

## **INFLUENCE OF MECHANICAL OSCILLATIONS ON THE ACCURACY OF MAKING GROOVES IN WOOD-BASED MATERIALS**

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### **Abstract:**

*This paper presents a study on the accuracy of the width of the groove channel depending on the magnitude of the mechanical vibrations. Wood-based parts, used in furniture production like plywood and medium-density fiberboard (MDF) were milled. The details are machined on a universal milling machine with bottom location of the working shaft model FD-3. The rotation frequency used for the experiments was  $6000\text{min}^{-1}$ . During the research, attention is paid to some technological factors such as the feed speed of the processed material which is from  $2\text{m}\cdot\text{min}^{-1}$  to  $10\text{m}\cdot\text{min}^{-1}$ , as well as milling area which ranges is from  $48\text{mm}^2$  to  $144\text{mm}^2$ . Measurements of the accuracy of the groove channel are made with an electronic caliper at a minimum of three points along its length. The investigation results can be used as a base for making some recommendations for the selection of technological factors.*

**Key words:** wood shapers; milling; vibrations; accuracy.

### **INTRODUCTION**

The mechanical processing of wood-based parts leads to certain deviations from their nominal dimensions. These deviations are due to a number of factors, some of which are inaccuracies in the cutting tools due to their wear, mechanical vibrations during operation, deformation of some of the machine parts, the elastic properties of wood and many factors related to the technology of processing details. The quality and accuracy of the obtained surfaces are also influenced by the different types of heat treatment of the wood as well as the choice of geometric parameters of the cutting tools (Banski and KMINIAK 2018, Gochev et al. 2020, Korcok et al. 2018, Kovac et al. 2018, Kminiak et al. 2018, Adamcik et al. 2021). High rotation frequency of the milling machines combined with unbalanced or poorly prepared cutting tools are the reason for increasing the intensity of vibrations of any mechanical system (Brezin and Antov 2015, Kovatchev et al. 2022, Vitchev et al. 2019, Vukov et al. 2020). Important attention should be paid to the preparation of the cutting tools. The sharper, clearing the wood cutting tool after work and correct installation are factors that greatly affect the ability of each cutting tool to process the wood quality. Deviations from the exact dimensions of the parts cannot be unlimited, because this leads to inaccuracies in the structural elements in a product. How well a particular part is processed can be determined by its deviations from those set in the drawing. It is known that the nature of the assembly between two connection sizes is determined by the joint between them. The joint is very important because it provides strength, solidity and the degree of mobility between the elements in assembly.

The aim of this work is measuring the accuracy of the groove width depending on the mechanical vibrations. The study was performed by milling specimens of Plywood and medium-density fiberboard (MDF), changing various technological factors during the experiments.

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**METHODOLOGY**

To conduct the experimental part, a universal wood shaper with bottom location of the working shaft is selected Fig.1. The cutting mechanism is driven by an asynchronous electric motor with a power of 3kW and rotation frequency of 2880min<sup>-1</sup>. The rotation frequency used for the experiments was 6000min<sup>-1</sup>. This is one of the most commonly used frequencies in milling machines. The selected rotational speed is realized by pulleys mounted on the electric motor shaft and the machine shaft.



**Fig. 1.**  
**Wood shaper general view.**



**Fig. 2.**  
**Groovecutter D=140mm.**

A cutter with diameter D = 140mm was used Fig 2. The technical data of the cutting tool are shown in Table 1. The inscriptions in the table are: D - diameter of the milling cutter, d – diameter of the bore, B – milling width, α – back angle of cutting, β – angle of sharpening, γ – front angle of cutting, z – number of teeth.

