

Review Article

Effects of wood seasoning on sustainable wood utilization

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ABSTRACT

Wood is a natural resource that has been used by humans for various purposes for thousands of years. From construction and furniture manufacturing to energy production, wood has been an essential material in human civilization. However, freshly harvested wood contains high moisture content, typically ranging from 30% to 200% depending on the species and environmental conditions. High moisture content negatively impacts the physical, mechanical, and machining properties of wood, making it less stable, weaker, and more prone to decay and deformation. To overcome these limitations, wood is subjected to a seasoning process, which involves reducing its moisture content to improve its properties and performance. Wood seasoning is a crucial step in wood processing, and it is commonly done by air drying, kiln drying, or a combination of both methods. The purpose of wood seasoning is to achieve a moisture content that is appropriate for the intended use of the wood, such as achieving an equilibrium moisture content that is suitable for the local climate and specific application. Proper seasoning techniques can significantly impact the quality, durability, and workability of wood, and therefore, have important implications for its utilization in various applications. Therefore, understanding the effects of wood seasoning on wood properties and its implications for utilization is essential for optimizing wood utilization in various applications. This paper aims to review the existing literature on the effect of wood seasoning on wood properties and its implications for utilization, focusing on the importance of proper seasoning techniques and their impact on wood performance, service life, and structural applications.

Keywords: Durability, machining properties, mechanical, physical, seasoning techniques

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INTRODUCTION

Wood is a widely used natural resource with various applications, ranging from construction and furniture manufacturing to energy production.^[1] The moisture content of wood commonly referred to as “seasoning,” plays a crucial role in its utilization. Seasoning is the process of reducing the moisture content of the wood to improve its stability, strength, and durability.^[2] The effects of seasoning on wood utilization have been extensively studied in the field of wood science and technology, and the findings provide valuable insights for the wood industry and other stakeholders. One of the primary reasons for seasoning wood is to reduce its moisture content, which affects its physical and mechanical properties.^[3,4] High moisture content in wood can result in dimensional changes, such as shrinkage and swelling, which can negatively impact its performance in various applications. Seasoning can minimize these changes

and improve the stability of wood, making it more suitable for construction, furniture, and other uses.^[5] The seasoning process also affects the strength and durability of wood. Freshly cut or green wood is relatively weak and susceptible to decay, insect infestation, and other forms of degradation due to its high moisture content. Seasoning reduces the moisture content and increases the density of wood, which can significantly improve its strength and durability.^[6] This is especially important for structural applications where the strength and stability of wood are critical, such as in building construction.^[3]

Furthermore, seasoning can influence the workability and machining properties of wood. Green wood tends to be more difficult to work with due to its high moisture content, which can cause problems such as warping, splitting, and uneven cutting. Seasoning reduces the moisture content and improves the machinability of wood, making it easier to work with and

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reducing waste during processing.^[7] Research studies have investigated various methods of seasoning, such as air drying, kiln drying, and chemical treatments, to optimize the process and achieve desired wood properties.^[1,8] For example, studies have compared the effects of different drying schedules and environmental conditions on wood properties, such as moisture content, shrinkage, and strength.^[9] Other studies have explored the use of chemical treatments, such as preservatives and anti-stain agents, during seasoning to improve wood durability and resistance to decay and insect attack.^[10]

Seasoning is a critical process that significantly affects the utilization of wood. It can improve the stability, strength, durability, and workability of wood, making it more suitable for various applications. The findings from research review provide valuable insights for the wood industry and other stakeholders in optimizing the seasoning process to achieve desired wood properties.

