RESEARCH ON THE CUTTING OF SPRUCE LOGS IN WINTER CONDITIONS WITH NARROW BAND SAW BLADES

Zhivko Gochev[1], Valentin Atanasov[2]
University of Forestry, 10 Kliment Ohridski blvd, 1756 Sofia, Bulgaria,
e-mail: [1]zhivkog@yahoo.com; [2]vatanasov_2000@yahoo.com

ABSTRACT

Experimental researches were performed in winter conditions with a horizontal band saw „Wood-Mizer" WM 3000. The tests were conducted in manufacturing conditions of the „Chil Tepe – 97" Ltd. facility in town of Laki by processing spruce logs. Two types of cutting tools were used: with normal and hardened teeth. The results are analyzed and some recommendations are proposed for more efficient use of this machine types.

Key words: horizontal band saw, narrow band saw blades, frozen wood

INTRODUCTION

Cutting of logs in the winter especially at low temperatures and snow is in terms different from those in other seasons. The presence of partially frozen water in the wood's cell walls, snow and ice on the bark of logs increases its static strength and requires the use of band saws blades with higher teeth resistance at lower cutting and feed speeds. Electric energy consumption is higher, cutting tools wear out faster and quality of machined surface deteriorates (Grigorov 1992).

The purpose of this paper is an experimental performance investigation of horizontal band saw „Wood-Mizer" WM 3000 by cutting logs with different band saws blades.

METHODS

The experimental studies were conducted in manufacturing conditions of the „Chil Tepe – 97" Ltd. facility in town of Laki. For this purpose was used horizontal band saw „Wood-Mizer", model WM 3000. Figure 1 shows the machine's cutting mechanism. Some of its technical features are:

D = 600 mm – saw wheel diameter;

L_o = 1480 mm – axle distance of wheels;

N_m = 22 kW – power of the motor which drives the leading wheel;

n_m = 24,42 s^{-1} – revolutions of the motor's shaft;

D_1 = 180 mm – diameter of the motor pulley;

D_2 = 300 mm – diameter of the wheel pulley;

Uϵ (from 2 to 51) $m.min^{-1}$ – feed speed.

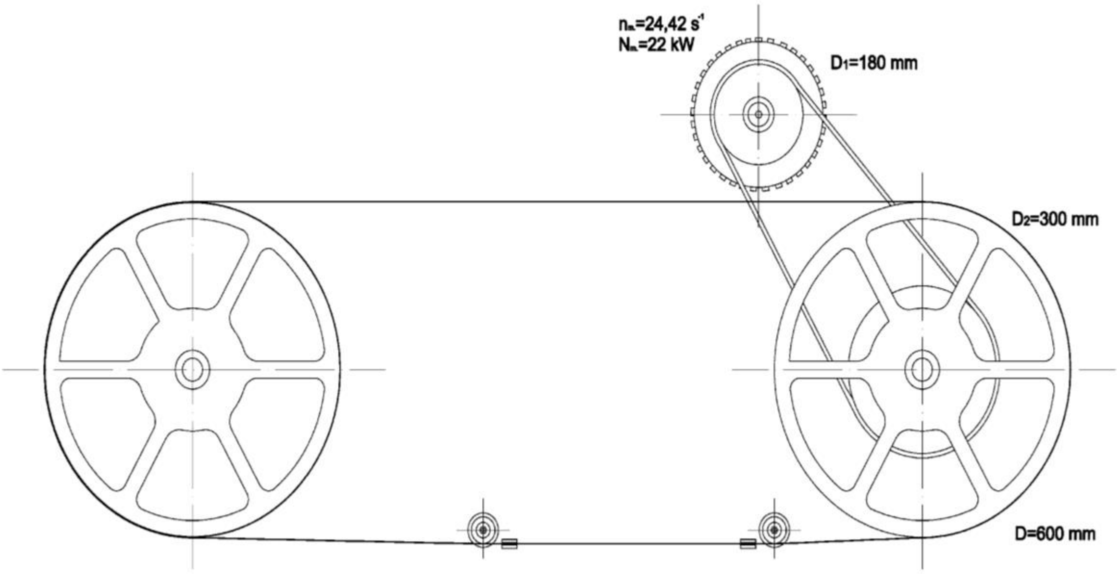

Figure 1: Cutting mechanism – „Wood-Mizer“, Model WM 3000

Figure 2: Logs of spruce in winter conditions

Spruce logs (Picea abies*)* with density ρ=805 kg.m^{-3} and moisture W=45 % were processed (Fig. 2).

