Chapter 6

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CALCULATION ASPECTS IN THE PRODUCTION OF PULP FROM SELECTED HARDWOOD SPECIES

Abstract: The production of pulp from hardwood species has due to morphological structure and chemical composition of wood various production cost ratio. The aim of this paper is to quantify the cost ratio of production costs and monitor the development of costs in the production of beech pulp, oak pulp and their mixture. Costs have been generated not only in consideration of the entry price of wood raw material, but also due to the required technical and technological parameters, which is necessary to keep during the production of pulp.

Key words: beech and oak wood, pulps, costs, calculation

6.1. Introduction

Pulp is produced by most of the wood, which consists of carbohydrate component (cellulose and hemicellulose), lignin and extractives. During production of pulp and paper we need to know how the economy affects our process and generates costs of starting material, which has been becoming increasingly expensive. The main factor which affects the yield of pulp is wood species. From wood with a higher proportion of carbohydrate a lower content of lignin and extractives we obtain higher yield pulp (MACLEOD M. 2007). In view of highest percentage of trees in the forests of Slovakia are beech and oak trees most processed in the territory of Slovak Republic. Price per 1 m^3 with bark is at the level for beech and oak at 41.0 € and 40.0 € for the appropriate mix of oak and beech species we use the average price of 40.5 € (TU VŠLP ZVOLEN 2013). The purchase price of raw wood is not significantly different. But these wood species are significantly different

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from each other by chemically and morphologically structure. It influences the yield and consumption of chemicals in oxygen delignification, which has important impact on development costs in the production of pulp.

6.2. Material and methods

Referenced samples of wood were collected randomly without defects, about 60 cm in length with a diameter of 23 cm oak, beech 24 cm. Chips were prepared manually, thickness of chips were 3-4 mm, that is standard size.

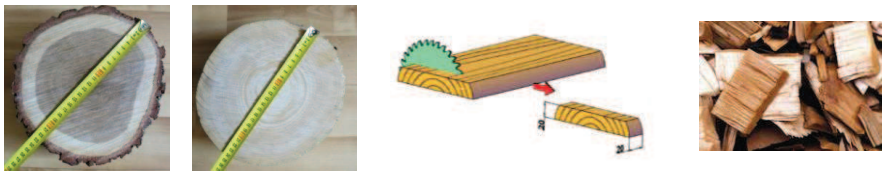

Fig. 6.1. Samples of wood oak, beech and sample preparation.

The chips produced kraft pulp was prepared in Hägglund bombs under the following conditions:

Conditions of kraft batch:

initial / final temperature	80/170 °C
total batch time	180 min.
active alkali content	16,0 % oven dry wood
concentration of active alkali	99,8 g/l Na2O
sulfidity	24,8 %
liquor to wood ratio	4 : 1

After kraft batch the contents of the bomb were emptied on a filtration system, disintegrated with blender according to the procedure VÚPC Bratislava, Slovakia. Disintegrated of pulp is screened in screening apparatus (0.25 mm), and free-dried at room temperature (20°C). The pulp yield and kappa number (STN ISO 302) were determined. On the basis of obtained yields were calculated cost of input raw material production per 1

ton of pulp from beech, oak, and their mixtures (MOLTEBERG D. 2004). At oxygen delignification were determined costs for pulp bleaching. As a reference sample was used beech.

6.3. Results and discussion

6.3.1. Yields pulps

The highest yield of unbleached pulp (Tab. 6.1.) was achieved in 50.13% beech and oak lowest at 46.79%. The yield of pulp from a mixture of both was 47.07% (but not the weighted average yields obtained the beech and oak). For all types of pulps has been screened a minimum quantity rejects and can say that rejects content was insignificant. Geffertová (2007 b) states yield to oak 46.5%. For a mixture of beech, oak and locust Geffertová (2007 a) states 45.0%. For beech states ANONYMUS (1980) 49.0%

From the above results it can be concluded that the common laboratory batch, there were influencing the tree species each other. Batch of pure oak and beech carried out differently in compare with the common mixed batch.

Table 6.1. Yield of kraft pulps, contents of rejects, Kappa number

Samples	Oak	Beech	Mixture (1:1)
Yield (%)	46.79 ±0.58*	50.13 ±0.15*	47.07 ±0.20*
Reject (%)	0.04 ±0.001*	0.02 ±0.001*	0,02 ±0.001*
Kappa number	26.5 ±0.09*	19.6 ± 0.8*	23.8 ± 0.17*

* *Standard deviation*

Source: own study

6.3.2. Wood loss during the cutting and debarking

Wood losses during the cutting are in the range from 0.7% to 2.6% and influence of the saw blade is in the range from 0.33% to 0.60% (BUČKO J. 2001). Wood raw material is purchased with length 4 and 4.5 m, in the

present. It is not necessary to cut of wood. Wood losses from debarking are in the range from 2% to 5% and it´s depending on the debarking effectiveness (95-98%) (EK M. 2009). The average density of oak wood is ρ_0 = 696 kg/m^3 and beech wood ρ_0 = 684 kg/m^3 (POŽGAJ A. 1997).

