ISSN 1068-798X, Russian Engineering Research, 2025, Vol. 45, No. 6, pp. 771–775. © Allerton Press, Inc., 2025.
Russian Text © The Author(s), 2025, published in Vestnik Mashinostroeniya, 2025, No. 4, pp. 331–335.

Wear of Circular Saw Blades when Machining Wood Chip Materials

V. A. Abbasov[a, *] **and M. S. Nasirov**[a, b, **]

[a] *Azerbaijan Technical University, Baku, AZ1073 Azerbaijan*
[b] *Baku Engineering University, Baku, AZ0102 Azerbaijan*
**e-mail: vaqif.abbasov@aztu.edu.az*
***e-mail: munasirov@beu.edu.az*

Received July 25, 2024; revised September 1, 2024; accepted September 9, 2024

Abstract—The article considers the effect of the properties of wood chip materials on the sharpening of circular saw blades with the aim to develop new technologies of sharpening cutting tools. The characteristic wear of saw blade teeth is investigated, and features of teeth sharpening are considered. The influence of imbalance on wear and sharpening of circular saw blades is analyzed.

Keywords: circular saw blade, uneven wear, runout, imbalance, wood chip material, accuracy

DOI: 10.3103/S1068798X25701254

Circular saw blades are widely used in various industries. In particular, saw blades are used in furniture manufacturing to machine various grooves and chamfers that are necessary for the rigidity of the assembled furniture elements [1, 2]. In furniture manufacturing, a major role is played by artificial wood-based materials: these include pressed, plasticized, glued and laminated wood, chipboard, and fiberboard. The quality of milling of these materials depends on their structure, physical and mechanical properties, and the composition of the adhesives. These factors affect the wear of the cutting teeth [3–5]: uneven face and flank wear leads to changes in the length of the cutting edge of the tooth, which contributes to significant runout of the saw blade [6].

Due to uneven wear of the cutting teeth, of which a saw blade can have between 18 and 96, the profile of the machined surface may be distorted when milling longitudinal or transversal grooves in workpieces, which negatively affects the quality of the parts during manufacture and assembly [7].

It has been established that when machining fiber-laminated wood materials, their anisotropy leads to different types of wear of the cutting teeth of circular saw blades when cutting grooves in the longitudinal-radial, longitudinal-tangential, and transversal directions [8]. Therefore, the study of the degree and nature of the wear of saw blade cutting teeth when machining wood-based materials is a relevant problem.

The objective of the study is to investigate the degree and nature of wear on the working surfaces of cutting teeth of circular saw blades, depending on the method of milling longitudinal and transverse grooves in chipboard materials with the aim to develop a new milling process with improved cutting tool wear rates.

The study was performed on ∅100 mm 24-tooth circular saw blades used to machine grooves of width 3.2 mm and depth 10 mm in chipboard. The density of the machined material was 650–750 kg/m^3. The solid content of urea-formaldehyde in the chips is 10% [9].

The wear of the cutting surfaces of saw blade teeth was studied for cutting longitudinal grooves of length 22000 m. Wear was measured using a special device equipped with an indicator of accuracy down to 1 μm. Additionally, the worn tooth surfaces were photographed using a toolmakers microscope. Traces of wear on the teeth were photographed on both their faces and flanks [10, 11].

The study was conducted according to the developed methodology in the production conditions of the HASANOGLU factory. For grooving chipboard, the circular saw blades were mounted on the spindle of a WEEKE-HOMAG OPTIMAT BHT-500 machine. The process parameters were as follows: saw blade rotation speed 4000 min^{-1}, longitudinal feed 25 m/min, cutting depth 4–10 mm. The saw blades had the KO-WS tooth configuration. The cutting teeth were made of TUNGSTEN HARTMETALL steel (German standard).

Observations of milling grooves in chipboard indicate that the cutting mode achieves a steady chip formation process, i.e., uniform wear of the cutting surfaces of the saw blades during machining. However, studies of the cutting marks revealed that the cutting surfaces of saw blade teeth undergo uneven wear, despite the steady chip formation. This issue calls for development of new technological processes for mill-

Fig. 1. Flank wear of two adjacent teeth of a circular saw blade after milling grooves in chipboard (×10): (*1*) and (*2*) adjacent teeth with a limited wear zone.

ing grooves and sharpening cutting teeth of circular saw blades [12, 13].

During the experiment, a new balanced circular saw blade was installed on the spindle and used to machine a 22000 m long workpiece; afterwards, the wear of the cutting surfaces of the tool was studied.