Two types of band saw blades of the company „Wood-Mizer“ were used: with hardened „Double Hard“ and normal teeth „Professional“. Some of the important specifications of the cutting tools are: tooth part-set size s' = 0,45 mm, angular parameters of teeth (γ/β) 4/32 and 10/30°, band thickness s = 1,1 mm, band width B=35 and 38 mm, pitch of the teeth t=22 mm and tooth height h' = 5 and 6 mm.

Feed speed is variable quantity and is regulated by the worker by experience. It depends on cutting height, wood density, working capacity of the band saw blade and cutting power. In the process of cutting was determined its average by the formula (1) (Gochev 2008).

$$U_{av.i} = \frac{L_{\log}}{t_i}, \qquad \textbf{(1)}$$

where:

$U_{av.i}$ – average feed speed, m.min^{-1};

L_{log} – log length, m;

t_i – time to make a cut on the log, min.

In each processed lumber was measured its average width, as shown in Fig. 3.

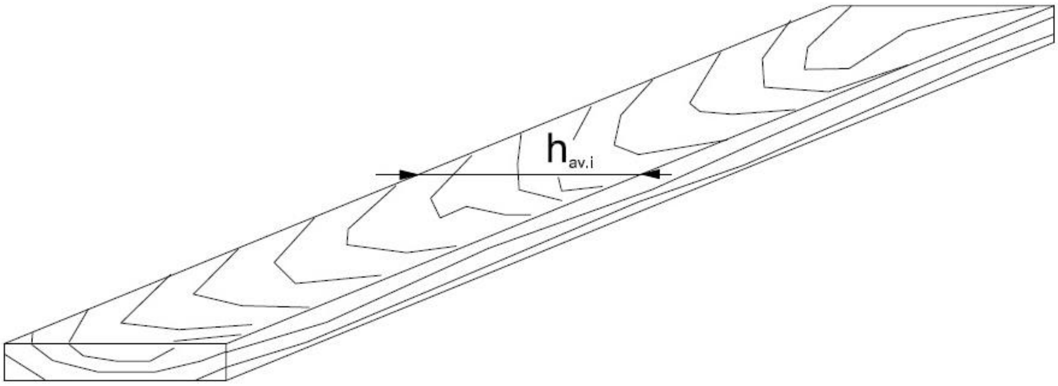

Figure 3: Average width of lumber

Since there was no information about the cutting speed in the technical documentation of the machine i.e. speed of the band, it was calculated by formula (2) (Obreshkov 1998).

$$V = \pi D \frac{n_m}{i}(1-\varepsilon), \quad \textbf{(2)}$$

where:

V – cutting speed, $m.s^{-1}$;

n_m – revolutions of the motor's shaft, s^{-1};

i – ratio of the belt drive;

ε – sliding coefficient of the belt.

The measurement of the cutting mechanism's input power during idle and load conditions was performed by using the power indicator built into the control panel of the machine.

The average power consumption of the cutting mechanism was calculated by formula (3) (Gochev 2008).

$$E_{av.} = \frac{N_{lc.av.}}{60 U_{av.} h_{av.}}, \quad \textbf{(3)}$$

where:

$E_{av.}$ – average power consumption, $kWh.m^{-2}$;

$N_{lc.av.}$ – average input power of the cutting mechanism, kW.

If the productivity of the cutting mechanism is defined in $m^3.h^{-1}$ then cutting schemes and size of logs would have a major impact. Therefore, productivity was established in $m^2.min^{-1}$. Its average value ($Q_{av.}$) was calculated by formula (4) (Gochev 2008).

$$Q_{av.} = U_{av.} h_{av.} \quad \textbf{(4)}$$

RESULTS AND DISCUSSION

The results of the experimental studies are presented in Table 1. Logs from 1 to 5 and 6 to 10 were cut with bands which teeth are hardened and those from 11 to 12 with normal teeth.

Table 1: Results of the experiments

Log №	L_{log} [m]	Number of cuts	$h_{av.}$ [m]	$U_{av.}$ [$m.min^{-1}$]	$N_{i.}$ [kW]	$N_{lc.av.}$ [kW]	$E_{av.}$ [$kWh.m^{-2}$]	$Q_{av.}$ [$m^2.min^{-1}$]
1.	4,06	12	0,19	11,77	1,47	7,28	0,05	2,28
2.	4,06	15	0,20	10,36		7,71	0,06	2,12
3.	4,06	13	0,17	12,42		7,81	0,06	2,14
4.	4,06	13	0,17	11,52		6,12	0,05	1,94

