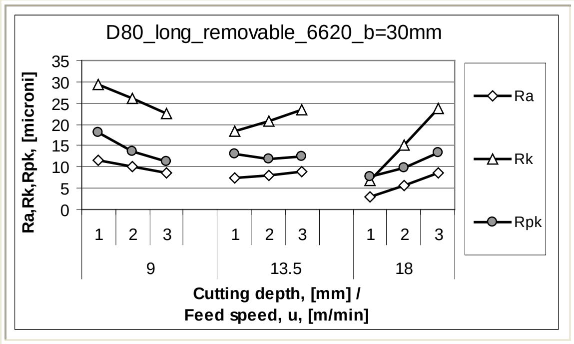


Fig. 4. Roughness parameters (*Ra*,*Rk*,*Rpk*), when using removable metal inserts

Among the parameters characterized by ISO 4287: 2001, *Ra* was used and by ISO 13565-2: 1999, *Rk* and *Rpk* were selected to be analyzed. (Table 3)

3. RESULTS AND DISCUSSIONS

The paper presents the comparison between the roughness parameters *Ra*, *Rk* and *Rpk*, measured experimentally after machining with two types of milling cutters with sintered carbide inserts, namely removable metal inserts and brazable inserts of a milling cutter of 80 mm diameter, at a rotation speed of 6620 rot/min. The first conclusion of the experimental results was that the milling width has no significant influence on the quality of the surface. The paper investigates only the samples having a width of 30 mm. The title of each diagram indicates the diameter of the milling cutter_measuring direction_type of the inserts_rotation speed (in rpm)_milling width (in mm) (Fig.4 ... Fig.12).

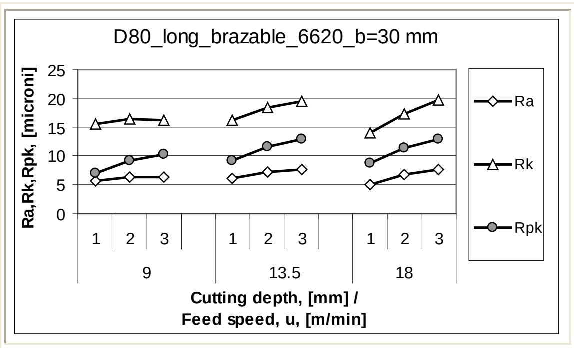


Fig. 5. Roughness parameters (*Ra*,*Rk*,*Rpk*), for brazable inserts, longitudinal milling

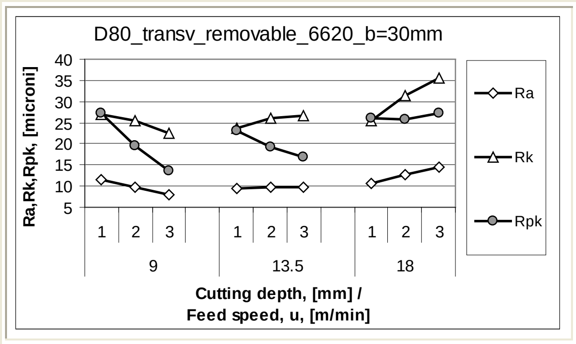


Fig. 6. Roughness parameters (*Ra*,*Rk*,*Rpk*), transversal milling, removable metal inserts

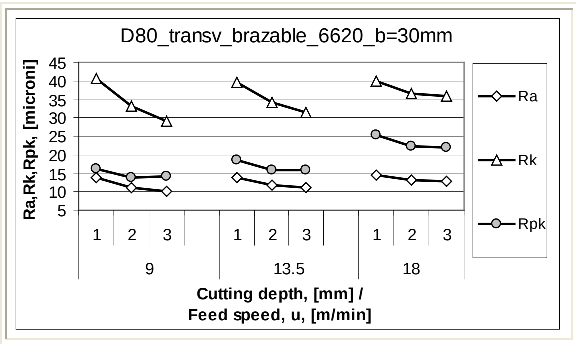


Fig. 7. Roughness parameters (*Ra*,*Rk*,*Rpk*), transversal milling, brazable inserts