Table 1

**Technical data of the cutting tool**

Type of instrument	D mm	d mm	B mm	α °	β °	γ °	z 6p	Material of the teeth
Groovecutter	140	30	12	16	55	19	6	HM

The cutting speed was calculated by the formula 1 (Vlasev 2007, Obreshkov 1997). At a rotation frequency of 6000min<sup>-1</sup> (100s<sup>-1</sup>) the calculated cutting speed was v = 44m·s<sup>-1</sup>.

$$V = \pi \cdot D \cdot n, \text{ m} \cdot \text{s}^{-1}, \tag{1}$$

where:

D – diameter of the cutting tool, m;

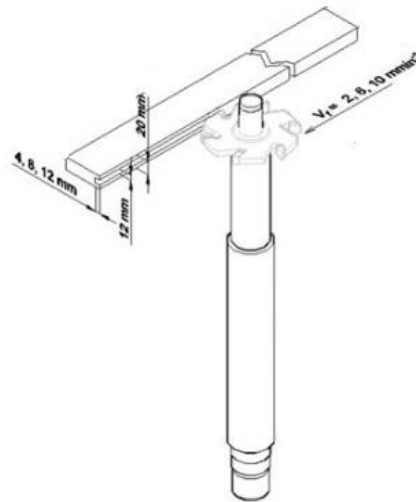
n – rotational frequency of the cutting tool, s<sup>-1</sup>.

Research in this paper was conducted at calculated speed. The experimental part included milling of Plywood and medium-density fiberboard (MDF) samples. Some of the test samples can be seen in Fig. 3.



**Fig. 3.**  
**Plywood and MDF test samples.**

Products made from wood-based materials are widespread. Particular attention should be paid to the quality of the processing and production of these products. Feed speed and milling area have a direct effect on the vibration speed, and hence on the quality of the treated surfaces (Kovatchev and Atanasov 2018). Undoubtedly, the vibration speed also affects the accuracy of the products. Fig. 4 presents the milling process of plywood and MDF test samples (Atanasov and Kovatchev 2019). The experiments were performed at feed speed  $2\text{m}\cdot\text{min}^{-1}$ ,  $6\text{m}\cdot\text{min}^{-1}$  and  $10\text{m}\cdot\text{min}^{-1}$ , the thickness of the removed layer is 4mm, 8mm and 12mm, the milling width is  $B=12\text{mm}$ , the width of the test samples is 20mm. The milling areas, which are obtained as a multiplication of the thickness of the removed layer and the milling width, are  $48\text{mm}^2$ ,  $96\text{mm}^2$  and  $144\text{mm}^2$ .



**Fig. 4.**  
**Milling process of plywood and MDF test samples.**

Table 2 shows the feed speeds and milling areas.

*Table 2*

<b>Survey factors</b>			
Feed speed $U$ , [ $\text{m}\cdot\text{min}^{-1}$ ]	2	6	10
Milling area $A$ , [ $\text{mm}^2$ ]	48	96	144

The dimensions of the milled channel are measured with a precision electronic caliper, whose measurement error is not greater than 0.01mm Fig.5.



**Fig. 5.**  
**Electronic caliper.**

The milling width  $B=12\text{mm}$  is measured in at least three sections along the length of the sample at a distance of 20mm from the beginning and the end, as well as in the middle Fig.6 (БДС 3780-84).



**Fig. 6.**  
**Groove channels.**

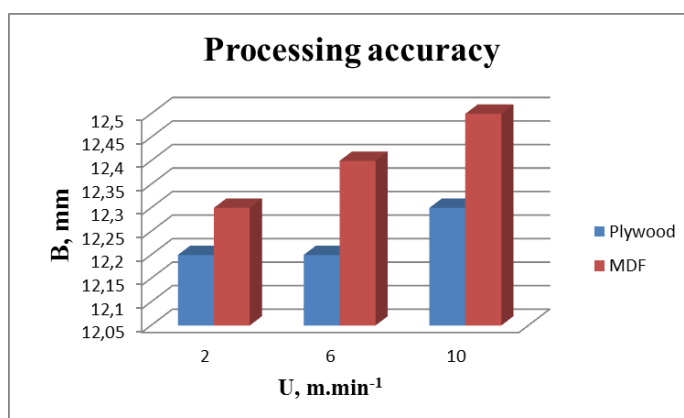
## RESULTS

The experimental part included work trials in milling of Plywood and medium-density fiberboard (MDF).

The measurement of the vibration speed  $V$  (r.m.s)  $\text{mm.s}^{-1}$  was performed according to (BDS ISO 10816-1: 2002) and its results were presented by the authors in their previous publication (Kovatchev and Atanasov 2021). Table 3 shows the values of the vibration speed according to (BDS ISO 10816-1: 2002), at milling width  $B = 12 \text{ mm}$ , milling area  $48 \text{ mm}^2$  and feed speed  $2\text{m.min}^{-1}$ ,  $6\text{m.min}^{-1}$  and  $10\text{m.min}^{-1}$ .

