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Corrugation of thermally modified maple wood at milling

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Abstract: *Corrugation of thermally modified maple wood at milling***.** This deals with plane milling of maple wood with consideration of technological parameters which are of significant effect on arithmetic mean deviation of the corrugation profile Wa of the treated wood surface. Process of the treatment was influenced by the cutting speed, which varied from 20, 30 and 40 $m.s^{-1}$ and the feeding speed 4, 8, 11 $m.min^{-1}$. Based on the results, it can be concluded that changes to the cutting speed in the process of plane milling led to the decrease of the arithmetic mean deviation of the corrugation profile, while the opposite effect occurred with changes to the feeding speed, where the increase of the arithmetic mean deviation of the corrugation profile occurred with increase of this parameter.

Keywords: corrugation, surface quality, cutting speed

INTRODUCTION

Wood has always had an important role in people's lives. Its importance consisted foremost in utility it provided, mainly as a reserve of firewood, as a material for making tools, as a parts of weapons or for construction of shelter (Gaff, 2009). During the gradual development, the use of wood expanded in to other industries, such as manufacture of furniture, ships, sports equipment, toys etc. Its utility is versatile and even the discovery of new materials failed to squeeze it out of some sectors. Compared to other materials, wood belongs among renewable materials and has a broad area of utilization, as in more exacting interiors and also in various exterior expositions (Dubovský et.al., 1998). Wood is much more valuable compared to other materials from the ecological perspective. Its life cycle is ecologically friendly and it's considered as a material with positive effect on the environment. Products made out of wood are more and more exhibited to exact expositions in which various debasing effects are present. This problem was addressed in two ways in the past, namely in the form of preserving agent treatment or by manufacture out of tropical wood species (Šefců et. al., 2000).

In the recent years, the interest in wood have significantly risen and therefore it is necessary to develop technologies which would increase the longevity and abolished the adverse properties of wood (Gaff, 2009). One of the options for improvement of wood properties, such as shape permanence, parasite resistance and longevity extension is thermal modification of wood. Demand of thermally modified wood has risen significantly recently (Gaff et. al., 2010). This interest is, mainly, due to the properties acquired in the manufacture process, which is ecological and utilizes only heat and vapor (Reiprecht and Vidholdová, 2008). Considering that this wood is completely ecological even after manufacture, it can be disposed of just like regular wood (Kačíková and Kačík, 2011). Even in the area of working the thermally modified wood there are no differences compared to native wood. The key to assurance of the demanded quality, which plays a significant role on the market, is the right choice of technical-technological factors?. It is given by the smoothness and accuracy of the treated surfaces (Gaff and Prokein, 2009). The wear of the tools also affects the surface quality significantly. Contact devices and light-optic methods, which have a great advantage in allowing non-contact measurement and only require very short measuring period with applications of modern methods of data processing, are most often used for checks and measurement of the surface quality (Afjehi et. al., 2004). When milling, it is necessary to choose an instrument made out of suitable material or an instrument with suitable cutting edge modification to prevent it from wearing (Lisičan, 1988).

MATERIALS

As a material, the cut pieces of Acer pseudoplatanus L. from the Poľana region were used. The cut pieces were cut lengthwise to two halves, from which one half was saved for consecutive use and the other half was thermally modified in a device for production of Thermowood (thermal chamber made by Hitwood Oy company, Finland).

Thermal modification was initiated by placing the maple bodies on a metal grill, which was consecutively inserted into the 103/6200 thermal chamber made by Hitwood Oy company, Finland (input parameters are listed in the Table 1). Thermal modification took place in individual time phases. The prepared thermally modified cut pieces were left in relative air humidity of 65% and temperature of 20°C for the purpose of humidity settlement.

Table 1. Thermal chamber parameters

Input technical parameters	
Moisture content of wood	10.5 to 12 %
Filling capacity of TW furnace	7 m^3
Water consumption	885 L
Electricity consumption	2950 kWh
Maximum reached temperature	191 °C

Subsequently, the material was leveled with the STEFF 2034 surfacer (Maggi, Italy) to final thickness of 20 mm. Modified material measured 20 × 100 × 500 mm. Subsequently, the samples were milled by only instrument – by blade at three different cutting speeds (4 m.min-1, 8 $m.min^{-1}$ and 11 $m.min^{-1}$) and three different feeding speeds (4 $m.min^{-1}$, 8 $m.min^{-1}$ and 11 $m.min^{-1}$).