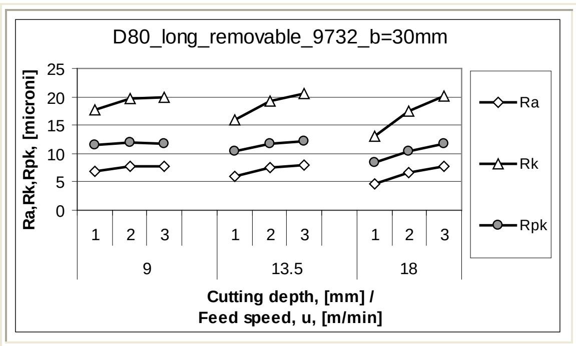


Fig. 8. Roughness parameters (*Ra*,*Rk*,*Rpk*), longitudinal milling, removable metal inserts

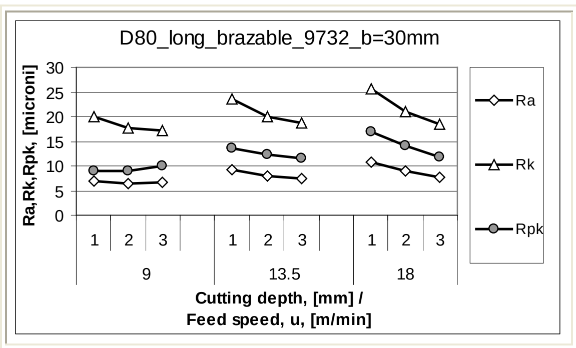


Fig. 9. Roughness parameters (*Ra*,*Rk*,*Rpk*), longitudinal milling, brazable inserts

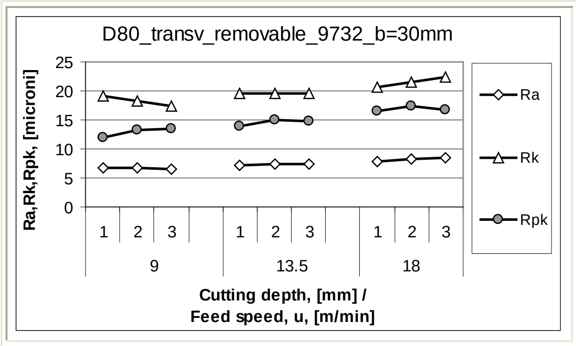


Fig.10. Roughness parameters (*Ra*,*Rk*,*Rpk*) transversal milling, removable metal inserts

The roughness parameters resulted after the experimental determination concluded to different values and tendencies depending on the way of mounting the inserts, rotation speed, feed speed, cutting depth and direction of processing, as follows:

- For the longitudinal milling, no matter of rotation speed, the lowest values of the roughness parameters were obtained for a speed feed u=18 m/min and cutting depth of 1 mm for both types of milling cutters (Fig.12, Fig 13);
- The results were more satisfactory for low rotation speeds when using brazable inserts, whilst the best quality of the surface was obtained at high rotation speeds when using removable metal inserts;
- The best quality of the surfaces processed transversally by milling was obtained at a feed speed of 9 m/min and a cutting height of 1mm for both rotation speeds studied, in the case of using removable metal inserts (Fig.14, Fig.15).

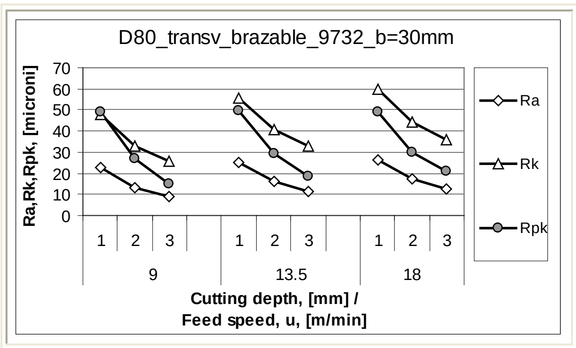


Fig.11.Roughness parameters (*Ra*,*Rk*,*Rpk*), transversal milling, brazable inserts