Table 3

Milling area A, $[\text{mm}^2]$	Vibration speed		
	48		
Feed speed U, $[\text{m.min}^{-1}]$	2	6	10
V (r.m.s), $\text{mm.s}^{-1}$ - Plywood	2,25	2,2	2,35
V (r.m.s), $\text{mm.s}^{-1}$ - MDF	2,15	2,23	2,25



**Fig. 7.**  
**Accuracy of the groove channel with a milling area of  $48\text{mm}^2$ .**

Fig. 7 shows that at milling area of  $48\text{mm}^2$  and material feed speed  $2\text{m.min}^{-1}$  and  $6\text{m.min}^{-1}$  the change from the exact width of the groove channel ( $B=12\text{mm}$ ) when milling plywood specimens is very small 0.2mm. When milling MDF test samples, the variation from the exact width of the groove channel was slightly larger 0.3 - 0.4mm, for feed speed  $2\text{m.min}^{-1}$  and  $6\text{m.min}^{-1}$ . By increasing the feed speed to  $10\text{m.min}^{-1}$ , with which the vibrational speed also increases, the deviation from the exact size is 0.3mm for the plywood test samples and up to 0,5mm for the MDF ones.

Table 4 shows the values of the vibration speed at milling width  $B = 12\text{mm}$ , milling area  $96\text{mm}^2$  and feed speed  $2\text{m.min}^{-1}$ ,  $6\text{m.min}^{-1}$  and  $10\text{m.min}^{-1}$ .

Table 4

<i>Vibration speed</i>			
Milling area A, [mm <sup>2</sup> ]	96		
Feed speed U, [m.min <sup>-1</sup> ]	2	6	10
V (r.m.s), mm.s <sup>-1</sup> - Plywood	2,35	2,35	2,45
V (r.m.s), mm.s <sup>-1</sup> - MDF	2,1	2,3	2,35

Fig. 8 shows the variation of the accuracy of the groove channel with a milling area of 96mm<sup>2</sup>. When the material feed speed is 2m.min<sup>-1</sup> and 6m.min<sup>-1</sup> the maximum deviations reach to 0.4mm for plywood test samples and 0.5mm for MDF test samples. When the feed speed increases to 10m.min<sup>-1</sup> deviation also increases to 0.5mm for plywood test samples and 0.6mm for MDF test samples.

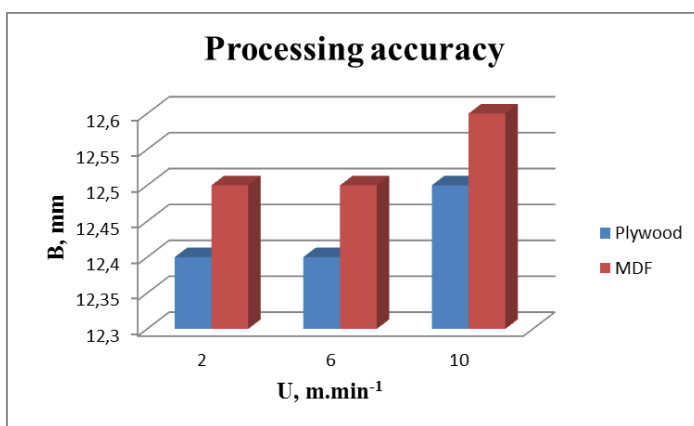


Fig. 8.

**Accuracy of the groove channel with a milling area of 96 mm<sup>2</sup>.**

Table 5 shows the values of the vibration speed at milling width B = 12mm, milling area 144mm<sup>2</sup> and feed speed 2m.min<sup>-1</sup>, 6m.min<sup>-1</sup> and 10m.min<sup>-1</sup>.

