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Machinability of three layer MDF boards made of wood fibres with different dimensions

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Abstract: *Machinability of three layer MDF boards made of wood fibres with different dimensions.* In work was prepared two kinds of fiberboards based on wood fibres with different dimensions. First type of wood fibres was received at higher level of milling and second one at lower. Fiberboards were subjected to drilling on CNC Center Busellato Jet 130. Drill Φ10 mm with one polycrystalline diamond edge was used. There were set three levels of feed per revolution: 0,1mm, 0,3 mm and 0,5 mm. Three layer MDF boards distinguish during drilling by similar machinability based on cutting resistance in compare to standard one layer MDF boards offered on market.

Keywords: wood fibers, three layer MDF boards, machinability, drilling, axial force, torque

INTRODUCTION

The beginnings of the industrial production of MDF according to Davim et al. [2009] date back to 2008. This type of wood material found very wide application. It is based on wood fibers which are made with milling of wood in defibrator. The MDF boards characterize of homogeneous structure which enable high quality of machining.

The increasing demand for wood raw material to production of wood-based panels enforced industry to introduce the innovations in technological processes. One of these innovations was addition of post-consumer wood [Cichy 2008]. Post–consumer wood may be considered even as full worth substitute instead of fresh one [Nicewicz 2014]. Another alternative solution was the use of fast growing wood species such as willow and poplar. This also concerns annual plants, especially straw [Bechta 2003].

Some efforts are also attempted to produce boards with mixture of fibers and chips. This technology is based on usage of much more expensive fibers for top layer and the chips (less expensive in production) for core layer. Received in this way product distinguishes by much better aesthetic and surface smoothness than standard chipboard. The studies performed by Frydrysiak [2013] show that 25% content of the wood fibers in the outer layer allow to obtain the product fulfilling requirements detailed in standards for this type of product.

Similar solution in order to decrease energy consumption in the manufacturing process of fiber boards is using fibers with lower degree of melt to core layer. Important is also fact that the material with less porous core layer, such as fiber-chip board, should promote deep milling process [Wilkowski et al. 2014].

In general, according to machinability properties of wood-based materials, MDF board is assumed as extremely easily being machined material as well in terms of tool wear and machining quality as cutting resistance [Gaitonde et al. 2008, Laszewicz et al. 2013]. In consequence, every modifications of MDF boards should be verified in this range, what took place in this work.

MATERIAL AND METHODS

There were made two kinds of three layer MDF boards. For production process there were used 2 types of fibers with different properties. The differences consist in visible in Fig.1 and Fig.2 different degree of melt.

Fig.1. View of fibers with higher degree of melt

Fig.2. View of fibers with lower degree of melt

In both variants of fiberboards, surface layer (SL) was made of fibers which were melt with higher degree. In general, these two kinds of material can be described as follows:

- Fibreboard A : SL – 100% of fibers melt with higher degree, CL –100% of fibers melt with higher degree.
- Fibreboard B: SL - 100% of fibers melt with higher degree, CL – 50% of fibers melt with higher degree and 50% of fibers melt with lower degree

The density of used in experiment fiberboards amounted 650 kg/m^3, thickness 17 mm and UF glue content 8%, as well in core layer as in surface layer. Mentioned above fiber boards were conditioned for 7 days in laboratory conditions (20±2°C, 60±5% humidity). The density profiles for both kinds of material was showed in Fig.3 and Fig.4.

