The Wear of Metal Carbide Stuck Circular Saw Blades Used in the Spruce Longitudinal Sawing Processing – A Factor Influencing Power Consumption

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Abstract: The power consumption for spruce wood processing is about 70%., as in the case of the other resinous species. The wear of the circular saw blades is one of the factors which influences both the power consumption and the processing quality significantly. That is why, there have been used circular saw blades with metal carbide plated teeth on a regular basis recently. For the manufacturing of this circular saw blade type, there are used the following constituent elements: wolfram carbide, titanium carbide as well as tantalum carbide, and as a binder, it is generally used a cobalt-based one. As a consequence of the increased durability of the circular saw blades, both the processing and manufacturing have emissions under the form of VOC, noise and dust, the power consumption increasing gradually. This phenomenon, partly due to the the wear of tools, on the one hand, represents a real danger for the environment and the worker’s protection at the working place, but also for the profit decrease. The authors of the present paper have analysed the influence of wear on the power consumption and the emissions generated throughout the sawing process and they consider that, by knowing the weariness degree, there can be found new materials with prolonged chipping capacity so that the reliability of the tools that are used should grow and the power consumption as well as the emission generated under the form of VOC, noise and dust should decrease throughout the chipping process.

Key words: sawing, lastingness, wear, spruce, power consumption, cost.

1. Introduction

The wood sawing with circular saw blades represents a cutting process used in about 70-80% of the cases, due to the ripping, cutting, edging and trimming operations on circular saws for ripping, cutting, edging and trimming without which the modern technologies cannot be conceived. Thus, the power consumed while sawing with circular saw blades is a parameter which is worth to be taken into consideration when referring to the wood industry technologies. The reduction of the consumption can be achieved by having in view the optimization of the various geometrical parameters of the tool, the optimization of the process parameters etc. The dimensions of the circular saw blades generally depend on both the characteristics as well as construction of the machines on which they will be installed and on the properties as well as the characteristics of the species which is to be processed, whitout neglecting the nature of the material out of which the tool is made and its teeth, respectively, which influence the reliability of the tool determined especially by the wear phenomenon.

2 Theoretical elements

Concerning the wear phenomenon, not only the manufacturers of the circular saw blades, but also their beneficiaries are looking for the optima regarding the use of certain metal carbides which should increase the reliability of this type of tools. The fundamental properties of metal carbides are the following ones: the high chipping capacity and high lastingness, respectively, compared with other steels. The metal carbide plated teeth of the saw blade can tolerate 900-1000°C heating, without reducing their hardness. By increasing the cobalt content, both the hardness and compressive strength decrease whereas tenacity increases (Table1).

<table>
<thead>
<tr>
<th>Metal carbides</th>
<th>Wood material</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Group</td>
<td>Tenacity variation</td>
</tr>
<tr>
<td>K 01</td>
<td>5 %</td>
</tr>
<tr>
<td>K 05</td>
<td>12 %</td>
</tr>
<tr>
<td>K 10</td>
<td></td>
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<td>K 20</td>
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<td>K 30</td>
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<tr>
<td>K 40</td>
<td></td>
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</tbody>
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Table 1. The characteristics of metal carbides depending of wood material characteristics [4]. Weariness consists in removing a random quantity of material from the active faces of the tool toothing in the present case of the circular saw blade. The causes of the circular saw blade weariness are the following ones: wear by adhesion, diffusion wear, oxidation wear, cutting wear due to the electric current, fatigue wear.
The most significant wear is the diffusion wear, which consists of the fact that due to the increased temperature in the cutting area, the wolfram carbide is dissolved in the cobalt binder, thus a low melting point coming into being. The material under processing (when it is a metal) extracts the carbon from the carbides allying itself with the cobalt. Thus, the soft alloy of cobalt-wolfram carbide softens the superficial hardness of the cutting tool. The factors which influence the weariness of the circular saw blade are the following ones: the cutting conditions, the cutting tool geometry, the wood material to be processed, the material of the saw blade teeth and vibrations (Fig.1).

Figure 1 Influence of cutting speed on wear [2].

Increasing the feed speed lead to increased weariness of saw blade due intensification of cutting forces and cutting temperature.

3 Experimental researches

![Figure 2](image2.png)

Figure 2 The lastingness (by productivity and by cost)

The lastingness of the toothed saw blade must be determined according to the individual lastingness of each tooth, having in view that not all the teeth are worn out uniformly throughout the cutting process. As a result in establishing the weariness of the toothed saw blade, the tooth with the highest weariness will be highlighted as it stands for the landmark when sharpening the tool so that all the cutting edges to be positioned on the same cutting circular line. With a view to establishing the wear degree of each tooth in the case of spruce processing, the weariness values have been measured both on the back edge and the front face for all the teeth. Here is the equipment used throughout the process of conducting the experiment:

The tests have been conducted on the FCT circular saw, produced by ROMAN Mechanical Enterprise having the following characteristics: a 380 V-supply voltage, a 50 Hz-frequency, a 4 kW-engine output, a 220 V-charging voltage.

Since the circular saw has not been provided with a self-acting feed system, it has been installed a power feed roller device (DAM), produced by Co-Matic company in 2007, AF 38 Model with a 380 V-supply voltage.

