



MACHINABILITY RATING OF WOOD MATERIALS FOR DRILLING

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Abstract

The paper presents a simplified method of relative machinability testing which was intended for wood materials. This method was based on the measurement of the drilling time for a constant depth of drilling. Drilling was performed by means of special test stand using a constant pressing force on the tool. In this case the time of drilling can be considered as a simplified machinability indicator. In order to verify the above, simplified method the cutting forces (standard machinability indicators) were measured using a piezoelectric sensor. Next the adequate correlations were tested. Finally it turned out that the simplified method is a quite good source of information about the relative machinability of wood materials.

Key words: wood materials, machinability indicators, drilling, axial force, torque

INTRODUCTION

Knowledge of the wood materials relative machinability, especially compared with the advanced knowledge of metals machinability, is embarrassingly poor. This is an important problem and requires a systematic research. The issue is becoming more and more important due to the dynamic development of new wood based materials and new methods of wood modification. There are quite a lot of publication which are related (directly or indirectly) to the problem of wood materials machinability [e.i. Serafettin et al. 2000; Dippon et al. 2000, Aguilera et al. 2000, Aguilera, Martin 2001, Hernandez et al. 2001; Buehlmann et al. 2001; Porankiewicz 2003; Hizioglu et al. 2004; Nemli et al. 2005, Lin et al. 2006; Philbin, Gordon 2006; Hizioglu 2007; Gaitonde et al. 2007; Davim et al. 2007, 2008]. Unfortunately all the authors (scientists from very different parts of the world) conducted their studies rather in random than in systematic way. The main problem is incomparable test procedures, and quite different machinability indicators which were used. The aim of this study was to develop a simplified method of relative machinability testing which would be useful for the comparison of different wood materials.

MATERIAL AND METHODS

The worked material contained samples made of 12 different types of wood based materials and made of 12 different species of wood. Selected species of wood represent both

hardwood and softwood. The wood came from moderate zone (7 species) and tropical zone (5 species). Samples of tested wood was selected with no visible defects. Average humidity of wood was 7%. Single point tool with a diameter 10 mm (Leitz 91193), made of PCD was used during experiments (Fig.1).

Two-staged experimental procedure was used. In the first stage drilling was performed by means of CNC machine tool (Busellato Jet 130). The cutting parameter were as follows: spindle speed $n = 6000$ rpm, feed per revolution $f = 0,2$ mm/rev. In this case the cutting forces were considered as machinability indicators. The cutting forces (axial force - F_z and torque - M) were measured by means of piezoelectric sensor (Kistler 9345A) and adequate amplifier (Kistler ICAM 5073). The signals were recorded by the NI PCI 6034 acquisition card with a frequency of 50 kHz. The elements of the measuring system are shown in Fig.2. The analysis of signals was performed using NI LabVIEW environment.

In the second stage of the experimental procedure drilling process was performed by means of special test stand using a constant pressing force on the tool.

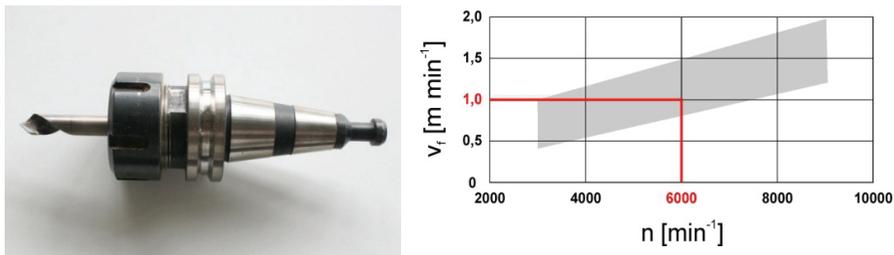


Fig.1. The tool (the left) and the standard range of cutting parameters for this tool (the right)

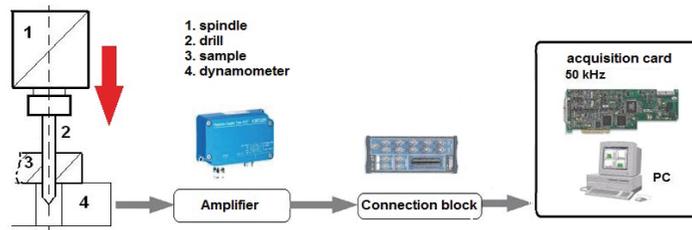


Fig.2. The cutting force measuring system (used during drilling by means of CNC machine tool)

The base element of the special test stand was drilling-milling machine Bernardo BF 30 Super (Fig.3). Elements of this stand are shown in Fig.3. In this case the time of drilling can be considered as a simplified machinability indicator. Time of drilling was measured by means of special measuring device (Fig.4) containing two main components: a light source – LED and a photo resistor. The whole device was powered by means of USB interface of PC. Spindle speed was $n = 2300$ rpm. The depth of drilling was constant for all materials (10 mm).

