Wood 493

Thermally Modified Wood: From Preservative to Potential Substitute




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Abstract or Executive Summary

For decades, wood has been a victim of the wrath caused by insects and fungi degrading wood, using its natural properties for food and habitat. There are preventative measures humans can take to prolong the life of wood products.

Pressure treating wood with chemicals such as CCA and ACQ provide adequate protection against organisms that feast on wood. The process involves using harmful chemicals that may leach out of the treated wood into the surrounding environment, causing potential hazards to the health of beings.

Thermally treating wood preserves the specimen without the use of chemicals. Anti-organism performance is comparable to that of the chemically treating wood. Using high temperature and steam in specialized kilns, cell structures are modified and the food sources for fungi and insects are eradicated.

Though the changes physically to the wood prevent it from being degraded by organisms, the changes affect the mechanical properties as well. The natural colour of the wood darkens with the increase in temperature, and swelling is reduced when exposed to humid environments thus increasing dimensional stability. Thermal modified wood also increases in brittleness and decreases in overall bending strength.

Thermally modified wood can continue to be a method of preserving wood. However, with its modified properties after heat treatment, the change to consistent hues throughout the cross-section resembling exotic wood species can enter new markets such as being a substitute for non-structural exotic wood products.

Key Words: Thermal treated, Heat treated, Chemically treated, Thermal modification

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1 Introduction

Naturally found in all parts of the world, there is an abundant supply of trees available to be harvested and be manufactured into useful products for human use. For many years, people have used the natural resource to create many useful tools and items. From primary material such as logs, timber, dimension lumber, to secondary products such as cabinets, furniture, doors, windows and paper.

Wood is unique because of its natural properties. When machined, natural grain patterns are visible, due to the growth rings of trees, thus enhancing the aesthetics of furniture and strength properties which allow for wood to be both stiff and flexible thus it can be used in vast applications.

Wood products are used in a variety of environments. Generally, wood products are either interior products or exterior products. Interior products are in an environment where it is away from moisture and in an environment with stable humidity, and exterior products are outdoors and are susceptible to weathering, moisture, and variable changes in humidity.

When tree logs are processed, the resulting dimension lumber contains water in its cells and will then require to be dried in order to maintain dimensional stability. However, though wood is dried, there is still moisture in the wood and can thus satisfy conditions in which mold and fungi can exist. Aside from fungi and mold, insects also infest on wood to feed on the naturally occurring sugars in wood.

There are methods to combat these natural threats to enhance the life of wood products. Paint and chemical finishes protect the surface of wood and thus minimizes or eliminates degradation of wood caused by natural weathering, or biological threats. By treating wood products, the lives of the products are prolonged. Aside from treating wood with chemicals, there is an alternative method to preserving wood and prolonging its usage life with additional unique features.

2 Background

By nature, wood is degradable and its rate of degradation depends on its use and species (Jones et Al, 2007). There are species of wood such as cedar which have natural extractives which resist insect infestation. Over the years there have been developments to combat the phenomenon of this natural process. There are two general methods aimed at prolonging the life of wood. Chemically treating or by thermally treating (modifying) wood. The aim is to neutralize the food supply fungi and insects thrive on.

2.1 Chemical Treating

For decades, wood has been preserved by using chemicals utilizing two methods: Pressure treating and non-pressure treating. Pressure treating uses chemicals such as chromated copper arsenate (CCA). However, as of 2004, CCA has been replaced by other chemicals such as amine copper quat (ACQ). Whereas non-pressure treatment methods apply the preservatives such as stains and lacquers by brushing, spraying or dipping the pieces. Pressure treating allows the preserving chemical to penetrate the wood specimen rather than simply coating the surface with the preservative (Canadian Wood Council, 2008).

