STUDY ON THE ROLE OF WOOD MOISTURE IN PROCESSING AND ITS IMPACT ON THE DURABILITY OF CHAIRS

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REVIEW

Abstract

The paper analyzes the influence of moisture on the mechanical properties and structural stability of the wood used in chair production. The study, conducted at a wood processing factory in Sighetul Marmației, explores how moisture levels impact processing stages such as cutting, sanding, and assembly, identifying the optimal moisture level to minimize the risk of warping and cracking. The research also examines the impact of residual moisture on the long-term durability of chairs, highlighting the direct relationship between moisture control and resistance to wear and deformation. The conclusions suggest that well-controlled moisture not only enhances the quality of the final product but also contributes to extending the furniture's lifespan, recommending the implementation of strict moisture monitoring procedures in manufacturing processes.

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INTRODUCTION

Wood, as an organic material, has the capacity to absorb and release moisture from its surrounding environment, a natural process that can significantly influence its physical and mechanical properties.

Wood moisture content can affect not only the appearance and quality of the material but also its durability and functionality over the long term.

Table 1

The Impact of Wood Moisture on Different Characteristics

Characteristic	High Moisture	Low Moisture
Durability	May decrease	May increase
Aesthetics	May cause deformations	May cause cracks
Functionality	May affect structural integrity	May improve strength

Wood moisture refers to the amount of water contained in the material, expressed as a percentage of its dry mass, and can vary depending on environmental conditions, such as temperature and relative humidity of the air. This factor plays an essential role for wood from multiple perspectives.

Firstly, moisture influences the behavior of wood under various environmental conditions. For example, wood with excessive or insufficient moisture content may present increased difficulties during processing.

Secondly, moisture influences the durability of wood. Wood maintained at an optimal moisture level will have an extended lifespan and demonstrate increased resistance to external factors, such as insect attacks or mold development.

Table 2

Wood Moisture Levels and Their Implications

Moisture Level	Implications
Too Dry	Increases the risk of cracks and splits
Ideal	Maximizes durability and ease of processing
Too Wet	Increased risk of deformation and mold growth

Moisture directly influences the properties of wood, causing dimensional variations through expansion when absorbing water and contraction upon losing it. These changes can impact the structural integrity and dimensional stability of the wood. Additionally, moisture plays a significant role in wood's resistance to mechanical stresses, such as bending, tension, and compression.

Wood maintained at an optimal moisture level will exhibit superior strength, while excessively dry or overly moist wood may become more brittle and less resistant to stress.

The quality of the wood surface, including aspects such as finishing or paint application, is also influenced by the moisture level. Excessive moisture content can lead to an uneven finish or peeling of the paint layer, while overly dry wood may encourage the formation of cracks in the finish layer.

Regarding the durability and aesthetics of wood products, errors in moisture measurement can have visible consequences. Wood with excessive or insufficient moisture levels may undergo deformations, such as warping or twisting, which can compromise not only the product's aesthetic appearance but also its functionality.

Wood moisture is a critical factor in wood processing, affecting both the quality and durability of finished products such as chairs. In recent decades, numerous studies and research have emphasized the importance of moisture control in the wood industry, showing that it affects the physical and mechanical characteristics of wood, such as dimensional stability, resistance to deformation, and long-term durability.

According to research, wood moisture significantly influences the material's mechanical properties, such as tensile and compressive strength, which are essential for the stability and durability of wooden structures, including furniture. Wood with an optimal moisture content exhibits greater resistance to cracking and deformation caused by variations in temperature and ambient humidity. (Kherais et. all 2023, Sala et. all 2020).

Studies have shown that the controlled drying process of wood plays an essential role in reducing internal stresses, which can lead to chair deformation or loss of structural stability over time. This study demonstrated that slow and uniform drying of wood allows for the maintenance of an optimal moisture level, thereby reducing the risk of defects and improving the durability of the final product. (Blanchet et. all 2016).

In addition, a recent study highlighted the importance of drying treatments and continuous moisture monitoring throughout the entire processing stage. The results indicated that uncontrolled moisture leads to premature structural degradation of chairs, affecting both their aesthetic appearance and functionality.(Emmerich et. all 2023)

MATERIAL AND METHOD

In the analysis and determination of wood moisture, the Gaussian Curve (Normal Distribution) is a valuable method for interpreting natural variations and the distribution of moisture in wood materials. This statistical approach allows for the identification and quantification of deviations and uniformity of moisture within the wood structure, which is essential in the context of evaluating the quality and performance of wood used in construction, furniture, and other industrial applications.