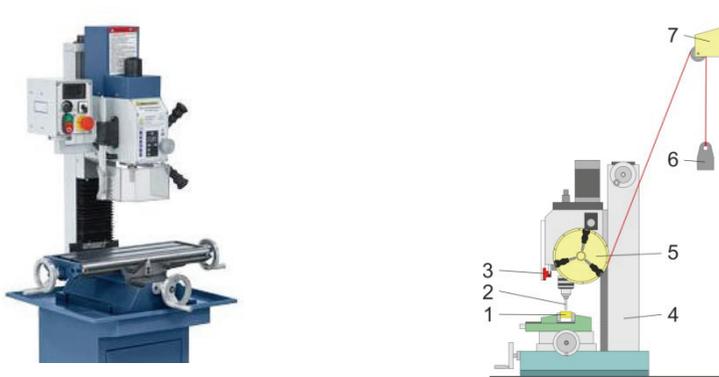


Fig.3. Special test stand using a constant pressing force on the tool (1 - sample material, 2 - tool, 3 - sensor, 4 - body of drilling machine, 5 - drive wheel, 6 - weight, 7 - block of housing fixed to the wall)

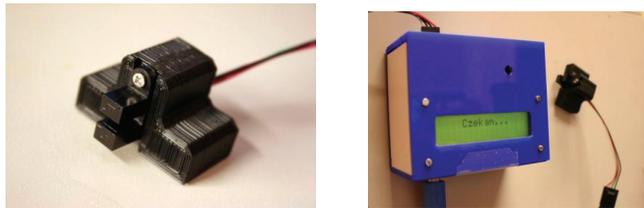


Fig.4. Slot sensor used in the drilling time measurement (left), display with the values measured with the sensor (right)

RESULTS

On the basis of the experimental results the three different kind of relative machinability indicators (based on axial force, torque and time of drilling) were calculated. For this purpose the medium-density fibreboard (MDF) was adopted as a reference material. The indicators of relative machinability for all tested materials were calculated according to the following formulas:

$$M_{Fz} = Fz_X / Fz_{MDF} \quad (1)$$

where:

M_{Fz} - relative machinability indicator based on axial force,

Fz_X - axial (feed) force for material X,

Fz_{MDF} - axial (feed) force for the reference material (MDF).

$$M_M = M_X / M_{MDF} \quad (2)$$

where:

M_M - relative machinability indicator based on torque,

M_X - torque for material X,

M_{MDF} - torque for the reference material (MDF).

$$M_T = T_X / T_{MDF} \quad (3)$$

where:

M_T - relative machinability indicator based on the drilling time,

T_X - drilling time for material X,

T_{MDF} - drilling time for the reference material (MDF).

Detailed values of defined above indicators are shown in the Fig.5 – Fig.7. It is worth noting that the ranking of the materials (the ranking due to the machinability) depends on the kind of machinability indicator. Moreover the correlation between different indicators were analyzed (Fig. 8 and 9). For the comparison the correlation between material density and machinability indicator based on axial (feed) force and indicator based on torque were determined (Fig.10 and 11).