EFFECT OF SEASONING ON WOOD UTILIZATION

Seasoning, the process of reducing the moisture content of wood, has significant effects on wood properties, which in turn impact its utilization in various applications.^[2] Proper seasoning techniques can result in improved wood properties, such as increased stability, enhanced strength, reduced risk of decay, and better machining performance.^[11,12] These improved properties make seasoned wood more suitable for a wide range of applications, including construction, furniture manufacturing, and wood products. The seasoning of the wood, also known as drying or curing, can have several effects on the wood.^[1] These effects are primarily related to changes in the wood moisture content and associated physical, mechanical, and chemical properties. The following are some of the effects of seasoning on wood:

Reduction of Moisture Content

Seasoning aims to reduce the moisture content of the wood to a suitable level for its intended use. As the wood dries, the moisture content decreases, which can result in reduced weight, decreased shrinkage, and improved stability.^[6]

Improved Dimensional Stability

Seasoned wood is less prone to shrinkage, warping, and twisting compared to green (unseasoned) wood, as the drying process helps to relieve internal stresses and stabilize the wood's dimensions.^[13,14]

Increased Strength and Hardness

The drying process can result in increased strength and hardness of the wood, as the removal of moisture leads to increased wood density and consolidation of wood fibers.^[6,13]

Enhanced Workability

Seasoned wood is often easier to work with in woodworking and carpentry applications, as it tends to be less prone to splitting, cracking, and other forms of degradation during processing.^[14]

Reduced Susceptibility to Decay and Insect Infestation

Lower moisture content in seasoned wood makes it less susceptible to decay and insect infestation, as many wood-destroying organisms require a certain level of moisture to thrive.^[7]

Improved Finishing Properties

Seasoned wood can have improved finishing properties, as it tends to absorb finishes, stains, and paints more uniformly and with fewer issues compared to green wood.^[11,14]

Enhanced Durability

Proper seasoning can improve the durability of wood by reducing the moisture content and associated risks of decay, insect infestation, and dimensional instability, resulting in longer-lasting wood products.^[7,13]

The effects of seasoning on wood properties are significant and have important implications for wood utilization. Proper seasoning techniques can result in improved stability, enhanced strength, reduced risk of decay, and better machining performance, making seasoned wood more suitable for a wide range of applications. Understanding the effects of seasoning on wood properties is crucial for optimizing wood utilization in various applications and ensuring the quality and performance of wood products.^[15]

ECONOMIC IMPORTANCE OF WOOD SEASONING

The economic importance of wood seasoning is significant as it can result in several benefits that impact the value and utilization of wood products.^[8] Properly seasoned wood tends to have improved stability, strength, and machining properties, which can lead to higher-quality wood products.^[3,5] Higher-quality wood products often command higher prices in the market, leading to increased economic value. Wood seasoning helps to reduce the risk of wood distortion, splitting, and decay, which can lead to significant losses in wood utilization.^[16] By minimizing these issues, wood seasoning can help to reduce waste and losses in wood processing, resulting in increased economic efficiency and cost savings.^[13]

Seasoning also reduces the moisture content of wood, making it less susceptible to decay and insect attack, and thus increasing the lifespan of wood products.^[5] This can result in reduced

replacement costs and increased durability, leading to economic benefits. Properly seasoned wood with improved machining properties can lead to increase manufacturing efficiency.^[1,17] Easier machining, reduced tool wear, and better surface finish can result in faster production times, higher productivity, and reduced production costs, leading to the improved economic viability of wood processing and manufacturing operations.

Seasoned wood with improved stability, strength, and durability can be utilized in a wider range of applications, opening up new market opportunities.^[5] This can include applications such as high-quality furniture, high-end construction, and specialty wood products, which often command premium prices in the market. Diversification of product offerings and tapping into new markets can lead to increased revenue and business growth.^[1] Meeting industry standards for wood products, which often require proper seasoning, is crucial for market acceptance and customer satisfaction.^[16] Compliance with industry standards can also provide a competitive advantage and help to secure contracts or partnerships with key stakeholders, leading to increased economic opportunities.

Wood seasoning has significant economic importance as it can result in improved wood quality, reduced waste and losses, extended product lifespan, enhanced manufacturing efficiency, expanded market opportunities, and compliance with industry standards.^[5,14,17] Proper wood seasoning practices can lead to increase economic value, improve profitability, and enhance competitiveness in the wood processing and manufacturing sectors.