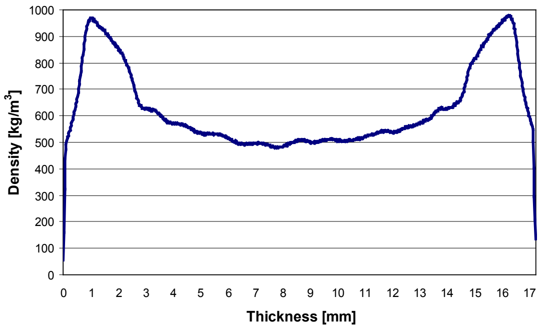

Fig.3. Density profile for fibreboard A

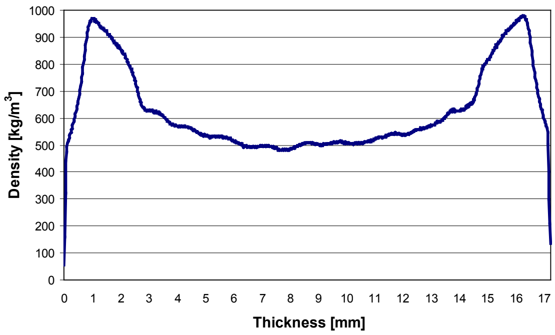

Fig.4. Density profile for fibreboard B

Their mechanical properties were presented in table 1.

Tab.1. Mechanical properties of experimental fiberboards

Variants of fiberboards	MOR [MPa]			MOE [MPa]		
	min	max	average	min	max	average
Fibreboard A	33,48	35,02	34,38	3014	3233	3095
Fibreboard B	26,17	34,03	32,05	2662	3188	2911

The study was conducted on CNC Center Busellato Jet 130. One edge, through drill Leitz equipped with cutting edge made of polycrystalline diamond was clamped in tool grip. The diameter of tool amounted 10 mm. The drilling was conducted with rotational speed 6000 RPM (cutting edge geometry: α=7,5°, b=75°, γ=7,5°). Samples with a size of 100 x 35 x 16 mm were clamped on a specially designed measurement platform. The platform was part of 2-components force and torque sensor Kistler 9345 A. Signal from sensor was transferred firstly to amplifier, then to acquisition card NI PCI-6111, which created possibility of a sampling frequency of 50kHz. Acquisition card was installed in a PC on which the signal recorded in LabVIEW Environment. The measurement platform was shown on Fig.5.

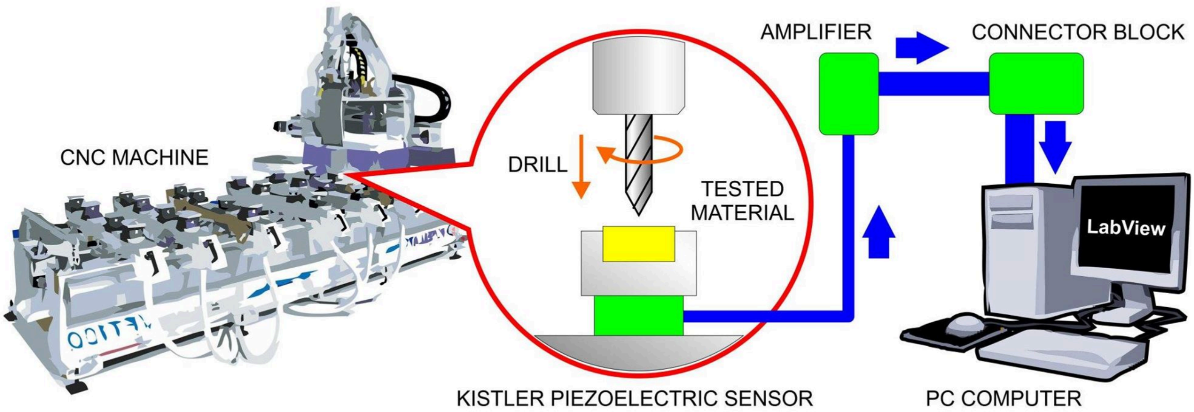

Fig.5. Scheme of measurement platform

In this work relative machinability indicators were calculated with use of method Wilkowski et al. (2013). According to the above as reference material MDF board with a density of 750 kg/m^3, 16mm thickness were used. Therefore, the indicators were calculated as follows:

$$MI_M = (M_{MDF} / M_i)$$
$$MI_F = (F_{MDF} / F_i)$$

where:
MI_M , MI_F - values of torque and axial force noticed during drilling in MDF board for each feed speed,
M_i, F_i - analogue values noticed during drilling i-th material (particular tested materials compared with MDF).

The first relative indices machinability refers to the torque and the axial force of the other.

RESEARCH RESULTS

Results show that there is no statistically significant differences between analyzed fiber boards (Fig.6÷Fig.11). In terms of cutting resistance during drilling it doesn't matter fact that inner layer consisted of wood fibers with different dimensions (assumed as worse quality product of milling process).