2.1.1 Pressure Treating

Pressure treating wood with preservatives requires pressure and a vacuum to force the chemical solution into the wood, past its surface. Small incisions can be made on the surfaces of wood to increase the penetration of the preservative solution. Seasoned lumber is stacked, spaced and loaded into a sealed vacuum chamber. The preservative solution is applied and fills the chamber fully submerging the stack of lumber. When the chamber is filled, pressure is applied according to the various schedules required for different species and load sizes. When the pressure stage is complete, the chamber is drained and the wood is removed from the chamber (Canadian Wood Council, 2008). The following figures depict the process of pressure treating wood.

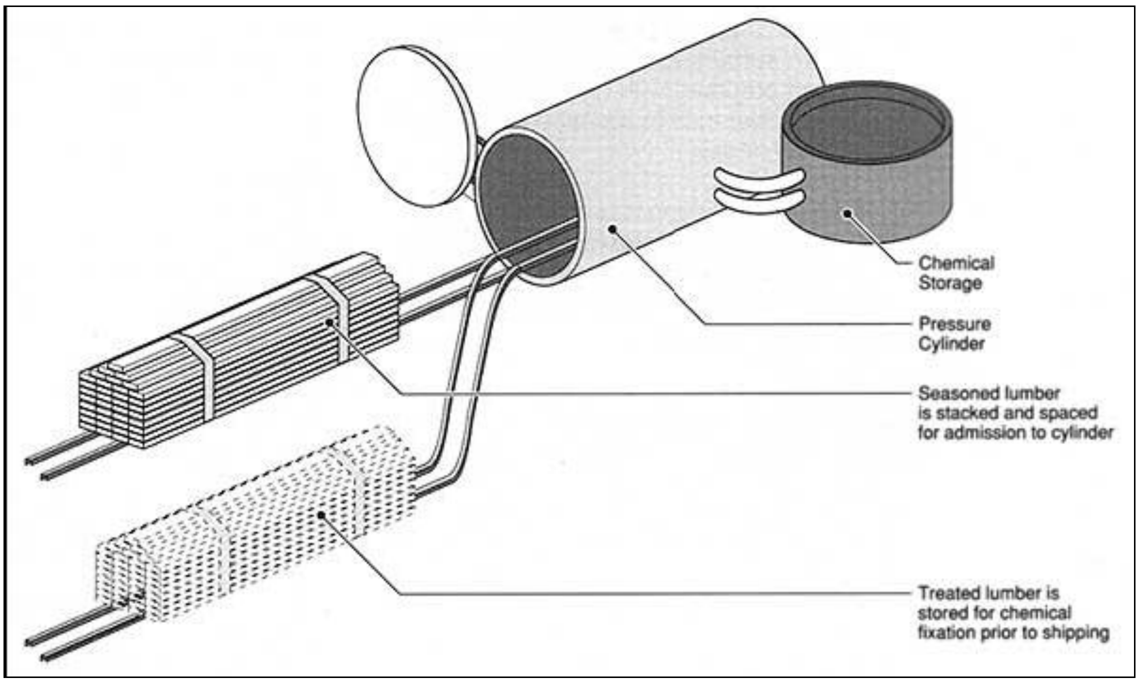

Figure 1 Pressure Treating Setup (Canadian Wood Council)

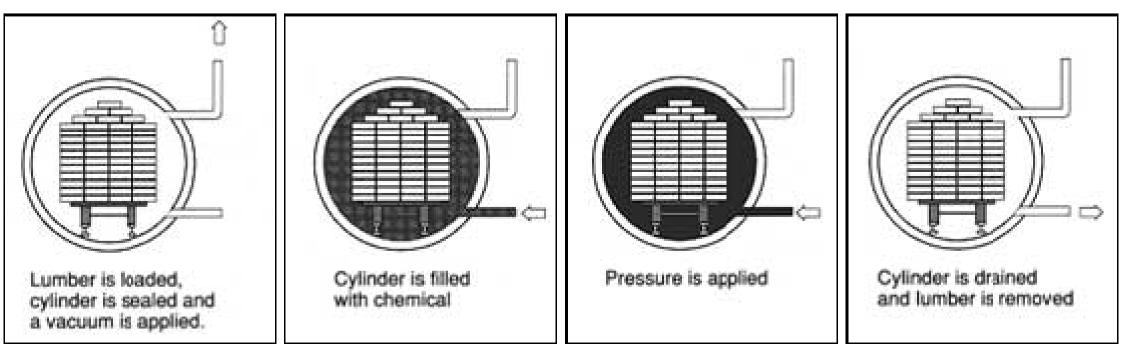

Figure 2 Pressure Treating Stages (Canadian Wood Council)