The circular saw blade used while conducting the experiments has had the following characteristics:
- outer diameter: 300 mm
- boring diameter: 30 mm
- number of teeth: 24
- saw blade thickness: 2.2 mm
- tooth thickness: 3.2 mm
- clearance angle: 10 grade
- cutting angle: 62 grade
- front rake angle: 18 grade
- toothing pitch: 40 mm
- radius of tooth rounding (a): 10 mm

Figure 3 Experimental circular saw blade

The longitudinal processing of spruce wood has been made on test samples having a 720 mm-length, a 140 mm-width, a 48 mm-thickness, a 8.4 %-humidity. The rotation speed of the circular saw blade has been measured registering 4215 rot/min, and the feed speed has reached 16.72 m/min.

There has been used an optical microscope for measuring the tooth by the tooth weariness of the circular saw blade. The weariness has been measured before processing and after 400 linear meters of cut samples.

Fig 4 Stand of test with Optical Microscope

The resulted data in the case of a few teeth are rendered as follows:

1st tooth:
- Initial state of 1-st tooth very well;

2nd tooth:
- Initial state: very well;
Fig. 6 a. Initial state of 2nd tooth; b. State after 400 linear meters.
Observation: - State of tooth after 400 linear meters: small weariness

6th tooth:
- Initial state very well;

Fig. 7 a. Initial state of 6th tooth; b. State after 400 linear meters

9th tooth:
- Initial state very well;

Fig. 8 a. Initial state of 9th tooth; b. State after 400 linear meters

19th tooth:
- Initial state very well

Figure 9 a. Initial state of first tooth; b. State after 400 linear meters knobs on cutting edge (0.07 mm).

21st tooth:
- Initial state very well

Figure 10 a. Initial state of first tooth; b. State after 400 linear meters

24th tooth:
- Initial state very well

Figure 11 a. Initial state of first tooth; b. State after 400 linear meters

After having processed the obtained data, there has been noticed that the second tooth is the mostly worn out tooth and it is rendered in the figure presented below:

Figure 12: 2nd Tooth Weariness Form at Spruce Processing:
a. on the back edge; b. on the front face;

After having obtained the experimental data, there has also been calculated the weariness from a theoretical point of view, the resulted data being rendered in the figure presented below:

Figure 13: Analytically Determined Teeth Weariness on Back Edge and Front Face:
a. in the case of spruce wood processing;
b. in the case of beech wood processing

The lastingness of circular saw blade represents the real cutting time up to the occurrence of the admissible weariness. From the figure it results the fact that the lastingness corresponding to the maximum productivity rises the processing costs as compared to the minimum ones with about 2% and the lastingness corresponding to the minimum cost diminishes the productivity as compared to the maximum one with about 7%.
4 Discussion and Conclusion

As the connection between weariness and lastingness is of the mirror type, it results that all the factors which lead to the increase of the weariness intensity cause the decrease of lastingness and the other way round.

The factors which influence lastingness are the same with those influencing weariness.

The criteria for determining the optimal lastingness are the following ones (see Figure 14): maximum productivity, minimum cost price; simultaneous exchange of tools at an operation line.

The determination of lastingness, which gives the maximum productivity, starts from the relation below:

\[ \tau_p = \tau_a + \tau_b, \]  

where:

- \( \tau_p \) stands for the time necessary to process a surface;
- \( \tau_a \) – time necessary to change the cutting edge or the cutting tool;
- \( \tau_b \) – basic time (real cutting).

The determination of lastingness, which gives the minimum price cost, is analysed on the basis of the relation given below:

\[ C_p = C_a + C_b, \]  

where:

- \( C_p \) stands for the cost of a surface processing;
- \( C_a \) – auxiliary cost necessary to the change of the cutting edge or cutting tool;
- \( C_b \) – basic cost.

In industrial applications, among other parameters, lastingness is used for determining the optimal cutting conditions and it can be measured both according to a classical method and by means of mathematical programming, but monitoring the cutting tool weariness is more useful throughout the manufacturing process.

By making a synthesis and analyzing the experimental data, we have reached the following conclusions:

- The weariness process increases significantly after processing 500-600 linear meters of spruce wood. The increase level, for the previously mentioned lengths, can reach 0.3 mm. The value of 2.5 mm is due to the presence of knobs on cutting edges.
- Taking into consideration the previously mentioned values, the working conditions must also include the level of the cutting saw blades.
- The weariness of the circular saw blade (that is the weariness of the cutting edge) increases in time, thus continuously and irreversibly changing the sawing process conditions.

- At the beginning of the spruce wood processing, the percentage of teeth in good working condition on the back edge has been of 100%, and after 1000 meters of cut samples, the percentage in good working condition has been of 37.5%.

At the beginning of the spruce wood processing, the percentage of teeth in good working condition on the front face has been of 100%, and after 1000 meters of cut samples, the percentage in good working condition has been of 12.5%.

The weariness phenomenon is irreversible in time, thus the consequence of the weariness phenomenon is the weariness of the cutting edge which increases in time.

The manufacturing process produces emissions, as a consequence of the increased time of using these saw blades, which represents a real danger for the environment.

The lastingness at spruce wood processing after 400 linear meters of cut samples can be determined by means of the relation given below:

\[ T = \frac{400}{16.72} = 23.92 \text{ min} \]  

(3)

As a conclusion, the authors consider appropriate to continue conducting experiments through the methodology used also in the case of other wood species, such as: fir, pine, but also for deciduous trees, such as: beech, oak, hornbeam etc. The extension of the range of values for certain parameters, such as: cutting speed (for a range of at least 5 stages), the tool lastingness, through the processing of at least 1500 linear meters are immediate objectives of the authors who aim at modelling some softwares which should give the choice of the optimal steel for each circular saw blade type designed to the specific processing of the wood belonging to various species.

It is required to continue research and establishment of optimal lastingness.

References:

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