Wood moisture naturally varies due to environmental factors and the specific characteristics of each type of wood. By collecting moisture measurements on

representative wood samples and applying the Normal Distribution, essential data can be obtained for:

- Determining the Mean Moisture Value: The central value (mean, denoted as μ) of the normal distribution provides an estimate of the average moisture content in the batch of wood samples. This is important for assessing the overall condition of the material and for determining its compliance with the moisture standards required for specific applications.
- Analyzing the Standard Deviation of Moisture: The standard deviation (σ) indicates the level of variability in the moisture content of the wood. In the context of wood quality, a small standard deviation indicates greater uniformity of moisture, which is desirable in industrial production processes, as it reduces the risk of warping and cracking.

Identifying Anomalies in Moisture Data: By analyzing the Gaussian Curve, extreme values, which may result from external factors or a potential structural defect, can be more easily identified. Thus, moisture values that are significantly higher or lower than the average can be interpreted as anomalies or errors, which helps in taking corrective measures in the drying and treatment processes.(Smith, W., & Jung, H. 2015).

The Gaussian distribution is particularly relevant in determining wood moisture due to the following aspects:

- Monitoring moisture and its variability through the application of the Gaussian Curve allows for quality control of wood at various stages of processing, from harvesting and storage to the drying and final processing stages. This ensures that the material meets the moisture requirements for durability and stability. (Brown, T., & Anderson, L. 2017).
- In industrial dryers, where wood is exposed to a flow of warm air to reach optimal moisture levels, data obtained through the Normal Distribution helps in modeling and optimizing the process. In this context, a well-calibrated distribution indicates uniform dryness, preventing material loss. (Popescu, C. M., & Bălan, D. 2019).

Based on the determined mean values and variability, specialists can adjust the drying and thermal treatment parameters, thereby maximizing energy efficiency and minimizing processing time.

The measurements will be used in the calculation of the Gaussian Distribution (Gaussian Curve) to obtain a reliable result for the evaluated batch.

The formula for the Gaussian distribution for a continuous random variable X, with mean μ and standard deviation σ, is:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

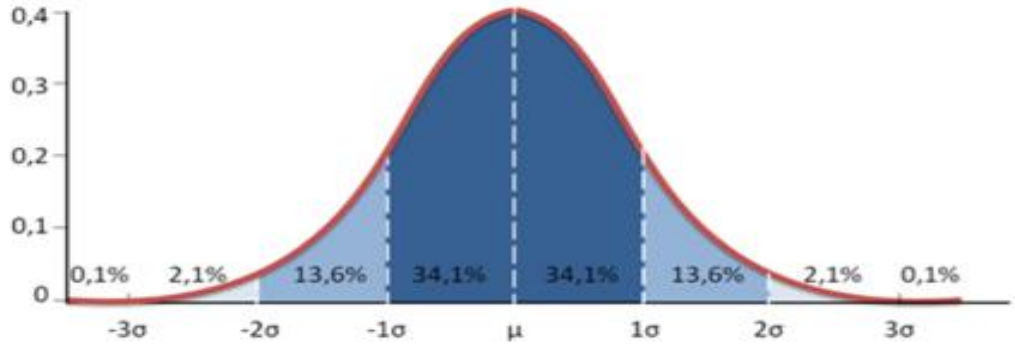

Figure 1 **Theoretical Gaussian Distribution**

The graph in figure 1 illustrates the theoretical gaussian distribution, characterized by the mean μ and standard deviation σ. The main features of this graph include:

1. Symmetry around the mean μ: the distribution is symmetric, featuring the classic "bell" shape
2. Standard deviation intervals: the graph highlights the proportions corresponding to each section between the means shifted by multiples of σ:

- approximately 68.2% of the data falls within the range of μ±1σ.
- approximately 95,4% of the data falls within the range of μ±2σ.
- approximately 99,7% of the data falls within the range of μ μ±3σ.

These intervals are graphically represented by different colored sections, marked in percentages (for example, 34.1% in each direction for the interval μ±1σ).