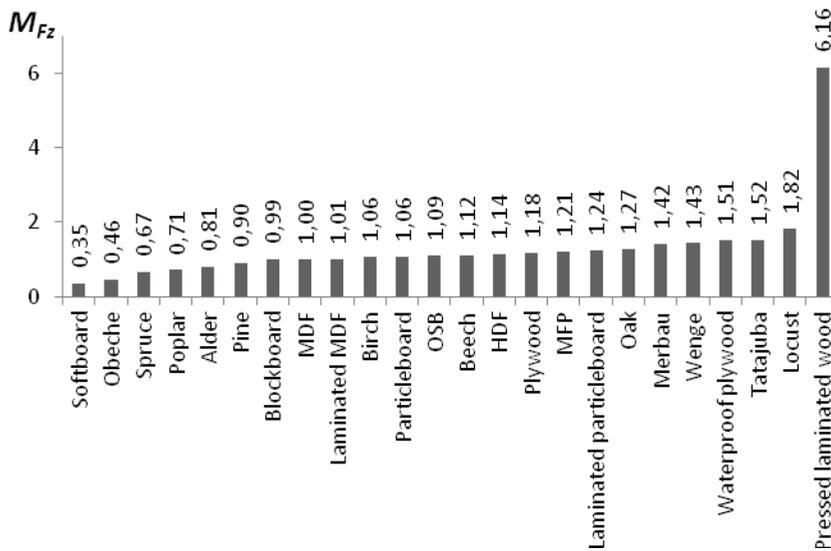


Fig.5. Relative machinability indicator M_{Fz} for tested materials

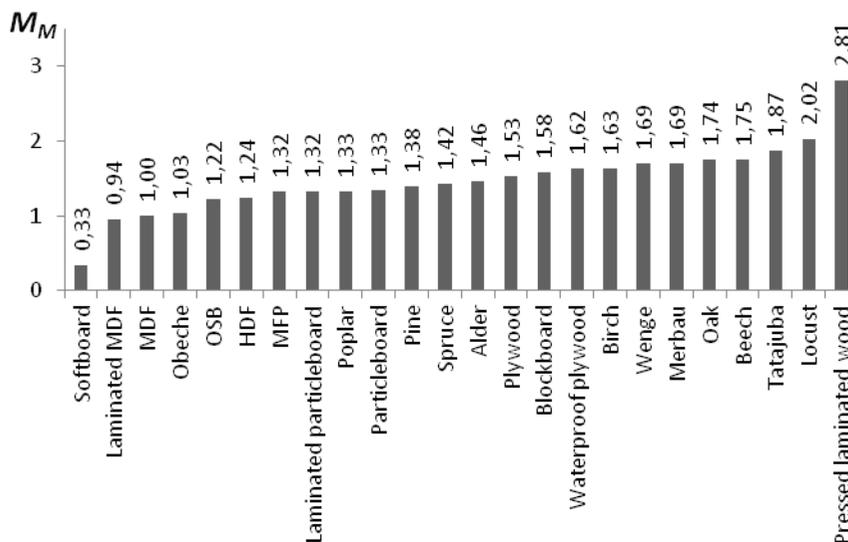


Fig.6. Relative machinability indicator M_M for tested materials

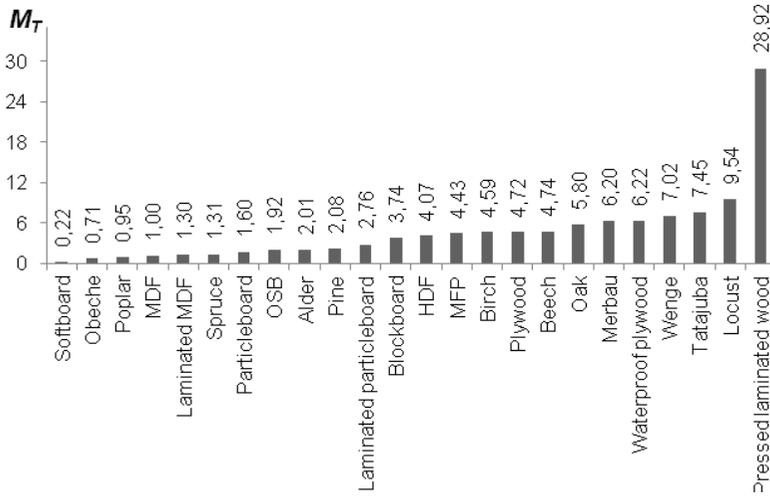


Fig.7. Relative machinability indicator M_T for tested materials

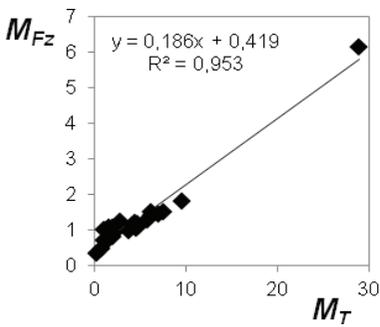


Fig.8. Relationship between M_T and M_{Fz} machinability indicators

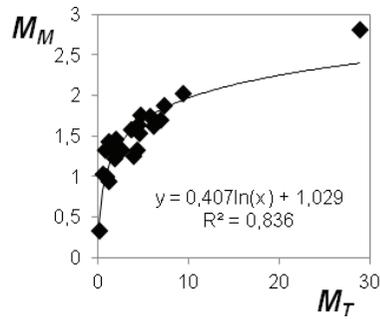


Fig.9. Relationship between M_T and M_M machinability indicators

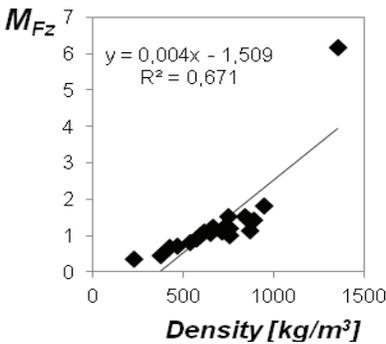


Fig.10. Relationship between density wood materials and M_{Fz} machinability indicator

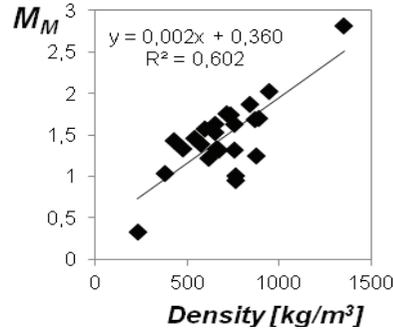


Fig.11. Relationship between density wood materials and M_M machinability indicator

CONCLUSIONS

It turned out that, presented in the paper, the simplified method turned out to be a quite good source of information about wood and wood based materials machinability. The level of correlation between relative machinability indicator based on drilling time and standard indicators based on cutting forces were rather high ($R^2=0,95$; $R^2=0,83$). It is worth noting that the drilling time was better source of information about machinability than materials density measurements.

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REFERENCES

- AGUILERA A. et al., 2000: Wood materials influence in routing operations: MDF case. *Holz als Roh- und Werkstoff* 58: 273-283.
- AGUILERA A., MARTIN P., 2001: Machining qualification of solid wood of *Fagus silvatica* L. and *Pinea excelsa* L.: cutting forces, power requirements. *Holz als Roh- und Werkstoff* 59: 483-488.
- BUEHLMANN U. et al., 2001: Wood-fiber plastic composites: machining and surface quality. 15-th International Wood Machining Seminar, Anaheim, CA.