Table 5

<i>Vibration speed</i>			
Milling area A, [mm <sup>2</sup> ]	96		
Feed speed U, [m.min <sup>-1</sup> ]	2	6	10
V (r.m.s), mm.s <sup>-1</sup> - Plywood	2,45	2,52	2,6
V (r.m.s), mm.s <sup>-1</sup> - MDF	2,3	2,4	2,5

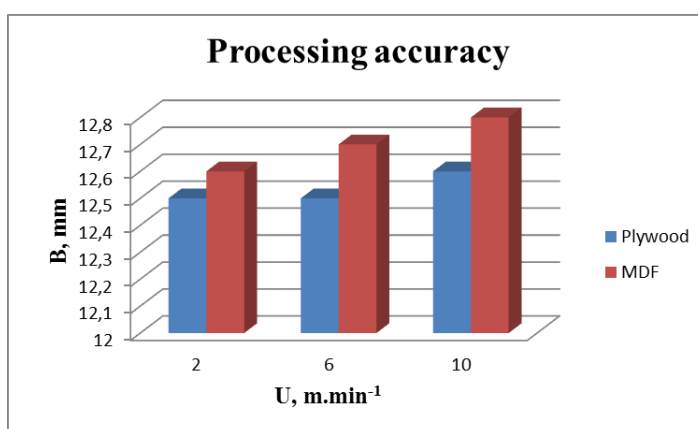


Fig. 9.

**Accuracy of the groove channel with a milling area of 144 mm<sup>2</sup>.**

From Fig. 9, it can be seen that regardless of the feed speed of the test samples, with a milling area of  $144\text{mm}^2$ , the deviations vary within greater limits of 0.5 – 0.8mm. The deviations tend to be smaller for the plywood test samples. For plywood test samples the maximum deviations reach up to 0.5mm for feed speeds of  $2\text{m}\cdot\text{min}^{-1}$  and  $6\text{m}\cdot\text{min}^{-1}$ , and for  $10\text{m}\cdot\text{min}^{-1}$  the deviation is 0.6mm. For MDF test samples, as the feed rate increases, the deviation from the exact size of the groove channel varies from 0.6mm to 0.8mm. It is well known that a number of factors such as cutting speed, feed rate, thickness of the removed layer and others directly affect the quality and accuracy of the processed parts. Similar tendencies of the obtained results are also observed by some other authors (Demir et al. 2022, Deus et al. 2019, Kminiak et al. 2017, Kubs and Kminiak 2017, Sutcu and Karagoz 2012, Vitchev 2019).

## CONCLUSION

As a result of research and analysis of the results, the following conclusions can be made. When the test samples are fed slowly the deviations from the exact dimensions during milling are not large. This is clearly visible in two milling areas  $48\text{mm}^2$  and  $96\text{mm}^2$  where the width of the grooves is in the range from 12.2mm to a maximum of 12.5mm. This trend was observed for both plywood and MDF test samples. At a feed speed of  $10\text{m}\cdot\text{min}^{-1}$ , where the vibrational speed increases, deviations from the exact size also increase. It ranges from 12.3mm to 12.6mm. The most inaccurate grooves are made with a milling area of  $144\text{mm}^2$ . With a milling area of  $144\text{mm}^2$  feed speed of  $2\text{m}\cdot\text{min}^{-1}$  the deviations from the machining accuracy are the smallest from 12.5mm to 12.6mm. When the feed speed is  $6\text{m}\cdot\text{min}^{-1}$  and  $10\text{m}\cdot\text{min}^{-1}$  the deviations from the exact dimensions are larger. For MDF test samples, the width of the groove can reach up to 12.8mm. Despite the close values of the measured vibration speed, it can be seen that as it increases, the deviations from the exact size of the groove increase.