2.1.2 CCA

Chromated copper arsenate is a chemical preservative used to treat wood to protect it against damage from the elements and from insect attacks. CCA was heavily used from the 1940s through to the 1970s. However, since then wood pressure treated with CCA is no longer being used in residential applications (USEPA, 2008).

To treat wood with CCA, small incisions are made in the surface of to increase the penetration of the solution of chromium, copper, and arsenic. The copper acts as the fungicide, the arsenic acts as the insecticide and the chromium binds the treatment solution to the wood. The wood is loaded in a sealed pressurized chamber forcing the CCA solution into the wood. The chemicals leave the wood with a green colour as shown below (Health Canada, 2009).

Figure 3 CCA Treated Wood (ccaresearch.org)

Though CCA treated wood does protect it from insect attacks, and natural weathering from the sun and rain, CCA treated products must be used correctly. The wood can not be used in applications where it is in direct contact with drinking water, or burned. Handlers and users must wear dust masks to avoid inhalation of contaminated saw dust (Health Canada, 2009).

There is a low risk of the chemicals leaching out of CCA treated wood thus causing illnesses. People can be exposed to the harmful chemicals found in CCA such as arsenic through residues found on the wood surfaces, or from accidentally ingesting soil or ground material that have been contaminated by leached chemicals. Exposure may lead to long-term health effects. Children are especially at risk because outdoor play structures, decks, tables and fences are made from CCA treated materials (Winnipeg Health Authority, 2003).

2.1.3 ACQ

As of 2003, CCA usage has been replaced by ACQ. Industry observers estimate approximately 80% of the market has now switched over to utilize ACQ (amine copper quat) treated wood. (Morris et al, 2006). The change was due to growing health and environmental concerns of the preservatives containing arsenic which is found in CCA. Other copper based preservatives such as ACQ were developed. Performing similarly to CCA, wood preserved with ACQ protects against weathering, fungi, and insects because copper is still existent, but rather than arsenic, ammonia (quat) is used to resist against insects. Because ACQ is the replacement product for CCA, the same structures such as outdoor play areas, fences and decks are made without the concern of arsenic leaching out creating health hazards.

However, ACQ treated woods accelerate the corrosion of fasteners quicker than untreated or CCA treated wood. Hot dipped, galvanized, or stainless steel fasteners must be used (Graham, 2009).

2.2 Thermally Treating

Wood has been preserved by being thermally modified for the last few decades mainly in the European market. Similar to chemically treating wood, the food sources for insects is neutralized as a result of thermally treating wood. The process of thermally preserving wood actually modifies the structure of the wood. There are four physical aspects of wood that are affected when thermally modified: Colour, dimensional stability, fungal resistance, and its mechanical properties.

Researchers have conducted experiments to determine the physical and mechanical properties of modified wood products. These physical properties are altered by the changes of cellulose, lignin, and hemi-cellulose within wood. The mechanical properties are affected by the changes of cellulose and lignin, and the physical properties such as the hygroscopic functions affected by the changes of the hemi-cellulose (Forintek, 2003).