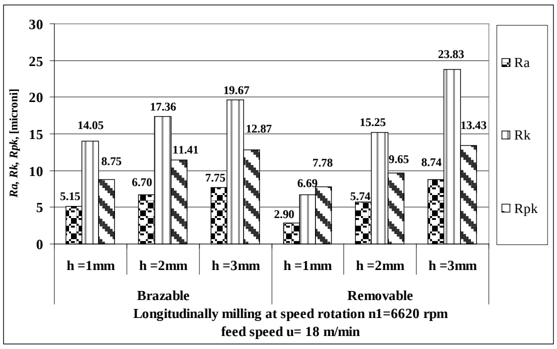


Fig.12.Roughness parameters (*Ra*,*Rk*,*Rpk*), longitudinal milling, u=18 m/min and n_2= 9732 rot/min

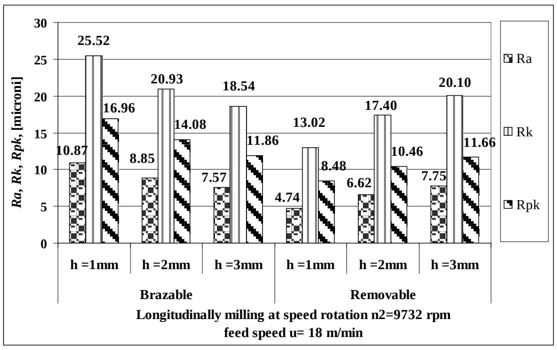


Fig.13.Roughness parameters (*Ra*,*Rk*,*Rpk*), longitudinal milling, u=18 m/min and n_2= 9732 rot/min

4. CONCLUSIONS

Conclusions regarding the influence of the way of mounting the inserts into the tool (removable metal inserts and brazable inserts) and of the working parameters on the quality of the processed surfaces by milling, using milling cutters of 80 mm diameter are as follows:

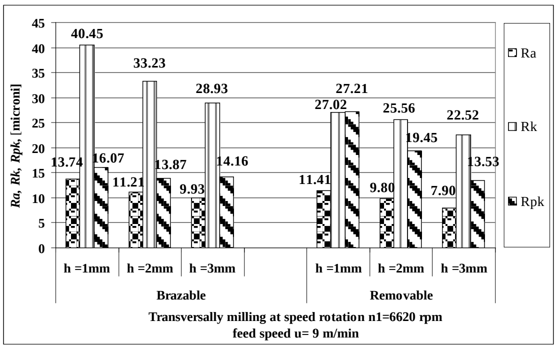


Fig.14.Roughness parameters (*Ra*,*Rk*,*Rpk*), transversal milling, u=9 m/min and n_1= 6620 rot/min

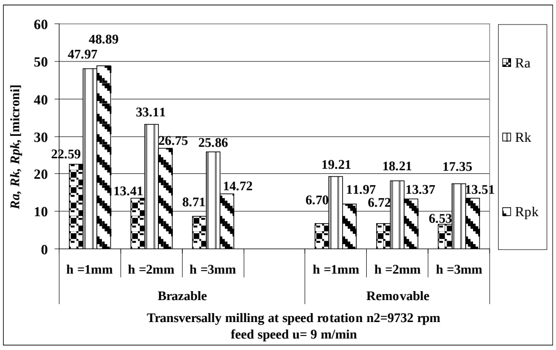


Fig.15.Roughness parameters (*Ra*,*Rk*,*Rpk*), transversal milling, u=9 m/min and n2= 9732 rot/min

- In case of longitudinal milling, the roughness value increases when the cutting height (h) increases;
- In case of transversal milling, the roughness value decreases when the cutting height (h) increases;
- The values of the roughness parameters *Ra, Rk, Rpk* are approx. two times higher on the transversal direction against the longitudinal one.
- In case of using the same milling tool it is recommended to mount removable metal inserts on it, both on the longitudinal and transversal milling.
- The best longitudinal processed surfaces are obtained for high feed speeds (u), whilst for the transversal milling are recommended low feed speeds and minimum cutting heights (h).

The present research offers clear information on the optimum milling conditions of birch wood in industry and thus the wooden products manufacturers are entitled to use the birch wood in order to enlarge the raw material basis in Romania.