Methods of Wood Seasoning Practices

Wood seasoning can be achieved through various methods, each with its advantages and disadvantages. Common methods of wood seasoning include air drying, kiln drying, and combination drying.^[5]

Air drying

Air drying, also known as natural drying or open-air seasoning, involves stacking freshly cut wood in a well-ventilated area and allowing it to dry naturally over time. The wood is typically arranged in a way that promotes air circulation, such as stacking it with spacers or stickers, to facilitate moisture evaporation. Air drying is a cost-effective method that does not require specialized equipment, but it can be slow and may result in longer seasoning times compared to other methods.^[9]

Accelerated air drying and pre-drying

The limitations of air drying have led to increased use of technology that reduces drying time and introduces some control into drying from green to 20%–25% of moisture content. Accelerated air drying involves the use of fans to force air through lumber piles in a shed. This protects the lumber from the elements and improves air circulation compared to air

drying. Small amounts of heat are sometimes used to reduce relative humidity and slightly increase temperature. Pre-dryers take this acceleration and control a step further by providing control of both temperature and relative humidity and providing forced air circulation in a completely enclosed compartment. Typical conditions in a pre-dryer are 27°C–38°C (80°F–100°F) and 65%–85% relative humidity.^[9]

Kiln drying

Kiln drying is a controlled process that involves placing wood in a kiln, which is a specially designed chamber where temperature, humidity, and airflow can be carefully controlled to accelerate the drying process. Kiln drying can result in faster and more uniform drying compared to air drying, allowing for shorter seasoning times and reduced risks of wood defects. However, kiln drying requires specialized equipment and energy resources, and the high temperatures used in kilns may cause wood to lose some of its natural color and character.^[3,9]

Combination drying

Combination drying is a hybrid method that combines air drying and kiln drying. It typically involves pre-drying wood using air drying to reduce the moisture content to a certain level, followed by kiln drying to further reduce the moisture content to the desired level. Combination drying can take advantage of the benefits of both air drying and kiln drying, allowing for more efficient and controlled drying while minimizing some of the drawbacks of each method.

Local Methods of Seasoning Wood

In addition to the commonly used methods of air drying, kiln drying, and combination drying, there are also local or traditional methods of drying wood that vary depending on geographical regions and local practices. Some examples of local methods of drying wood include:

Sun drying

Sun drying is a simple and low-cost method of seasoning wood that involves placing freshly cut wood in an open area exposed to direct sunlight. The heat from the sun helps to evaporate the moisture from the wood, reducing its moisture content over time. Sun drying is commonly used in regions with hot and dry climates, where sunlight and dry air can facilitate the drying process. However, sun drying may not be as effective in regions with high humidity or during rainy seasons.

Wind drying

Wind drying, also known as wind seasoning, is a method that relies on natural wind flow to accelerate the drying process of wood. Wood is typically stacked in an open area where there is a constant breeze, allowing the wind to carry away moisture from the wood. Wind drying can be effective in regions with consistent and strong winds, but may not be suitable in areas with low wind speeds or during calm weather conditions.

Smoke drying

Smoke drying is a traditional method that involves exposing wood to smoke from a fire, which can help to dry and preserve the wood. The smoke acts as a preservative and insect repellent, while also drying the wood by driving out moisture. Smoke drying is commonly used in some indigenous and traditional communities for preserving wood for various applications, such as construction, furniture making, and tool handles.

It is important to note that local methods of drying may not always result in consistent and controlled drying, and the quality of seasoned wood may vary depending on the specific conditions and practices used. Proper monitoring of wood moisture content and careful consideration of local climate, resources, and practices are necessary to ensure effective and efficient wood seasoning using local methods.

