DIGITALISATION AND CIRCULAR ECONOMY:
forestry and forestry based industry implications

12th International Scientific Conference WoodEMA 2019

Varna, September, 11-13, 2019

WeMa UNION OF SCIENTISTS OF BULGARIA

DILEMMAS OF TECHNOLOGICAL INNOVATIONS ON THE EXAMPLE OF SELECTED PRODUCTS BASED ON OAK WOOD

Marek Wieruszewski,

Elżbieta Mikołajczak

Leszek Wanat

The idea of research

- The study discusses the importance of selecting of the type of processing technology of the raw oak wood material on the quality of semi-finished timber (cladding).
- The influence of the importance of innovation and efficiency factors in the technological and economic aspects was verified.
- The comparative analysis of various, including traditional and innovative technologies, allows for the conclusion that new investments are justifiable in the wood-based industry.

Why?

- The purpose of this study was to assess the selected methods of oak lumber processing into lamella and cladding components.
- The benchmarking was based on the material and qualitative efficiency of target elements.
- As a consequence, an attempt was made to indicate the most reasonable method for making semi-finished products used in the production of lamella panels.
- The method was also expected to guarantee the appropriate qualitative and dimensional structure of semi-finished oak products.
- The study was carried out in 2017 with establishments processing oak wood into cladding materials based on innovative solutions for making boards by cutting fresh lumber.

And…

- Two technologies were considered:

1._making boards of pre-dried lumber, referred to as the “dry method” in this study;

2._making wet boards from fresh lumber to be subsequently dried and cut into elements of appropriate dimensions, referred to as the “wet method” in this study; compared to the traditional method for making boards from pre-dried lumber, it offers better performance indicators for lower-quality lumber.

- The main objective of the “wet” technology is to reduce the damage to lumber during the drying process, especially including: considerable horizontal and vertical deformation of boards; drying cracks; and large material losses in the process of drying lumber of lower quality classes.

Material and methods

- This study focused on oak roundwood (*Quercus robur L*. and *Quercus petraea L*.) for producing boards used to make single-strip boards, and on hardwood lumber used to make multi-strip boards, grouped in 11 research batches.
- In the dry technology, 131.245 m^3 of lumber were processed into a total of 8226.184 m^2 of single-strip boards.
- In the wet technology, 88.62 m^3 of lumber were processed into a total of 8526.310 m^2 of single-strip boards.

Dry technology

- In the dry technology, it takes 38–39 days to dry the lumber. The process starts after the chamber is filled with lumber batches. Ca. 45 m^3 of lumber can be dried in one process. After drying, the basic problem is the quality of lumber which changes its dimensions and geometry during the process. Sometimes, if bent or distorted, it cannot be further processed into single-strip boards due to the risk of damage to machinery.
- The analysis focused on the distribution of lengths of 186-mm-wide boards made using the dry technology. A very small proportion (13%) of long boards (2215 mm) suggests the material utilization rate was low. This is because the lumber bends when drying, resulting in improper processing and in improperly planed boards in the final production stage. A large proportion (57%) of short boards (1107 mm) results from the manipulation of defective (improperly planed) boards. An auxiliary analysis of performance ratios found that lumber was not efficiently used due to a decline in its quality after the drying process.

Wet technology

- The drying process of boards made of fresh lumber takes ca. 5 days and begins when the chamber is filled with boards loaded in twelve bins.
- A large proportion (ca. 51%) of 2215-mm-long E-class and F-class boards results from a good utilization of materials and from the absence of geometric distortions after the drying process. The analysis of the percentage share of boards of different quality classes (all lengths combined) also confirms the good utilization of materials. The outcomes of the wet technology were analyzed separately for each research sample and as the average value for all samples. The wet technology was found to make a more efficient use of materials and to be more productive than the dry technology, as also confirmed by the comparison of material consumption standards.