Log №	L_{log} [m]	Number of cuts	$h_{av.}$ [m]	$U_{av.}$ [m.min^{-1}]	$N_{i.}$ [kW]	$N_{lc.av.}$ [kW]	$E_{av.}$ [kWh.m^{-2}]	$Q_{av.}$ [m^2.min^{-1}]
5.	4,05	11	0,20	9,98		8,67	0,07	2,01
6.	4,05	16	0,29	8,09		8,93	0,06	2,34
7.	4,06	12	0,20	8,09		7,13	0,08	1,58
8.	4,02	15	0,19	13,18		5,82	0,04	2,55
9.	4,06	23	0,29	6,86		8,66	0,07	1,96
10.	4,06	16	0,26	8,17		8,54	0,07	2,16
11.	3,97	20	0,37	5,12		8,16	0,07	1,87
12.	4,03	12	0,23	8,06		6,61	0,06	1,87
Generalized average values								
Band saw blade № 1		12,80	0,19	11,21	1,47	7,52	0,06	2,10
Band saw blade № 2		16,40	0,25	8,88		7,82	0,06	2,12
Band saw blade № 3		16,00	0,30	6,59		7,39	0,07	1,87

Cutting speed i.e. the speed of the band calculated by formula (2) was V=28 m.s^{-1}.

Figure 4 shows the relationship between the height of cut and feed speed. The results show that with increasing height of the cut the feed speed decreases. This dependence is more distinct in the second band since its cutting height varies more widely. However, there are exceptions which result from defects in the wood. The fact that the operator didn't load the machine to its optimum capacity should not be missed.

The band with normal teeth didn't show good performance and after cutting of the second log was removed for sharpening.

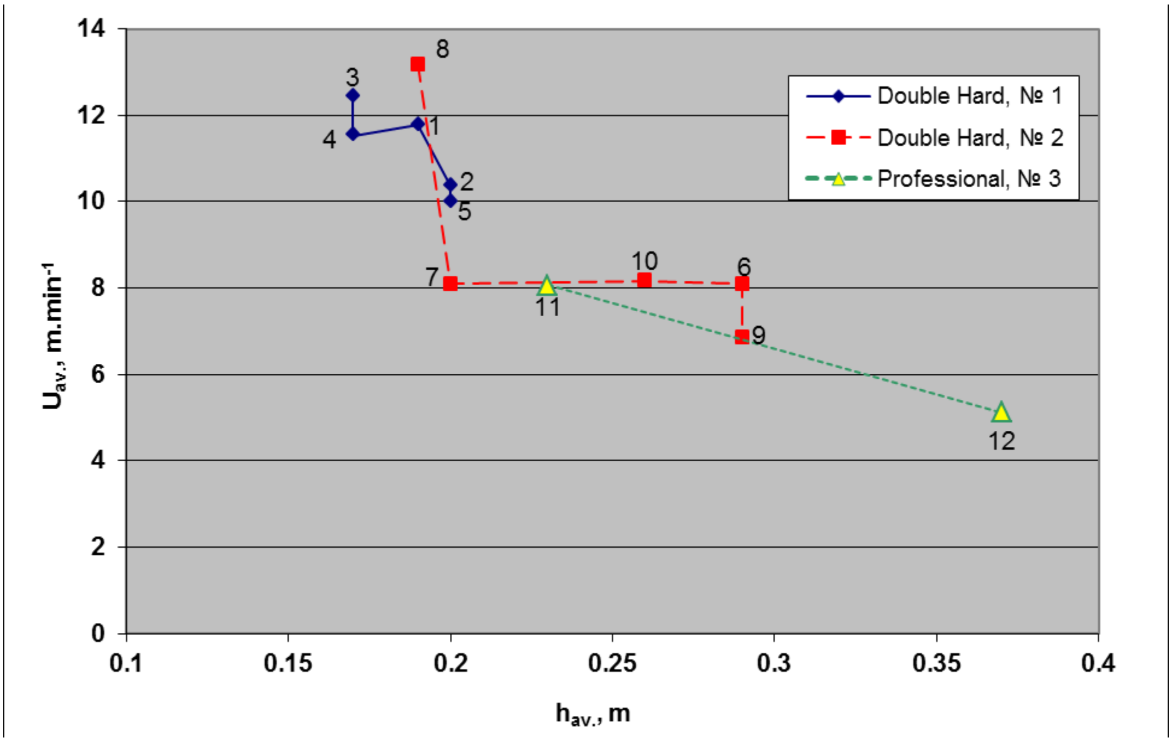

Figure 4: Influence of cutting height ($h_{av.}$) on the feed speed ($U_{av.}$) when cutting frozen spruce logs. Figures from 1 to 12 on the graph show the log's number

The graph in Fig. 5 shows the relationship between the feed speed, input power of the cutting mechanism, electricity consumption and cutting mechanism productivity. The figure shows that it is difficult to find direct dependence between the feed rate and power of cutting mechanism. This is due to the fact that studies are carried out in manufacturing conditions where the cutting height is a changing value. Furthermore, the defects in the wood and the rate of its freezing also have a strong influence.