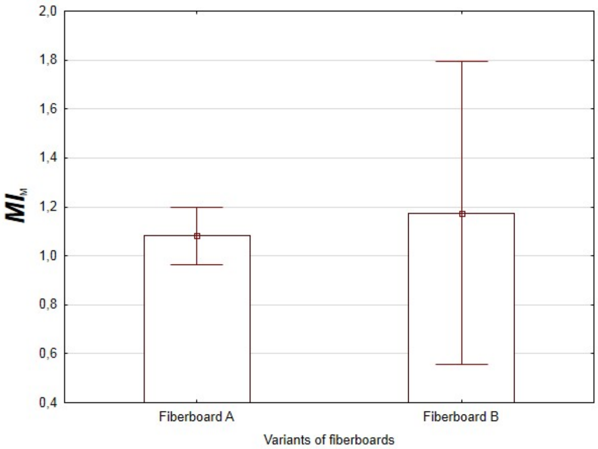

Fig.6 Relative machinability indicator $\boldsymbol{MI_M}$ for two variants of fiberboards for feed per revolution Δ= 0,1mm

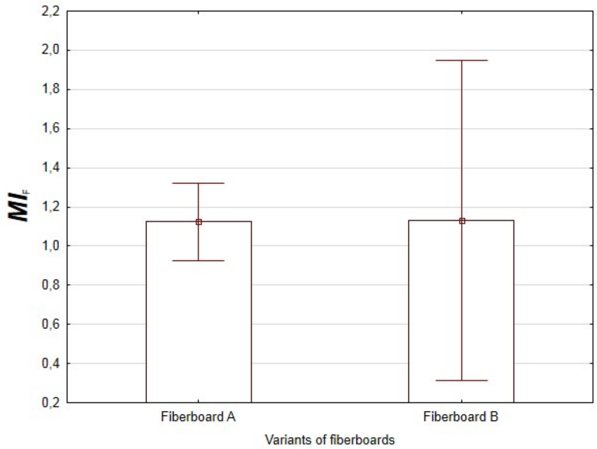

Fig.7 Relative machinability indicator $\boldsymbol{MI_F}$ for two variants of fiberboards for feed per revolution Δ= 0,1mm

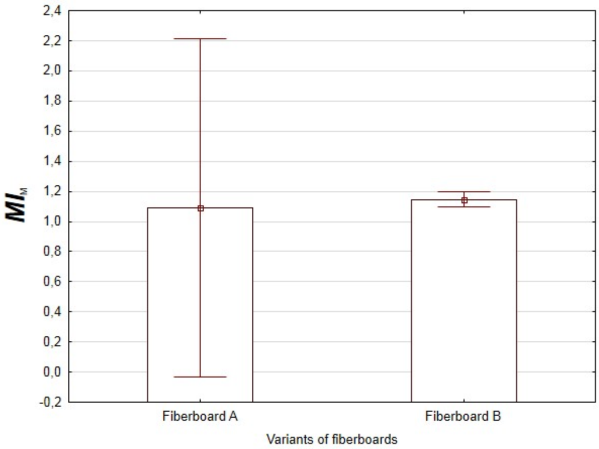

Fig.8 Relative machinability indicator $\boldsymbol{MI_M}$ for two variants of fiberboards for feed per revolution Δ= 0,3mm

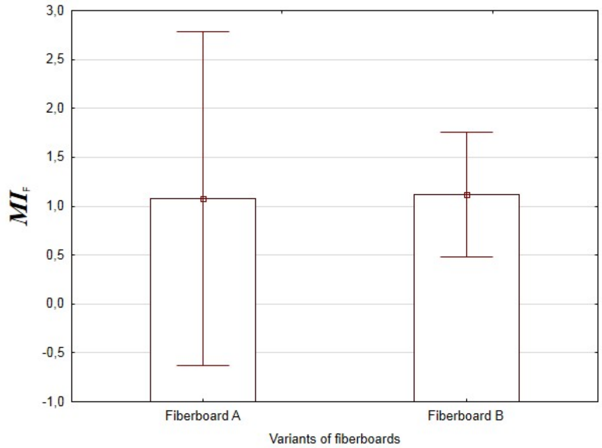

Fig.9 Relative machinability indicator $\boldsymbol{MI_F}$ for two variants of fiberboards for feed per revolution Δ= 0,3mm