2.2.1 Colour

When wood is succumbed to the thermal modification process, the natural colour of the wood species is altered and becomes a darker shade of brown. Different shades can be achieved depending on the temperature of the process. The higher the temperature that is exposed to the material, the darker the hue will be. The change of the colour occurs throughout the entire cross section of the specimen. The heating process can be controlled in order to obtain the desired darkness. This feature of wood that is modified has its advantages. The thermal modification process can be used to make a light shaded low value species of wood resemble a darker, more attractive high-valued exotic wood product available at a more affordable price (Thermo-Drewno, 2009). This can be seen in Figure 4 below.

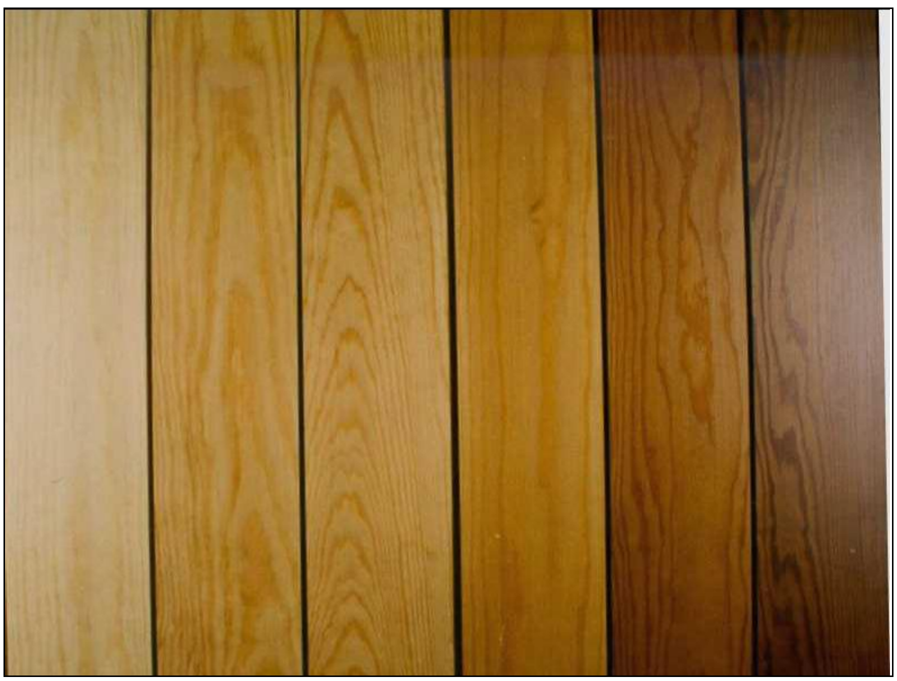

Figure 4 Hues of Heat Treated Pine from 120°C to 220°C at 20°C intervals (Thermowood)

2.2.2 Dimensional Stability

The physical properties are altered when wood is modified. The process degrades the hemi-cellulose within the pieces thereby changing the hygroscopic behavior of the wood.

The changes allow for any new moisture that is penetrated into the thermally treated wood to quickly evaporate due to a reduction in the absorption rate. Minimizing the water that is taken in by the wood, this enhances the dimensional stability because there is no swelling and shrinking due to the absence of water (Forintek, 2003).

Tests were conducted by VTT of Finland to determine the effects of thermally modifying wood in terms of swelling both radially and tangentially. Compared to a control of untreated wood, it was found that thermally treated wood was much more stable as shown in the following figures.