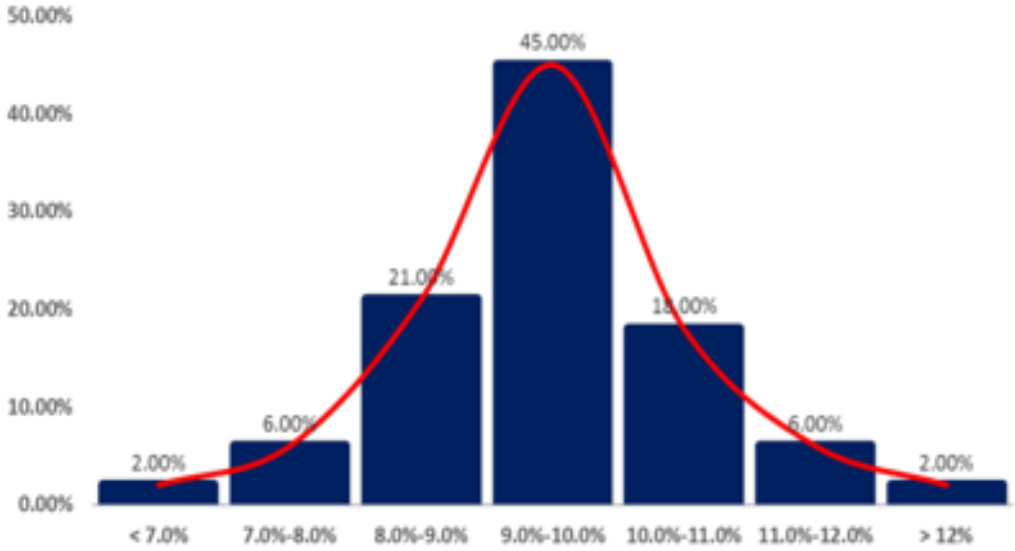

Figure 2 **Wood Moisture Distribution**

The graph in figure 2 shows a frequency distribution of wood moisture in percentages, using moisture intervals. This is an empirical distribution, as it represents real measurement data, and it is compared with a gaussian curve (drawn in red) to check conformity with the normal distribution

1. Bell shape: the graph appears to roughly follow a normal distribution, having a symmetric shape with a maximum around the value of 9-10% humidity
2. Mean and modes: the humidity values are most common in the range of 9-10% (with a frequency of 45%), which suggests that the mean humidity is close to this range.

There is a decrease in frequency towards the extremes (<7% and >12%), indicating a relatively small standard deviation, suggesting a distribution concentrated around the mean.

The graph confirms that the moisture content of the wood follows a distribution close to gaussian, with the majority of values concentrated around a mean, and with a standard deviation that can be calculated based on the empirical distribution. Fitting real data to a gaussian distribution (the gaussian curve) facilitates the assessment of moisture variability and the optimization of industrial wood treatment processes.

RESULTS AND DISCUSSIONS

To validate the process and approve the material for use in furniture manufacturing, it is necessary to take the following values into account:

- >+2% - maximum 16% (for example-10-12% = 16%)
- required value – minimum68% (for example 8-10% = 68%)
- <-2% - maximum 16% (for example-6-8% = 16%)

To validate and approve the material for use in the chair manufacturing process, measurements were taken on 1 batch of 10

chairs with the following moisture percentages:

Chair	Humidity(%)	Measurement example
1	9.6	
2	7.4	
3	8.0	
4	9.1	
5	8.4	

6	8.2	
7	8.0	
8	8.1	
9	9.5	
10	17.4	

Classification of chairs into categories according to the requirements

The requirements for validation are:

- Required value (range 8-10%): at least 68% of the chairs must fall within this range.
- High values (>10%): a maximum of 16% of the chairs.
- Low values (<8%): a maximum of 16% of the chairs

Distribution of measurements:

Chairs with moisture in the 'required' range (8-10%):

- The chairs 1, 4, 5, 6, 7, 8 şi 9.
- Total number: 7 chairs, which is 70%

Chairs with moisture >10% (moisture over +2%):

- Chair 10
- Total number: 1 chair, which is 10%.

Chairs with moisture <8% (moisture below -2%):

- Chair 2
- Total number: 1 chair, which is 10%.

Interpretation of the results

According to the requirements:

- The required value (8-10%) is met: 70% of the chairs fall within this range, exceeding the minimum requirement of 68%.
- High values (>10%): 10% of the chairs exceed the 10% threshold, which is within the maximum allowable limit of 16%.
- Low values (<8%): 10% of the chairs have moisture below 8%, which is also within the maximum limit of 16%.

The batch can be validated for the following reasons:

- 70% of the chairs fall within the required range (8-10%).
- The percentage of chairs with moisture greater than 10% is 10%, below the allowable limit of 16%.
- The percentage of chairs with moisture below 8% is 10%, which also complies with the maximum limit of 16%.

The batch can be used in the manufacturing process without implementing any isolation measures. However, it is recommended to periodically monitor the moisture of the chairs to ensure continued compliance with quality st

CONCLUSIONS

The application of the gaussian curve in determining the moisture content of wood significantly contributes to obtaining high-quality materials with uniform properties and increased strength. The statistical interpretation of moisture variability aids in standardizing industrial processes and maintaining the integrity of the wood under optimal conditions for various applications. Thus, the gaussian curve proves to be an essential analytical tool for the management of quality and durability of wood materials.

Therefore, understanding and controlling wood moisture is an essential area of research in the wood processing and furniture production industry, significantly impacting the quality and durability of chairs.

In conclusion, the control of wood moisture is essential both in processing operations and in ensuring the durability and functionality of wooden chairs. Optimal moisture contributes to efficient processing, reduces the risk of warping, and improves the long-term durability of furniture pieces. Thus, careful monitoring and management of moisture are critical steps in achieving a quality product with an extended lifespan.

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