The generalized average productivity of the cutting mechanism for bands with hardened teeth „Double Hard“ is respectively 2,10 and 2,12 $m^2.min^{-1}$. The obtained value for the band with normal teeth "Professional" is 1,87 $m^2.min^{-1}$ i.e. in the winter with partially frozen wood is appropriate to use bands with hardened teeth to have higher productivity.

In addition to the lower productivity, the band with normal teeth shows higher power consumption (0,07 $kWh.m^{-2}$) than the other two bands. The reason for this could be the rapid wear which is followed by a lower feed speed.

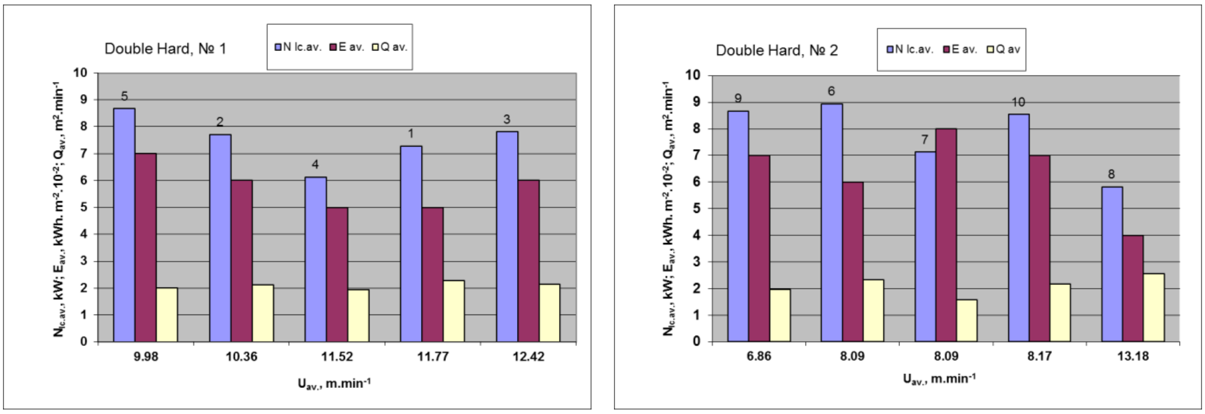

Figure 5: Influence of feed rate ($U_{av.}$) on the input power of the cutting mechanism ($N_{lc.av.}$), electricity consumption ($E_{av.}$) and productivity of the cutting mechanism ($Q_{av.}$) . Figures from 1 to 10 on the graph show the log's number

The only indication that the band with normal teeth outperforms those with hardened is the input power of the cutting mechanism (7,39 kW). This is because of the lower feed speed in this type of bands.

CONCLUSION

Based on the studies on the spruce logs cutting with narrow band saw blades in winter conditions, the following conclusions and recommendations can be outlined:

1. Although the spruce is considered as softwood, in winter conditions as a result of partially frozen water in the wood cell gaps and the presence of ice on log's bark it appears as hardwood. In this case bands with less front angle of cutting (γ) and possibly with hardened teeth should be used.
2. Band saw blades with hardened teeth showed twice longer duration of work before the need of sharpening.
3. Roughness of the resulting surfaces is not a priority of the company where the tests were carried and engine load could reach its nominal values. However, in the working

process was found that production capacity was lost. Therefore, it is necessary to pay attention during operator training on cutting regimes, especially the relationship between feed speed and cutting height.

4. Because of the characteristics of cutting in winter conditions are necessary more comprehensive studies to be carried out in this area for soft coniferous and solid deciduous wood.

REFERENCES

1. Theme № 122 (2008). Comparative investigation on working capacity of wide band saw blades with setting, swaging and stellite teeth, Team leader Assoc. Prof. Z. Gochev, NIS/LTU, 100 p. (in Bulgarian)
2. Grigorov, P. (1992). Wood cutting, Zemizdat, Sofia, 335 p. (in Bulgarian)
3. Obreshkov, P. (1998). The most important for the band saw blades. Preparation and maintenance, Publishing House BM, Sofia, 74 p. (in Bulgarian)