Table 1. Drying time and volume of dried material

	Technology	
	DRY	**WET**
Drying time [days]	38	5
Input volume for one drying cycle [m^3]	45	9
Drying performance [m^3/day]	1,184	1,800

Source: authors' own elaboration

The differences between the drying processes used in both technologies are shown in Table 1.

Results

- The key difference between the dry and wet technologies is the duration of the drying process. In the traditional dry technology, the materials are dried for 38 days whereas only 5 days are required in the new, innovative wet technology.
- Despite a small unit load (9 m^3) being dried, the performance of the wet technology is by more than 50% higher as the drying time is very short (5 days) compared to the dry technology.
- This is possible because of a higher batch turnover rate and a higher fragmentation of dried material (larger surface exposed to drying).
- Furthermore, in the wet technology, the quality of dried material is considerably higher.
- This has an effect on the performance of the entire process: the wood is not bent and the cracks do not grow as big as in the dry technology.
- As a summary of this study, Table 2 shows a comparison of the dry and wet technology by different criteria. It indicates the positive aspects of processing under the assumption that lower-quality lumber is used.

Table 2. Comparison of various aspects of the dry and the wet technology

Criterion	Technology	
	Dry	**Wet**
Energy efficiency of the drying process	High (1)	Low (0.25)
Material stresses	High	Low
Drying process	High risk posed by thicker materials; slow moisture drainage; risk of discoloration, cracks and deformation	Low risk, slick materials; rapid moisture drainage
Post-drying defects	Frequent discoloration (post-drying stains) of materials, cracks and deformations related to stresses in wood	Low risk of post-drying defects such as discoloration, cracks in strips and permanent deformations related to material stresses
Shape and thickness of processed strips	Boards are formed into blocks and are cut into strips; vulnerability to deformation; a non-linear shape of strips after cutting is particularly troublesome (a part of the material is affected by that issue); transverse distortions; uncertain distribution of thickness of strips after the production process is complete	Once dried, the strips are processed separately; low risk of deformation after processing; high precision in setting the width and thickness of strips; better parameters for further processing; better quality of finished products
Production of D-class strips	Very difficult, high material consumption	Normal, just as in any other class; lower material consumption compared to the dry technology

Conclusions (1)

- The production of strips based on the dry technology is a relatively simple method employed by most timber companies. However, it demonstrates some limitations and defects, including: poor performance and quality ratios, and low precision in setting the dimensions. This makes the producers look for solutions that are both relatively simple and innovative. In this case study, the technological limitations of the dry method resulted in the need to verify whether switching to the wet technology is a good option.

Conclusions (2)

- The wet technology delivers higher performance because the drying of slick strips reduces the risk of deformation caused by material stresses.
- The wet technology is primarily intended for lower-quality lumber types, enabling an optimum use of materials when processing wood into single-strip components.
- Compared to the wet technology, the dry technology has a highly energy-intensive lumber drying process.
- In the dry technology, the lumber drying process is conducive to the formation of strips made of wood of non-uniform colors. The discoloration has a strong detrimental effect on the appearance of the floor and is the basis for complaints.

Conclusions (3)

- A lot of material is lost when preparing lumber in the dry technology due to defects occurring in the drying process and to changes in the geometry of lumber.
- The production process of single-strip boards in the wet technology allows the products to remain dimensionally stable which is crucial for further processing and repeatability.
- Products made using the wet technology demonstrate a greater dimensional stability in subsequent processing stages (after the strips are dried).
- The materials made using the wet technology form a class of boards with a better structure which is more consistent with the assumptions.

- Благодаря за вниманието!
- Thank you for Your attention!

DIGITALISATION AND CIRCULAR ECONOMY:
forestry and forestry based industry implications

12th International Scientific Conference WoodEMA 2019

Varna, September, 11-13, 2019

DILEMMAS OF TECHNOLOGICAL INNOVATIONS ON THE EXAMPLE OF SELECTED PRODUCTS BASED ON OAK WOOD

Marek Wieruszewski,
Elżbieta Mikołajczak
Leszek Wanat

UNION OF SCIENTISTS OF BULGARIA