Table 2. Technical parameters of the single-spindle bottom milling machine

Equipment	Surface
Manufacturer	Czechoslovak musical instruments
Type	FVS
Year	1975
Supply voltage	380 V
Frequency	50 Hz
Power consumption	5,2 kW
Motor speed	1440; 2880 min^{-1}
Spindle speed	3 000; 4 500; 6 000 min^{-1}

Using the Form Talysurf Series Intra 2 contact induction measure instrument made by Taylor Hobson Company (Germany), we have measured the corrugation of the surface after the plane milling. We have evaluated the measured values using the table evaluation.

RESULTS

Based on the data listed in the Table 3., representing the effect of cutting speed on the values of the arithmetic mean deviation of the corrugation profile Wa, it results that the cutting speed has no statistically significant effect on the values of the observed property. The lowest values of the observed property were achieved at cutting speed of 60 m.s^{-1}.

Table 3. The correlation of cutting speed with values of Wa

Cutting speed (m.s^{-1})	**20**	**30**	**40**
The average value of waviness (µm)	2,64	2,34	1,82
Standard error (mm)	0,12	0,12	0,12
- 95,00 % (mm)	2,51	2,21	1,69
+95,00% (mm)	2,98	2,67	2,16

Table 4. The correlation of feeding speed with values of Wa

Feed rate (m.min^{-1})	**4**	**8**	**11**
The average value of waviness (µm)	2,84	3,15	3,83
Standard error (mm)	0,12	0,12	0,12
- 95,00 % (mm)	2,63	2,91	3,75
+95,00% (mm)	2,99	3,47	3,99

As opposed to the cutting speed, the feeding speed has an opposite effect on the arithmetic mean deviation of the corrugation profile Wa (Table 4). Based on this fact, we can regard feeding speed as a statistically significant parameter. It is apparent from the values that with the increase in feeding speed, the values of observed property also increase.

Table 5. The correlation of the thermal modification with values of Wa

Treatment	**Native**	**160 °C**	**180 °C**	**210 °C**	**240 °C**
The average value of waviness (µm)	3,43	3,54	4,13	3,99	4,32
Standard error (mm)	0,12	0,12	0,12	0,12	0,12
- 95,00 % (mm)	3,25	3,39	3,99	3,78	4,13
+95,00% (mm)	3,59	3,85	4,24	4,02	4,41

Based on the measured values (Table 5.), the higher values of the arithmetic mean deviation of the corrugation profile of the thermally modified wood, in the range of 160-240°C, than those of the native wood (20°C treatment) are apparent. However, these differences are so low that they are on the verge of statistical significance. From the listed graph, it results that the thermal modification of maple wood has no significant effect on the final corrugation of the treated material.

Based on the listed outputs, we can conclude apparent effect of the cutting speed on the observed parameter. The values of the arithmetic mean deviation of the corrugation profile decreased with increasing cutting speed. On the contrary, with increase in the feeding speed we can observe increase in the observed parameter values. For quality treatment, it is necessary that the cutting speed is sufficiently high considering the feeding speed of material, because at higher feeding speeds the reduction of final quality of the treated surface occurs.

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Streszczenie: *Falistość modyfikowanego termicznie drewna buka przy frezowaniu.* Praca dotyczy oceny obróbki frezowaniem modyfikowanego temicznie drewna buka i wpływu parameteów obróbki na falistość powierachni wyrażoną parametrem Wa. Zmiennymi w procesie były prędkość skrawania wynosząca 20, 30 oraz 40 m.s-1przy posuwie 4, 8, 11 m.min-1. Badania wykazują że zwiększanie prędkości skrawania zmniejsza falistość powierachni, zwiększanie prędkości posuwu przynosi odwrotny efekt.

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