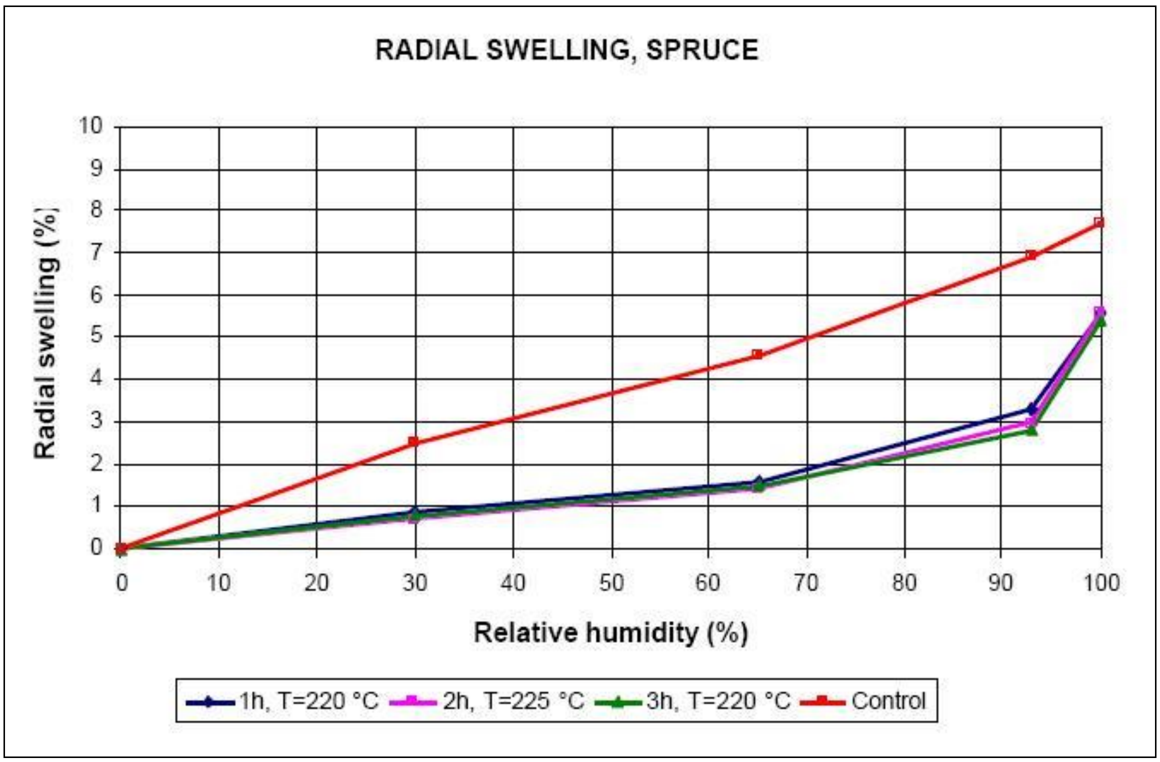

Figure 5 Radial Swelling of Thermally Treated Spruce (Thermowood)