SEASONING DEFECTS IN WOOD

The seasoning process of wood, if not carried out properly, can result in several defects or issues that may impact its quality and utilization. Some common seasoning defects in wood include:

Checking and Cracking

Checking refers to the formation of cracks on the surface of the wood while cracking refers to the development of cracks that penetrate through the wood. These defects can occur when the wood dries too quickly or non-uniformly, leading to excessive moisture loss from the outer layers, while the interior remains moist.^[3,6]

Warping

Warping refers to the deformation or distortion of wood in its shape, such as twisting, cupping, bowing, or cooking. It can occur when the wood dries unevenly or when there are differences in moisture content between different parts of the wood.^[1,14]

Staining and Discoloration

Seasoning defects can also result in staining or discoloration of the wood. Stains or discoloration may occur due to uneven drying or the growth of fungi or mold on the wood surface during the seasoning process.^[6,9]

Loss of Strength and Durability

If wood is over-dried during seasoning, it can result in reduced strength and durability. Over-drying can lead to excessive shrinkage and loss of mechanical properties, which may affect the performance and longevity of wood products.^[14]

Insect Infestation

Improper seasoning can leave wood vulnerable to insect infestation, as insects are more likely to attack the wood with high moisture content. Insects such as termites, powder post

beetles, and wood borers can cause significant damage to improperly seasoned wood.^[7]

Mold and Fungal Growth

If wood is not properly dried during seasoning, it can be susceptible to mold and fungal growth, which can affect the appearance and integrity of wood products.^[6]

It is important to follow proper seasoning techniques, including controlled drying methods, appropriate moisture content monitoring, and adequate ventilation, to minimize the occurrence of seasoning defects in wood and ensure optimal wood quality for utilization.

Wood Utilization and Recommended Moisture Content

Wood utilization, including its various applications such as construction, furniture making, and woodworking, depends significantly on the moisture content of the wood. Recommended moisture content for different wood uses is typically determined based on industry standards and guidelines, research studies, and practical experience.

In construction, wood is commonly used for structural purposes such as framing, beams, and posts. For these applications, wood with a moisture content between 15% and 19% is typically recommended, as it provides good stability and strength.^[7] Wood with moisture content above 19% is considered too wet and may lead to issues such as warping, splitting, and decay, while wood with moisture content below 15% may be too dry and prone to brittleness and shrinking.^[9]

In furniture making, the recommended moisture content of wood depends on the specific type of furniture being built. For indoor furniture, a moisture content between 6% and 8% is generally recommended to prevent excessive shrinking or swelling after construction.^[13] For outdoor furniture or furniture used in humid environments, wood with a slightly higher moisture content of around 10–12% may be recommended to account for potential moisture changes in the environment.^[18]

In woodworking, which includes activities such as carpentry, cabinetry, and woodturning, the recommended moisture content of wood can vary depending on the specific project and desired outcome. In general, wood with a moisture content of 8–10% is often used for woodworking projects, as it strikes a balance between stability and workability.^[15] However, some woodworkers may prefer slightly higher or lower moisture content depending on their techniques, tools, and project requirements.

It is important to note that recommended moisture content may vary depending on the species of wood, geographical location, and environmental conditions.

CHALLENGES AND POTENTIAL SOLUTIONS OF WOOD SEASONING

Wood seasoning can present challenges that require appropriate solutions to achieve optimal results. Here are some common challenges facing wood seasoning practices;

Non-uniform Drying

Achieving uniform drying of wood can be challenging, as different wood species, sizes, and shapes may dry at different rates, resulting in uneven moisture content and potential defects. Proper drying techniques, such as air drying, kiln drying, or a combination of both, along with monitoring and control of drying parameters, can help achieve more uniform drying.^[6]

Cracking, Splitting, and Warping

Rapid and uneven drying can result in the cracking, splitting, and warping of wood, which can reduce its quality and usability. Slow and controlled drying, along with appropriate drying techniques and monitoring, can help to reduce the risk of these defects.^[3,14]

Mold, Decay, and Insect Infestation

Wood that is not properly dried and stored can be susceptible to mold growth, decay, and insect infestation, which can degrade its quality and durability. Proper storage, such as storing dried wood in a dry and well-ventilated environment, along with quality control measures, can help to prevent these issues.^[14]