The following table (Table 6.2) shows the average wood losses during the cutting (1.65%) and debarked wood (3.5%).

Table 6.2. Wood loss during the cutting and debarking

Wood species	A	B	Total loss of wood (C) A+B (t)
	Wood loss - cutting (t)	Wood loss - debarking (t)	
Beech	0.0113	0.0239	0.0352
Oak	0.0115	0.0244	0.0359

Source: own study

Purchased from 1 m^3 of wood raw material enters the cooking room (cooking room = ρ_0-C):

beech **0.6488** t/m^3
oak **0.6601** t/m^3

6.3.3. The net yield of pulp from 1 m^3 wood

The following Table 6.3.shows the yields that we obtain from 1 m^3 after cutting and debarking wood. For the calculation we used the following relationship:

$$\rho_0 - (\text{total loss of wood, table 2}) \times (\text{yield, table 1}) \qquad (6.1)$$

Table 6.3. The screened pulp yield

Wood species	Oak	Beech	Mixture
Yield (t)	0.3252	0.3089	0.3081

Source: own study

The values in Table 6.3. do not take into the consideration the losses of pulp. With these losses is necessary to calculate during the screening, oxygen delignification (OD) and bleaching of pulp and there are about 7% (www.metso.com).

6.3.4. Costing of 1 ton pulp production

The following Tab. 6.4. shows the cost for the wood material if we want to produce 1 ton of bleached screening pulp.

Table 6.4. Costing to produce of pulp from raw wood

Wood species	**Oak**	**Beech**	**Mixture**
Not screened pulp yield (t/m^3)	**0,3252**	**0,3089**	**0,3081**
Screened pulp yield (t/m^3)	**0,3024**	**0,2873**	**0,2865**
The cost per 1 m^3 of wood (€)	**40.0**	**41.0**	**40.5**
The cost per 1 t pulp (€)	139.20	135.71	141.30

Source: own study

Further increase in costs causes during OD higher amount of lignin in the oak pulp and from mixture in compare with beech pulp. To reduce one unit of kappa numbers is needed to add chemicals around 2.0 kg NaOH and 1.3 kg O_2 (www.metso.com).

The following Table 6.5. shows the consumption of NaOH and O_2 to the OD if the required kappa number is 15.0.

Table 6.5. Costing to OD for required Kappa number (input bleached line)

Wood species	Oak	Beech	Mixture
Specified Kappa number	26.5	19.6	23.8
Required Kappa number	15.0		
Difference	11.5	4.60	8.80

Wood species	Oak	Beech	Mixture
NaOH (kg/t pulp)	23.0	9.20	17.60
Consumption O_2 (kg/t pulp)	14.95	5.98	11.44
Costs NaOH (€/t)	9.20	3.68	7.04
Costs O_2 (€/t)	1.50	0.60	1.14
Total costs (€/t) (to achieve the same Kappa number at the output)	10.70	4.30	8.14

Source: own study

As a default value for comparison of costs for pulp from various wood species we determine the cost of producing for 1 ton of beech pulp.

Price per ton of NaOH : 400 €,

O_2 : 100 €

(www.alibaba.com)

More detailed interpretation of costs changes is referred in the Tab. 6.6.

Table 6.6. The cost of input raw wood and OD

	Beech - reference sample	**Oak**	**Mixture**
The cost of input raw material production 1 t pulp	135.71	+ 3.49	+ 5.59
The cost of OD 1 t pulp	4.30	+ 6.40	+ 3.84
Total increased cost of production 1 t pulp	-	+ 9.89	+ 9.43

Source: own study

6.4. Summary

Different chemical composition of wood species had an effect on the process of batch and we achieved lower yields in pulp oak 46.79% and a mixed pulp 47.07% in compared with 50.13% beech pulp. Batch of a mixture of the two wood species we received yield, which has not been the weighted average yield of pure oak and beech. During batch occurred to influence of each other wood species.

Kappa number was determined at the highest oak pulp 26.5 and lowest in beech pulp 19.6. The mixture was determined kappa number 23.8.

These facts directly affect the overall economy of production and growth of costs to produce 1 ton of pulp. Based on the obtained results and calculation (Table X.6.) can be state that the production of pulp from oak is at € 9.79 higher in compare with beech pulp. Pulp prepared from a mixture of wood species (1:1) is also more expensive, it is at € 9.43 in compare with beech pulp. Average daily production in mills in the Slovak Republic is 600 t. Based on this fact, in such daily production, the differences in the costs are an important aspect for production of pulp.

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