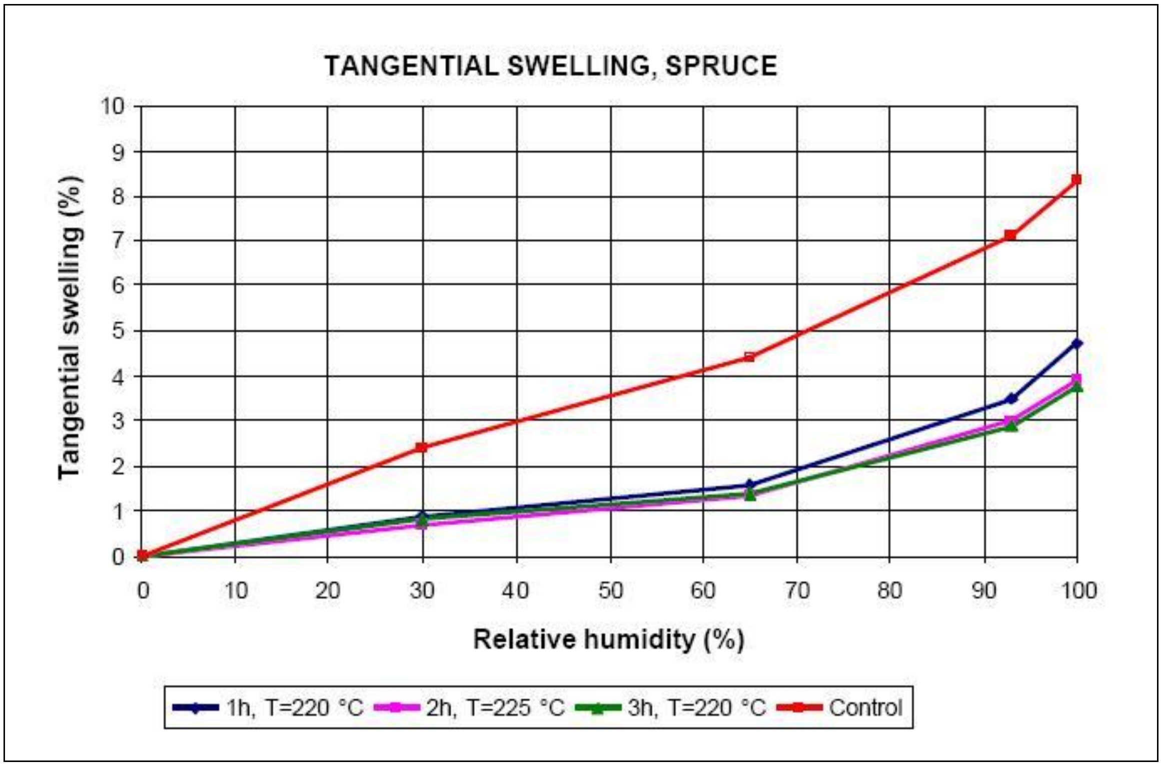

Figure 6 Tangential Swelling of Thermally Treated Spruce (Thermowood)

It was also found that with increased temperatures used to treat the wood there was also enhanced in dimensional stability. The percentage of thickness swelling decreases with an increase in treatment temperature.

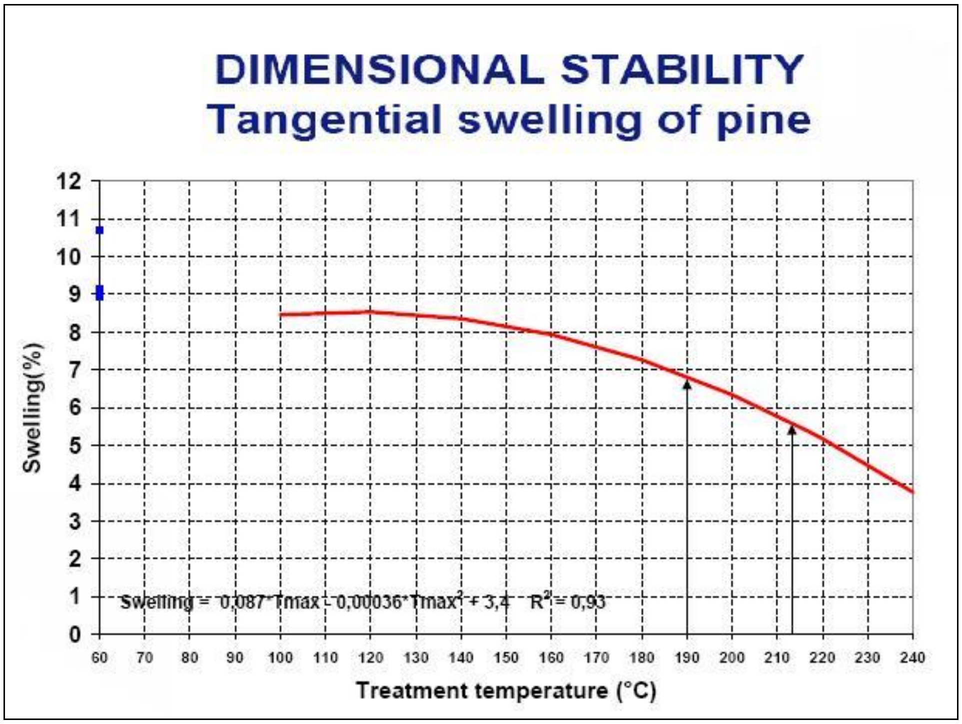

Figure 7 Tangential Swelling to Treatment Temperature (VTT)

2.2.3 Fungal Resistance

Wood is a major food source for certain types of fungi and insects. These organisms are what contribute to wood decay. They can not inhabit and use wood as nourishment if oxygen, water, and temperature needs are not satisfied. The major component of wood cells is lignocellulose. The cellulose encased in lignin is what provides wood its strength. Certain types of fungi and insects feed on it, which leads to wood decay (Morris).