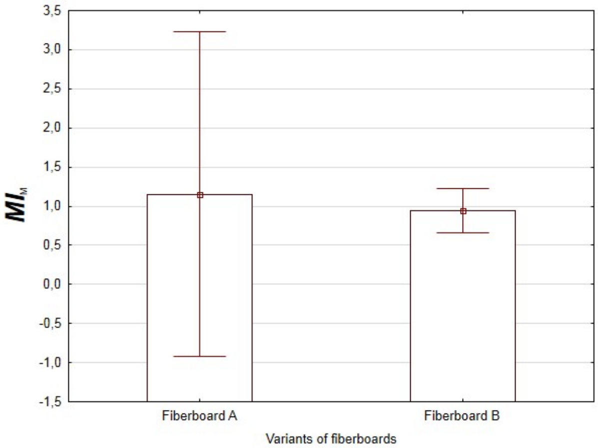

Fig.10 Relative machinability indicator $\boldsymbol{MI_M}$ for two variants of fiberboards for feed per revolution Δ= 0,5mm

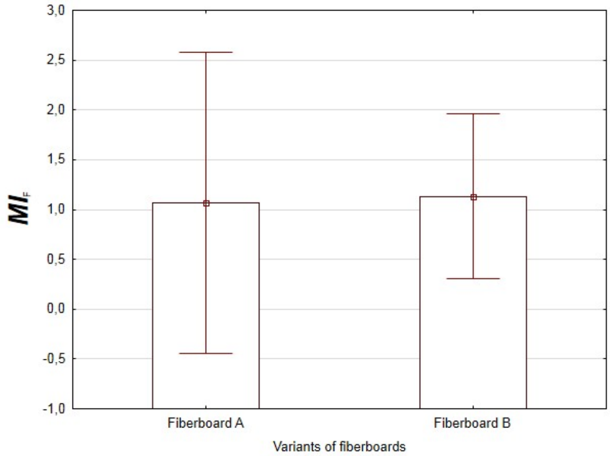

Fig.11 Relative machinability indicator $\boldsymbol{MI_F}$ for two variants of fiberboards for feed per revolution Δ= 0,5mm

However, slightly visible improvement of machinability indicator defined with MI_M and MI_F is remarkable for feed per resolution Δ=0,1mm and Δ=0,3mm (Fig.6-Fig.9). In case of Δ=0,5mm both indicators amounted Just about 1, what mean that machinability of three layer fiberboards made in laboratory conditions is similar to machinability of standard MDF produced in industry (Fig.10. and Fig.11.).

CONCLUSION

From these results were obtained following conclusions:

- Manufactured in laboratory conditions three layer MDF boards characterize with similar machinability indicators based on cutting resistance during drilling in compare with commonly accessible on market one layer MDF boards.
- In terms of machinability criterions connected with cutting resistance, dimensions of wood fibers used in core layer of MDF boards in production process have no importance.

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Streszczenie: *Skrawalność trójwarstwowych płyt MDF wytworzonych z włókien drzewnych o różnych wymiarach.* W pracy wytworzono dwa rodzaje płyt włóknistych w oparciu o włókna drzewne o różnych wymiarach. Pierwszy rodzaj włókien drzewnych otrzymano przy wyższym stopniu rozwłóknienia, a drugi przy mniejszym. Płyty poddano wierceniu na centrum obróbczym Busellato Jet 130. Zastosowano jednoostrzowe wiertło z diamentu polikrystalicznego o średnicy 10mm. Ponadto, przyjęto trzy poziomy posuwu na obrót: 0,1mm, 0,3mm i 0,5mm. Trójwarstwowe płyty MDF otrzymane w laboratorium, cechowała podobna skrawalność podczas wiercenia do standardowej jednowarstwowej płyty MDF oferowanej na rynku.

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