- DAVIM J.P. et al., 2007: Drilling investigation of MDF. *Journal of Material Processing Technology*, In press.
- DAVIM J.P. et al., 2008: An investigation study of delamination in drilling of MDF using response surface model. *Int J Adv Manuf Technol* 37: 49-57.
- DIPPON J. et al., 2000: Ortoogonal cutting mechanics of medium density fiberboard. *Forest Product Journal* 50 (7/8): 25-30.
- GAITONDE V.N. et al., 2007: Taguchi multiple-performance characteristics optimization in drilling of medium density fibreboard (MDF) to minimize delamination using utility concept. *Journal of Material Processing Technology* 196: 73-78.
- HERNANDEZ R. E. et al., 2001: Wood machining properties of white spruce from plantation forests. *Forest Product Journal* 51 (6): 82-88.
- HIZIROGLU S., 2007: Mechanical properties and surface characteristics of colombian wood composites. *Journal of Composite Materials* 41 (18): 2225-2234.
- HIZIROGLU S. et al., 2004: Surface characteristics of wood composites manufactured in Thailand, Some of the parameters influencing surface roughness of particleboard. *Building and Environment* 39: 1358-1364.
- LIN R.J.T. et al., 2006: Machinability investigation of medium-density fireboard. *Holzforchung* 60: 71-77.
- NEMLI G. et al., 2005: Some of the parameters influencing surface roughness of particleboard. *Building and Environment* 40: 1337-1340.
- PHILIBIN P., GORDON S., 2006: Recent research on the machining of wood-based composite materials. *International Journal of Machining and Machinability of Materials* 1 (2): 186-201.
- PORANKIEWICZ B., 2003: Cutting edge wear and quality at cutting secondary wood products. Wyd. AR w Poznaniu.
- SERAFETTIN E. et al., 2000: Mechanics of routing medium density fiberboard. *Forest Product Journal* 50 (9): 65-69.