## REFERENCES

- ADAMCIK L, KMINIAK R, BANSKI A (2022) The effect of thermal modification of beech wood on the quality of milled surface, *Acta Facultatis Xylogologiae Zvolen*, 64(2):57-67 ISSN 1336-3824.
- ATANASOV V, KOVATCHEV G (2019) Determination of the cutting power during milling of wood-based materials, *Acta Facultatis Xylogologiae Zvolen*, 61(1):93-101 ISSN 1336-3824.
- BANSKI A, KMINIAK R (2018) Influence of the thickness of removed layer on granulometric composition of chips when milling oak blanks on the CNC machining center. *Chip and Chipless Woodworking Processes* 11(1):23-30, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).
- BREZIN V, ANTOV P (2015) *Engineering ecology*, Sofia, ISBN 978-954-332-135-3, pp. 259 (in Bulgarian).
- DEMIR A, CAKIROGLU E, AYDIN I (2022) Effects of CNC processing parameters on surface quality of wood-based panels used in furniture industry, *Drvna Industrija*, volume 73, 4(22):363-371 ISSN 0012-6772.
- DEUS P, ALVES M, VIEIRA F, BILESKY L (2019) Analysis of the cutting parameters in front milling for medium density fiberboard, *BioResources* 13(2):3404-3410 ISSN 1930-2126.
- GOACHEV Z, VITCHEV P (2020) Determination of performance indicators of PCD abrasive wheels for sharpening of tungsten carbide tools. *Chip and Chipless Woodworking Processes* 12(1):65-70, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).
- KMINIAK R, BANSKI A, CHAKHOV D (2017) Influence of the thickness of removed layer on the quality of created surface during milling the MDF on CNC machining centers. *Acta Facultatis Xylogologiae Zvolen*, 59(2):137-146 ISSN 1336-3824.
- KMINIAK R, SIKLIENKA M, SUSTEK J (2018) Influence of the thickness of removed layer on the quality of created surface when milling oak blanks on the CNC machining center. *Chip and Chipless Woodworking Processes* 11(1):79-86, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).
- KORCOK M, VANCO M, BARCIK S, GOGLIA V (2018) Influence of tool angular geometry on surface quality after milling of thermally modified oak wood. *Chip and Chipless Woodworking Processes* 11(1):87-96, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).
- KOVAC J, KRILEK J, HARVANEK P (2018) The analysed activity of cutting forces for the chipless cutting wood. *Chip and Chipless Woodworking Processes* 11(1):97-104, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).
- KOVATCHEV G, ATANASOV V (2018) Determination of vibration during milling process of some deciduous wood species. In 8<sup>th</sup> International Science Conference Hardwood Conference, Sopron, ISBN 978-963-359-095-9, ISSN 2631-004X, pp. 112–113.

KOVATCHEV G, ATANASOV V (2021) Determination of vibration during longitudinal milling of wood-based materials, *Acta Facultatis Xylogologiae Zvolen*, 63(1):85-92 ISSN 1336-3824.

KOVATCHEV G, ATANASOV V, RADKOVA I (2022) Influence of mechanical oscillations on the accuracy of making grooves in solid wood, 13<sup>th</sup> International Science Conference "Chip and Chipless Woodworking Processes", Tatranska Lomnica, TU-Zvolen, ISSN 2453-904X (print) ISSN 1339-8350 (online), pp. 65-71.

KUBS J, KMINIAK R (2017) The effect of selected factors on the milled surface quality of thermally modified solid beech, *BioResources* 12(1):1479-1490 ISSN 1930-2126.

OBRESHKOV P (1997) *Woodworking Machines*, Sofia. Pp. 182 (in Bulgarian).

SUTCU A, KARAGOZ U (2012) Effect of machining parameters on surface quality after face milling of MDF, *Wood Research*, 57(2):231-240 ISSN 1336-4561.

VITCHEV P (2019) Evaluation of the surface quality of the processed wood material depending on the construction of the wood milling tool. *Acta Facultatis Xylogologiae Zvolen*, 61(2):81-90, ISSN 1336-3824.

VITCHEV P, ANGELSKI D, MIHAILOV V (2019) Influence of the processed material on the sound pressure level generated by sliding table circular saw. In *Acta Facultatis Xylogologiae Zvolen*, 61(2):73-80, 2019, DOI: 10.17423/afx.2019.61.2.07.

VLASEV V (2007) *Exercise And Drilling Manual On Woodworking Machines*. Sofia, pp. 78 (in Bulgarian).

VUKOV G, SLAVOV V, VITCHEV P, GOCHEV Z (2020) Forced spatial vibrations of a wood shaper caused by the cutting forces on the worn cutting tool. *Chip and Chipless Woodworking Processes* 12(1):109-117, Zvolen, ISSN 2453-904X (print), ISSN 1339-8350 (online).

БДC 3780-84 (2002) *Wood shaper with bottom location of the working shaft. Accuracy standards.*

БДC ISO10816-1:2002 (2002) *Evaluation Of Machine Vibration By Measurement On Non – Rotating Parts – Part 1: General Guidelines*, pp. 25.