There are certain conditions that need to be met in order to have degrading fungi to grow on wood. The ideal moisture content of wood needs to be approximately 20% if the moisture content of wood is either too high or too low the degrading fungi will not grow with those conditions. From the thermal modification process, the hygroscopic properties are modified and there is virtually no moisture in the wood, thus increasing the fungal resistance of the thermally treated wood (Forintek, 2003).

Modified wood at high temperatures achieve fungal resistance because not only does the moisture content become drastically reduced, thus removing a habitable condition, hemicellulose breaks down and is accompanied by the formation of dehydration products. Products of the decomposition of these compounds contribute to fungal resistance (Mazela et al, 2004).

2.2.4 Mechanical Properties

The thermal modification process changes the physical structure of the wood. The cellulose is affected and thus the mechanical properties are changed. The result is that the wood is more brittle when compared to wood that is not modified thermally. Though the brittleness is increased, it does not deter modified wood from being machined to produce non-structural products (Forintek, 2003).

Compared to untreated wood, thermally treated wood have varying strength values when compared. The mean bending strength and tension strength of boards with no defect is lower while the mean bending modulus of elasticity is higher. Bending modulus of elasticity is comparable to untreated boards (Widmann, 2007).

Test	**Results Compared to Untreated Wood**
Mean Bending Strength	30-40% Lower
Mean Bending MOE	8-10% Higher
Mean Tension Strength	45-50% Lower
Mean Tension MOE	Same Level

Table 1 Mechanical Properties Compared to Untreated Wood (Data from Widmann, 2007)

2.2.5 How Thermally Modified Wood is made

There are four major European thermal wood modification processes. Each regional manufacturer has a specific type of technology and name.

- *Thermowood – Finnish*
- *Platowood – Dutch*
- *Retification – French*
- *Oil Heat Treatment – German*

These different wood modification methods all have similar processes. They all subject the material to temperatures close or above 200°C in a controlled environment with low oxygen. Without adding chemicals, by only using heat and pressure, the modification reduces mechanical properties while increasing stability and durability (Voss, 2001). Heat treatment where wet wood is heated to 230°C provides an atmosphere that is steam saturated environment which thereby protects the wood (Jones, 2007).

2.2.5.1 Equipment

In the process of thermally modifying wood to preserve and protect it from fungi and insect attacks, high amounts of water, temperature, and steam are used. The equipment must be made from stainless steel to prevent corrosion from natural corrosive acids and chemicals that are removed from wood during the drying process much like a conventional kiln (Jartek). With the need for temperatures above 200°C, wood modification systems require safety devices, and blowers that are non standard (Finnish).

2.2.5.2 Phases

Thermally modifying wood is a multiple step process to improve natural wood for improved stability, change in colour, and reduced biodegradation. By minimizing the amount of moisture the wood, these properties of wood can be achieved. To remove moisture from wood, the specimens are subjected to a typical 5 step process.

1) Pre-drying Stage – The wood is dried in a conventional wood kiln to attain a moisture content of 14-18%.
2) Hydro-thermolysis Stage – The specimen is heated to 150°C to 180°C in an aqueous environment at super-atmospheric pressure
3) Drying Stage – A conventional wood kiln using common procedures to a moisture content of 8-9%
4) Curing Stage – Once again heated to 150°C to 190°C in dry atmospheric conditions

5) Conditioning Stage – Conditioned in the same conventional kiln as in the drying stage, the moisture content of the is elevated to a level necessary for manufacturing