Energy and Time Requirements

Wood drying requires energy for heating, ventilation, and moisture measurement, and the time required for proper seasoning can vary depending on wood species, initial moisture content, and drying method, which can impact the overall production timeline and costs. Efficient drying techniques, proper monitoring, and control can help to optimize energy usage and reduce drying time.^[14]

Seasonal and Weather-dependent Factors

Outdoor drying methods, such as air drying, are influenced by seasonal and weather-dependent factors, such as temperature, humidity, and precipitation, which can affect the drying rate and quality of wood.^[9] Appropriate selection of drying methods, monitoring, and control can help to mitigate the impact of seasonal and weather-dependent factors.^[3,6]

Quality Control and Monitoring

Monitoring and controlling the moisture content, temperature, and other drying parameters require careful attention to ensure consistent quality and performance of the dried wood. Regular monitoring, quality control measures, and skilled personnel can help to ensure proper seasoning and quality of wood.^[14]

Equipment and Infrastructure Requirements

Proper wood seasoning may require specialized equipment and infrastructure, such as kilns, drying sheds, and moisture measuring devices, which can add to the costs and logistical challenges. Investment in appropriate equipment and infrastructure, along with proper maintenance, can help to improve drying efficiency and control.^[7] It's important to implement these solutions following established guidelines and standards for wood seasoning to achieve optimal results and minimize challenges.

CONCLUSION

Wood seasoning is a critical process that significantly affects the utilization of wood in various industries and applications. Through different seasoning techniques, such as air-drying, kiln-drying, and solar drying, wood is dried to reduce its moisture content, resulting in improved wood properties, including reduced dimensional changes, increased strength, and enhanced durability. The effects of seasoning on wood properties are well-documented in the literature, with studies demonstrating the positive impacts of properly seasoned wood in construction, furniture, and wood-based composites. However, the seasoning process is influenced by several factors, such as wood species, initial moisture content, temperature, humidity, and airflow, which need to be carefully controlled to ensure optimal results.

Despite its benefits, wood seasoning also presents challenges and limitations, such as the time required, energy consumption, and potential quality issues. Addressing these challenges and finding solutions to improve the efficiency and effectiveness of the seasoning process are important areas for further research and development.

Conclusively, understanding the seasoning effect on wood utilization is crucial for industries and applications that rely on wood as a primary material. Properly seasoned wood can result in improved performance and durability, leading to better utilization in various applications. Further research and innovation in wood seasoning techniques, process optimization, and quality control will continue to enhance the utilization of wood and contribute to sustainable and efficient wood-based industries.

RECOMMENDATIONS

Based on the importance, challenges, and effect of wood seasoning on utilization, the following recommendations are made:

Follow Appropriate Wood Seasoning Practices

Proper wood seasoning practices, including appropriate drying schedules, moisture content monitoring, and storage

conditions, are essential to achieve desired properties and performance in the final wood.

Products consider the specific wood species and its properties

Different wood species have different characteristics and properties, including their response to seasoning. Consider the specific wood species being used and its inherent properties when determining the appropriate seasoning method and duration.

Monitor and Control Moisture Content

Monitoring and controlling the moisture content of wood during seasoning is critical to achieving optimal results. Use reliable moisture measuring devices and follow established moisture content standards for different wood applications.

Consider the Intended End-use

Consider the intended end-use of the wood product when determining the optimal moisture content for seasoning. Different wood products may require different moisture content levels depending on their application, such as furniture, flooring, construction, or woodworking.

Follow Industry Standards and Guidelines

Follow established industry standards and guidelines for wood seasoning, such as those provided by the Forest Products Laboratory, the Forest Products Society, and other reputable sources. These standards provide recommended practices for wood seasoning and utilization. It is important to note that wood seasoning practices may vary depending on factors such as wood species, initial moisture content, drying method or history, and specific application requirements.

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