TRIESKOVÉ A BEZTRIESKOVÉ OBRÁBANIE DREVA, 8(1): 365–370, 2012
Zvolen, Technická univerzita vo Zvolene, ISBN 978-80-228-2385-2

SHORT-TIME METHOD OF MACHINABILITY RATING OF WOOD-BASED MATERIALS DURING MILLING

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Abstract
A major disadvantage of the classical method of machinability assessment (based on the tool life testing) is the high level of time-consumption and material-consumption. The basic aim of the study was the comparison of the results obtained using the classical and short-time method. The worked materials were as follows: MDF, standard chipboard, laminated chipboard, MFP and compreg. In the study the five spindle speeds were used. The difference in the results of both methods does not exceed 10%. Short-time method turned out to be quite economical and effective. Particularly important advantage of short-time method is a relatively high level of material savings (average value of material savings indicator was nearly 60%).

Key words: *milling, machinability, tool life, cutting speed*

INTRODUCTION

The machinability means vulnerability to machining (cutting) process realized by means of the machine tools [Jemielniak 1998, Miernik 2000]. Machinability, which can be defined as the workability during the machining process, is one of the most important technological properties of wood and wood based materials [Górski, Podziewski, Szymanowski 2010]. Unfortunately there is no universal, widely accepted indicator of machinability. Moreover machinability must be defined for some specified cutting conditions. One of the most important criterion of machinability is a tool life [Jemielniak 1998]. Therefore the standard method of experimental machinability assessment is classical tool life test taking into account the impact of cutting speed. This classical, experimental procedure leads to a determination of the presented below relationship (called Taylor formula) between the tool life (corresponding to the established tool-life criterion) and cutting speed:

$$T = f(V) = C/(V)^k \qquad (1)$$

where: V [m/s] - cutting speed; T [min] - tool life; C [min] and k [-] – constant coefficients.

Above relationship can be considered as classical indicator of machinability. The method involves the systematic examination of the tool wear observed in the rake face or in major flank face. A major disadvantage of the classical method of machinability testing is the high

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level of time-consumption and material-consumption. The basic aim of the study was the comparison of the results obtained using the classical and short-time method.

MATERIALS AND METHODS

The study was realized by means of standard CNC router and standard milling cutter (the cutting diameter - 40mm). The worked materials were as follows: MDF (Medium Density Fiberboard), standard chipboard, laminated chipboard, MFP (Multi-Functional Panel) and compreg (special plywood manufactured from hardwood veneers with special phenol resin in high temperature and under high pressure). During the experimental procedure the grooves were made by means of single pass-operation (the depth: 6 mm). The experimental procedure contained using of the five spindle speeds: 10000 – 18000 rpm and one, constant feed per revolution: 0,15 mm.

The standard tool wear indicator - VBmax (maximum wear observed on the major flank surface) was measured by means of workshop microscope. During the standard tool life tests the tool-life criterion was VBmax = 0,20 mm. In the accelerated tests the reduced level of tool-life criterion (VBmax = 0,15 mm) was accepted. Obviously the short-time method for determining the functional dependence (according to the Taylor formula) between tool life and cutting speed was generally based on accelerated tests – hence the reduction of material consumption. The only but very important exception were tests for the highest spindle speed (18000 rpm). In this case the tool-life criterion was the same (VBmax = 0,20 mm) for both (classic and short-time) methods.

RESULTS AND DISCUSSION

The effect of the cutting time on tool wear (VBmax [mm]) for different cutting speeds is shown in Fig. 1 – 5 (separately for different worked materials). Averaged, functional relationships between the tool life (T [min]) and the cutting speed (V [m/s]) are shown in Fig. 5-10. It is worth noting that these relationships were determined by means of both (classical and short-time) methods which are compared with each other in this paper. It turned out that both methods gave quite similar results. It is clear that the cutting speed effects, in a significant way, tool life. The increase in cutting speed causes the significant acceleration of tool wear process. Strict mathematical relations (according to the Taylor formula) which were determined by means of classical and short-time method are presented in table 1. Additional information presented in this table is the material savings indicator which was estimated according to the following formula:

$$MS = 100\%(M_{CL} - M_{ST})/M_{ST} \qquad (2)$$

where: MS – material savings indicator; M_{CL} – material consumption in the classical method; M_{ST} – material consumption in the short-time method.