Experiments to determine the length of the milled groove were conducted with the aim to reduce the removed layer when sharpening the cutting surface of saw blade teeth. It was found that increasing grooving length in chipboard workpieces leads to an increase in the unevenness of the wear of tooth cutting surfaces between sharpening operations; notably, on the flanks of adjacent teeth, traces of wear are observed in different areas. Fig. 1 presents a photograph of two adjacent teeth that shows that the traces of wear on the flank of the first tooth (*1*) are located on the left, while the traces on the flank of the other tooth (*2*) are on the right.

Studies on the other saw blade teeth have shown that the flank wear pattern is repeated. This indicates that such wear of the cutting teeth is associated with runout of the circular saw blade during rotation and its imbalance. When grooving chipboard, cutting forces arise at the moment of contact of the teeth with the material; their direction is variable. The cutting forces that occur during groove milling and the runout of the tool increase instability of chip removal. Therefore, the flanks of the cutting teeth of saw blades undergo uneven wear. Experiments have shown that the type and nature of wear on the cutting surfaces of saw blades complicates their sharpening. All saw blade

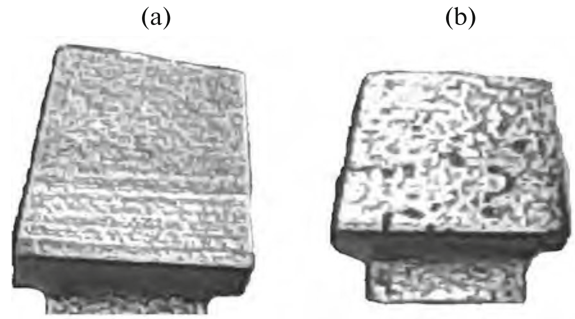


Fig. 2. Faces of randomly selected adjacent teeth after sharpening.

teeth must be sharpened with the same thickness of removed stock to ensure identical cutting edge lengths, which decreases tool runout.

According to the manufacturer's maintenance instruction card, when sharpening the cutting surfaces of saw blades for milling grooves of length 22000 m in chipboard, the removed stock should have a thickness of 0.01 mm and after sharpening, the surfaces of all teeth should be smooth. Photographs of sharpened surfaces of two adjacent cutting teeth are shown in Figs. 2a, 2b. It was found that after sharpening, wear marks are not completely removed from the cutting surfaces of more than half of the 24 teeth. Both pictured teeth were sharpened in the same mode with 0.01 mm of removed stock. The results indicate remaining traces of wear on the surface of the second tooth (see Fig. 2b).

The experiments have shown that in order to completely remove traces of wear on the cutting surface of a tooth, the thickness of the removed stock must be 0.05–0.1 mm. However, that mode of sharpening cutting teeth leads to uneven removal of metal from their surface, and therefore to uneven cutting edge lengths. Uneven cutting edge lengths lead to saw blade runout during groove milling. Saw blade runout leads, in turn, to an increase in groove widths, which negatively affects the precision of the parts during assembly. In addition, with different degrees of sharpening of the cutting teeth, the actual diameter of the saw blade varies in the direction of each tooth. This leads to runout in the vertical direction during grooving. In such cases, the depth and geometric shape of grooves milled in chipboard end up deviating from design-specified values.

When milling horizontal surfaces of grooves in the longitudinal direction, waviness is observed: it depends on the number of teeth of the saw blade and the diameter of the oppositely arranged teeth obtained after sharpening. Waviness of the bottom surface of grooves milled in chipboard occurs as a result of milling with cutting teeth of uneven height. The surface profile after milling has the appearance of a cycloid, which negatively affects the assembly of furniture elements.

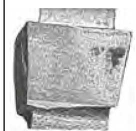
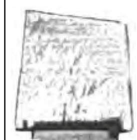
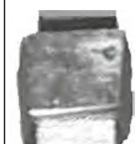
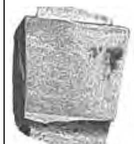
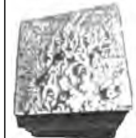
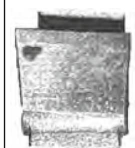
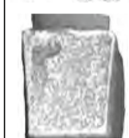
Considering that saw blades are supposed to create cylindrical surfaces in space when rotating, then when milling grooves, the shape of the cut must also be cylindrical. However, it has been shown that the shapes of the grooves milled by circular saw blades with cutting teeth of uneven height significantly deviate from the theoretical groove shape specified in design drawings for the milled parts. Thus, during grooving, difference in tooth radii after sharpening leads to the removal of different chip volumes and the formation of waves of different lengths on the surface of the part.

The effect of the length of grooves milled in chipboard on the wear of the surface of saw blade cutting teeth when milling grooves of length 5000, 10000, 15000, and 20000 m has been determined experimentally. In order to maintain durability of the saw blades over the effective period of machining grooves in chipboard in these modes, the cutting tool was made of cemented carbide VK-8 (TUNGSTEN HARTMETALL German standard). During longitudinal milling of grooves in chipboard plates with a density of 650–750 kg/m^3, saw blades with the following cutting tooth angles were used: $\alpha = 22°–25°$ and $\delta = 60°–65°$, at a feed per tooth $S_z = 0.3$ mm.