5. REFERENCES

1. Dogaru, V. *Frezarea lemnului (Wood milling*), Transilvania University of Brasov, 2003.
2. Iskra, P.; Tanaka, C. The influence of wood fiber direction, feed rate and cutting width on sound intensity during routing,

2005, *Holz als Roh-und Werkstoff*, **63,** 167-172
3. Fotin, A., Salca, E., Cismaru, I. *Considerations regarding birch forestry***,** Proceedings of International Conference „Wood Science and Engineering in the Third Millennium", Faculty of Wood Industry, Transilvania University of Brasov, 2007.
4. Brenci, L. Research concerning the influence of cutter wear upon the quality of profiled wooden surfaces (Studii privind influenta uzurii cutitului asupra calitatii suprafetelor profilate din lemn). *ProLigno*, 2006, **2,** N^{o}.1, 65-73.
5. Fotin, A., Cismaru, I. - Outline of birch use in wood industry, *Proceedings of International Postgraduates Students Conference* Contemporary State and Development Trends of Forests in Cultural Landscape, Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry, Brno, Czech Republic, 2006.
6. Salcă, E., Cismaru, I., Fotin, A. Evaluarea calitatii suprafetei la frezarea profilata a lemnului de arin si mesteacan (Evaluation of surface quality after profiled milling of alder and birch wood)**,** 2008, *ProLigno*, **4**, N^{o}.2,.57-68.
7. Vega, M.; Aguilera, A. Surface roughness and cutting power for machining radiata pine 2005. *Bosque* **26(1),** 101-108.
8. De Moura, L. Hernandez, R. Characteristics of sugar maple wood surfaces machined with the fixed-oblique knife pressure-bar cutting system, 2007, *Wood Sci Technol* **41,** 17-29.
9. Keturakis, G.; Juodeikiene, I. Investigation of Milled Wood Surface Roughness *Materials Scienc*e, **13**, No.1, 47-51.
10. Fujiwara, Y. *Evaluation of wood surface roughness as related to tactile roughness*, Ph.D Thesis Graduate School of Agriculture, Kyoto University, Japan, 2004.
11. Gurau, L.; Mansfield, H.; Irle, M. Processing roughness of sanded wood surfaces, 2004, *Holz roh Werkst* **63,** 43-52.

6. ADDITIONAL DATA ABOUT AUTHORS

1) Lecturer Dr. Fotin, A.; Proff. Dr. Cismaru, I.; Ass. Proff. Dr. Cosereanu, C.; Ass. Proff. Dr. Brenci, L. M. & Proff. Dr. Curtu, I.
2) The tool influence on the quality of the birch wood straight milled surfaces
3) Fotin, A./ Lecturer Dr. Eng./ Transilvania University of Brasov/ Faculty of Wood Industry/ B-dul. Eroilor 29, 500036 Brasov / +40268415 315, *adrianafotin@unitbv.ro*
Cismaru, I./ Proff. Dr. Eng./ Transilvania University of Brasov/ Faculty of Wood Industry/ B-dul. Eroilor 29, 500036 Brasov/ Tel/Fax :0040 268 415315, icismaru@unitbv.ro
Cosereanu, C./ Ass. Proff. Dr. Eng./ Transilvania University of Brasov/ Faculty of Wood Industry/ B-dul. Eroilor 29, 500036 Brasov /Tel/Fax: +40268415 315, *cboieriu@unitbv.ro*
Brenci, L.M./ Ass. Proff. Dr. Eng./ Transilvania University of Brasov/ Faculty of Wood Industry/ B-dul. Eroilor 29, 500036 Brasov /Tel/Fax: +40268415 315, brenlu@unitbv.ro
Curtu, I./ Proff. Dr. Eng./ Transilvania University of Braşov – Faculty of Mechanics/ B-dul. Eroilor 29, 500036 Braşov/ Te/Fax 0040 268 415315/ curtui@unitbv.ro
4) Corresponding Author: Fotin, A./ Lecturer Dr. Eng./ Transilvania University of Brasov/ Faculty of Wood Industry/ B-dul. Eroilor 29, 500036 Brasov / +40268415 315, adrianafotin@unitbv.ro