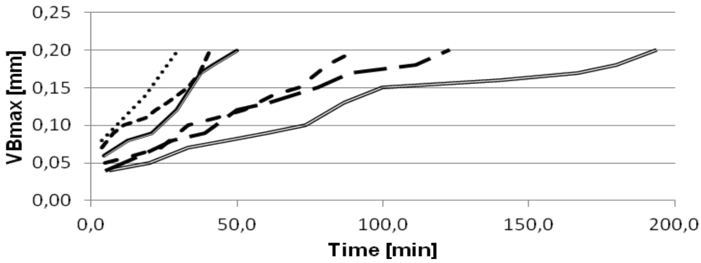

Fig.1 Standard chipboard machining – effect of the cutting time on tool wear (for different cutting speeds)

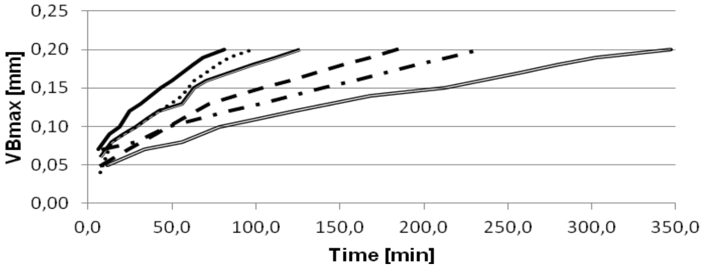

Fig.2 MDF machining – effect of the cutting time on tool wear (for different cutting speeds)

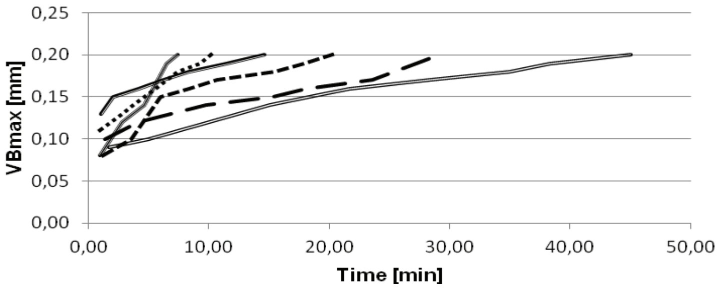

Fig.3 MFP machining – effect of the cutting time on tool wear (for different cutting speeds)

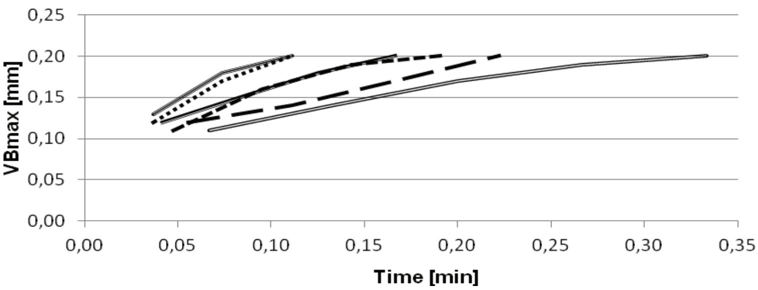

Fig.4. Laminated chipboard machining – effect of the cutting time on tool wear (for different cutting speeds)

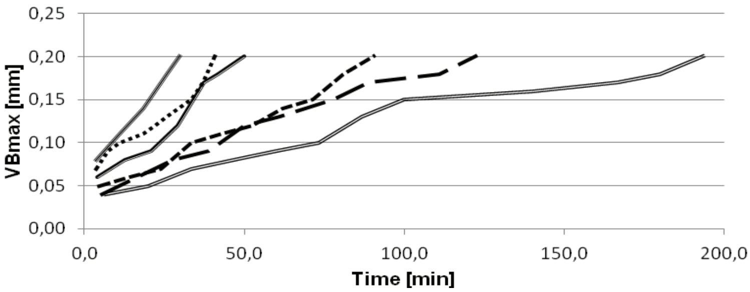

Fig.5. Compreg machining - effect of the cutting time on tool wear (for different cutting speeds)

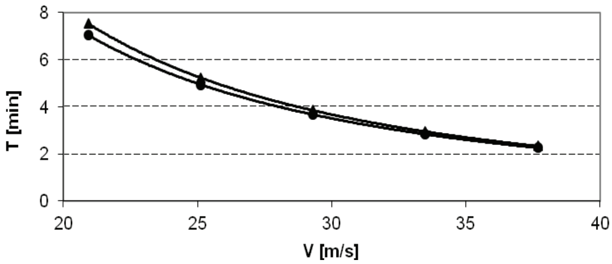

Fig.6. Standard chipboard machining – relationship between tool life and cutting speed (the triangular and circular markers represent results of classical method and short-time method respectively).