Photographs of select teeth (1, 5, 10, 15, and 24) with the most characteristic face and flank wear when machining 20000 m long grooves with a ∅100 mm circular saw blade with the number of teeth $Z = 24$ are given in Table 1, with additional indication of the actual wear of the surface before and after blade sharpening with removed stock thickness up to 0.06 mm. It can be observed that the nature and topography of both face and flank wear of saw blade tooth 5 is different from the wear of tooth 1 (see Table 1) and other teeth. It has been established that for all 24 teeth of the saw blade, the wear is different in terms of both area and size. Therefore, sharpening the teeth by 0.02 mm does not ensure uniform surface smoothness (see columns 4 and 5). Note also that after sharpening, traces of wear remain on teeth faces and flanks: for example, on the faces of teeth 3, 5, 7, 8, 10, 16, 17, and others (out of 24 teeth, not shown in the table), and additional sharpening is required.

It is known that chipboard includes layers of glued wood; therefore, when milling grooves in these layers, the cutting surfaces of the saw blade undergo intensive wear, which, along with other parameters, is influenced by cutting depth and roughness (roughness here means tears on the surface generated after grooving chipboard). Increased wear intensity leads to dulling of the cutting teeth of the saw blade, which in turn leads to an increase in the cutting force and specific

Table 1. Photographs of face and flank wear on select teeth of a circular saw blade before and after sharpening

Tooth no.	Before sharpening		After sharpening	
	face	flank	face	flank
1	2	3	4	5
1				
5				
10				
15				
24				

work of the milling machine. Such operating conditions of saw blades require careful determination of milled groove length between sharpening operations. These groove lengths can be used to predict the efficient life of a saw blade used for chipboard milling.

During experimental milling of 5000 m long grooves in chipboard, the following parameters were set: groove depth 5 mm, saw blade feed per tooth $S_z =$ 0.3 mm, saw blade rotation speed 4000 min^{-1}. The degree of flank wear of saw blade teeth in this machining mode is shown in Fig. 3. For a ∅100 mm saw blade with 24 teeth, the flank wear varied in the range 0.008–0.02 mm, i.e., the degree of wear of the cutting teeth was uneven. Therefore, for sharpening the saw blade, it is necessary to determine the greatest wear of the teeth and use that value to determine the thickness of material to be removed during sharpening.

Figure 3 presents average degrees of flank wear h of the cutting teeth depending on the length l of the grooves milled in medium-density fiberboard (MDF) and in chipboard. The comparison shows that the flanks of saw blade teeth wear out in different ways

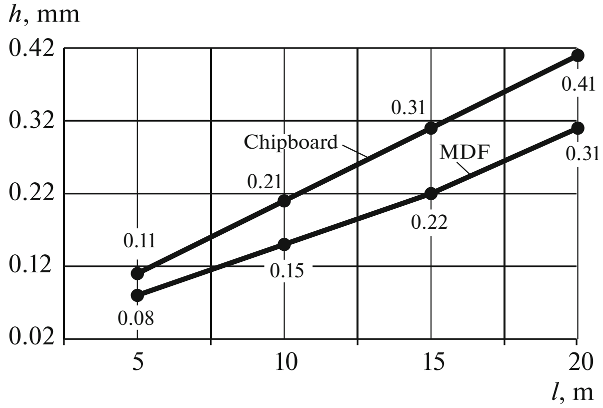


Fig. 3. Dependence of cutting tooth flank wear *h* on machining length *l*.

depending on their mechanical properties. Saw blades undergo greater wear when machining chipboard compared to MDF.

The experiments have shown that flank wear of saw blade teeth increases monotonously as the milled groove length is increased and the machined materials are changed. It was found that when machining chipboard, the flank wear of saw blade teeth is 2 times greater compared to machining MDF. For example, when milling 10000 m long grooves in chipboard, the tooth wear is 0.22 mm, and for the same groove length in MDF it is within 0.14 mm. Similar results were obtained for grooves of other lengths (see Fig. 3).

CONCLUSIONS

It has been shown that the wear of the cutting teeth of circular saw blades when machining wood-based materials, chipboard and MDF, is uneven, depending on milled groove length; therefore, for teeth sharpening, the thickness of the stock to be removed on the face and the flank should be determined based on maintaining equal length of the cutting edges.

It has been established that uneven wear of saw blade teeth leads to imbalance of the saw blade, which negatively affects the precision and quality of the machined parts.

It has been established that the problem of eliminating saw blade imbalance, which reduces the rigidity of the spindle assembly of the machine when milling grooves in wood-based materials, requires further experimental research on optimizing the wear of cutting teeth based on machining length and tool sharpening conditions, as well as determination of rational values for the thickness of stock to be removed during sharpening such that uniform cutting edge length is maintained.

FUNDING

This work was supported by ongoing institutional funding. No additional grants to carry out or direct this particular research were obtained.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

REFERENCES

1. Melekhov, V.I., Solov'ev, I.I., and Ponomareva, N.G., Formation of coaxial fields of residual stresses in the circular saw blade, *Izv. Vyssh. Uchebn. Zaved., Lesn. Zh.*, 2022, no. 2 (386), pp. 170–177. https://doi.org/10.37482/0536-1036-2022-2-170-177. https://cyberleninka.ru/article/n/formirovanie-koaksialnyh-poley-ostatochnyh-napryazheniy-v-polotne-krugloy-pily.
2. Melekhov, V.I., Solov'ev, I.I., Tyurikova, T.V., and Ponomareva, N.G., Improving the stability of wood-cutting saws by thermoplastic action on the distribution of residual stresses in the blade, *Izv. Vyssh. Uchebn. Zaved., Lesn. Zh.*, 2020, no. 6 (378), pp. 172–181. https://doi.org/10.37482/0536-1036-2020-6-172-181
3. Konstantinov, V.F., Borisov, V.A., and Pakhomov, P.K., Reducing the wear rate of wood cutting tools, *Resour. Technol.*, 2020, vol. 17, no. 3, pp. 111–123. https://cyberleninka.ru/article/n/snizhenie-intensivnosti-iznashivaniya-rezhuschego-instrumenta-dlya-drevesiny.L https://doi.org/10.15393/j2.art.2020.5262
4. Lyubchenko, V.I. and Druzhkov, G.F., *Stanki i instrumenty mebel'nogo proizvodstva* (Machines and Tools for Furniture Production), Moscow: Lesn. Prom-st., 1990.
5. Zhusupov, K., Kozbagarov, R., Kaliev, E., et al., Studies of the mechanisms of wear and destruction of carbide tools with multicomponent nanostructured systems, *Vestn. Kaz. Akad. Transp. Kommun.*, 2023, no. 3 (126), pp. 65–73. https://doi.org/10.52167/1609-1817-2023-126-3-65-73
6. Abbasov, V.A. and Bashirov, R.J., Features of ultrasound application in plasma-mechanical processing of parts made of hard-to-process materials, *Obrab. Met. (Tekhnol., Oborud., Instrum.)*, 2022, vol. 24, no. 3, pp. 53–65. https://doi.org/10.17212/1994-6309-2022-24.3-53-65
7. Wang, Y., Chang, M., Huang, X., et al., Cutting tool wear prediction based on the multi-stage Wiener process, *Int. J. Adv. Manuf. Technol.*, 2023, vol. 129, pp. 5319–5333. https://doi.org/10.1007/s00170-023-12648-8
8. Zheng, G. and Lin, Y., Tribological properties of micro-groove cemented carbide by laser processing, *Micromachines*, 2021, vol. 12, no. 5, p. 486. https://doi.org/10.3390/mi12050486
9. Torkghashghaei, M., Shaffer, W., Ugulino, B., et al., Improvement of the wear resistance of circular saws used in the first transformation of wood through the utilization of variable engineered micro-geometry performed on PVD-coated WC-Co tips, *Appl. Sci.*, 2022,

vol. 12, no. 23, p. 12213.
https://doi.org/10.3390/app122312213

10. Miran, M., Influence of temperature distribution on circular saw blade natural frequencies during cutting, *BioResources*, 2021, vol. 16, no. 1, pp. 1076–1090.
https://doi.org/10.15376/biores.16.1.1076-1090

11. Kováč, J., Harvánek, P., Krilek, J., et al., Analysis of cutting conditions in the process of cross-cutting wood by circular saws, *BioResources*, 2021, vol. 16, no. 1, pp. 1029–1041.
https://doi.org/10.15376/biores.16.1.1029-1041

12. Yu, M., Wang, B., Ji, P., et al., Study on the dynamic stability of circular saw blade during medium density fiberboard sawing process with thermo-mechanical coupling, *Comput. Electron. Agric.*, 2023, vol. 211, p. 108042.
https://doi.org/10.1016/j.compag.2023.108042

13. Krilek, J., Ťavodová, M., Kováč, J., and Tichý, B., Impact of irregular tooth pitch of circular saw blades on power for wood cross-cutting, *Drvna Ind.*, 2020, vol. 71, no. 1, pp. 3–11.
https://doi.org/10.5552/drvind.2020.1824

Translated by A. Ovchinnikova