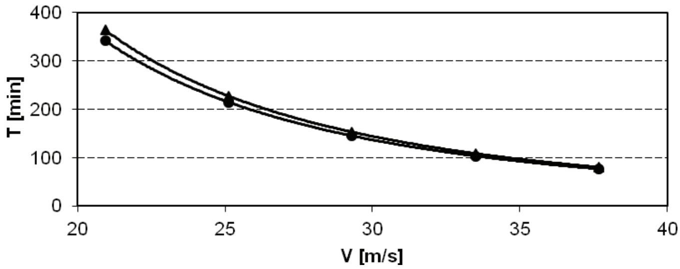

Fig.7. MDF machining – relationship between tool life and cutting speed (the triangular and circular markers represent results of classical method and short-time method respectively).

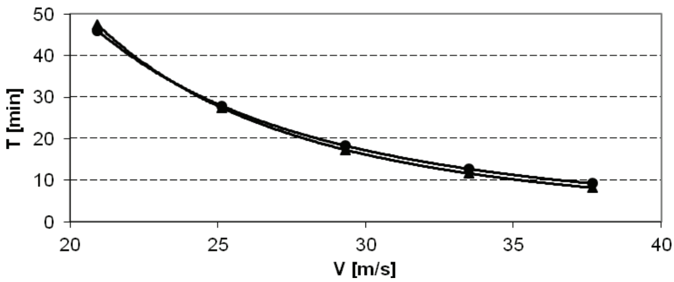

Fig.8. MFP machining – relationship between tool life and cutting speed (the triangular and circular markers represent results of classical method and short-time method respectively).

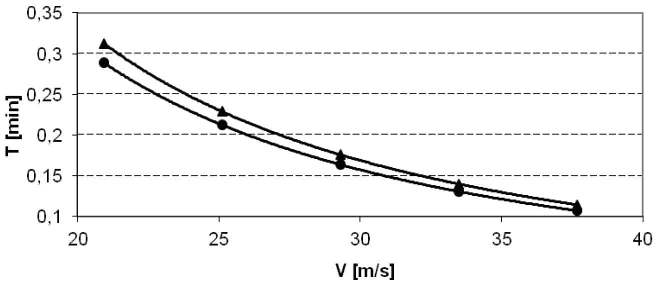

Fig.9. Laminated chipboard machining – relationship between tool life and cutting speed (the triangular and circular markers represent results of classical method and short-time method respectively).

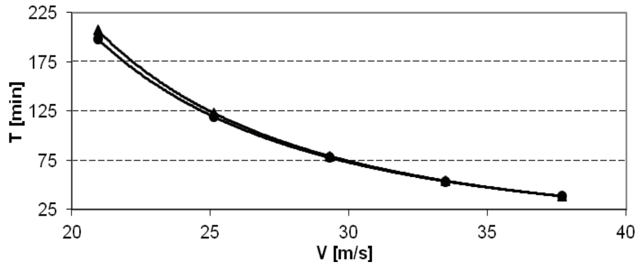

Fig.10. Compreg machining – relationship between tool life and cutting speed (the triangular and circular markers represent results of classical method and short-time method respectively).

Tab.1. Taylor formulas and material savings

Material	Taylor formula		Material savings indicator MS [%]
	by classical method	by short-time method	
MDF	$T=918000(V)^{2,58}$	$T=794000(V)^{2,55}$	46 %
chipboard	$T=2570(V)^{1,94}$	$T=3300(V)^{2}$	55 %
lam. chipboard	$T=57,4(V)^{1,71}$	$T=49,5(V)^{1,69}$	52 %
MFP	$T=188000(V)^{2,73}$	$T=414000(V)^{2,98}$	103 %
compreg	$T=1240000(V)^{2,86}$	$T=944000(V)^{2,78}$	40 %

CONCLUSIONS

Short-time method of machinability testing used in the study turned out to be quite economical and effective in comparison to classical method. In general, the difference in the results of both methods does not exceed 10% (Fig.6-10). Particularly important advantage of short-time method is a relatively high level of material savings (average value of material savings indicator was nearly 60%).

Acknowledgement: All the experiments presented in the paper were financed by National Science Centre in Poland as the grant NN 309 007537 ("Machining of wood based materials" 2009-2013).

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