Depending on the time duration and the temperature of the various stages, different shades of modified wood can be achieved (Boonstra et. Al, 2007)

3 Benefits

3.1 Environmental

By using only dry kilns in various environments and process controls, wood can be modified using only water and heat and no chemicals. Since chemicals are not involved in the modification process, the potential of having harmful chemicals leach into the environment from thermally preserved wood is eliminated (Finnish, 2003). Thermally modified wood can be an environmentally friendly alternative to products which are treated with chemicals such as CCA in all non-structural and above ground applications (Forintek, 2003). Commonly, most outdoor applications are treated with chemicals to prolong the service life of wood products. Modified wood is a chemical free substitute.

3.2 Stability

Due to the modification process changes to the hemi-cellulose which affects the physical properties of the wood, thermally modified woods become more dimensionally stable. Thermally modified wood maintains its physical form. Cupping is not an issue unlike CCA treated and untreated wood that is coated with stain or paint, which are both affected by cupping (Finnish). Therefore it is advantageous to be used in a stable product in areas where it is exposed to moisture such as windows and door frames reducing problems such as window sashes or doors sticking to the frame because the material expands and contracts. Using modified wood in situations similar to that would greatly reduce the problems of dimensional instability (Christmas et al., 2007).

3.3 Value

The process of heat treating wood is an environmentally friendly way to alter the aesthetics of natural wood. An undesired, low valued wood such as blue stain wood can be thermally treated to fully conceal the unwanted blue stain (Brooks). Also, the appearance of a low value wood can be modified to resemble that of a high valued exotic species of wood. One could have an item made from domestic wood species and have the look of an exotic wood species in their products. In addition, many different hues can be obtained which may provide options for the usage of woods which are considered un-aesthetically pleasing, thereby creating potential uses for those wood species (Mec, 2005).

Another aspect of value that thermally treated wood has is its process and composition. The image of heat modified products is one that promotes environmentally friendly products since no chemicals are involved in its process.

3.4 Insects and Fungi Resistance

Compared to normal wood, modified wood is resistant to insects such as the long horn beetle. The modification process breaks down the sugars and leaves the wood unappealing to the pests searching for nourishment therefore resisting insect attacks (Finnish, 2003). Because the modifying process greatly reduces the amount of water the wood, it does not provide a hospitable environment in which fungi grow. The heat treating process does not use chemicals which can leach into the surrounding environment. Without using chemicals to protect wood and to deter insects and fungi, modified wood can be used to resist insects and fungi naturally if a species without natural extractives is to be used (Forintek, 2003).

3.5 Mimicking Exotic Species

Having an array of hues available to be produced during the thermal treating stages, domestic species can be modified to have the colour of their entire cross section resemble that of an exotic species. Thermally modified wood is a good substitute for tropical hardwoods, by being a competitor to the exotic woods that are dark in colour since the colours can be matched to resemble the higher valued products. By utilizing thermally modified wood, the end product can be assured that the stock is from a domestic species and not from an exotic species that may or may not come from unsustainable forests (Widmann et al., 2007)

4 Weaknesses

4.1 Environment

The drying process only uses water and heat to change the properties of the wood. However, the process can release any extractives from the wood into the atmosphere if it is not properly handled. If not dealt with, the extractives can emit undesired odors to the surrounding areas. However, it can be burned to avoid exposing the odors from the extractives that are being expelled (Finnish, 2003).

4.2 Stability

The mechanical properties of heat treated wood are reduced and are lower than that of natural untreated wood, specifically with stiffness and strength properties. To avoid exposing the weaker properties caused by the modifying process, higher grade lumber can be treated or by adjusting the product design minimums to compensate for the weaker modified members (Christmas et al., 2007).

4.3 Value

Though it may have increased value due to its appearance being similar to more expensive and rare wood species, there are some drawbacks to having domestic woods thermally treated. Some strength properties are compromised when undergoing the heat treatment (Christmas et al., 2007). Aesthetically increasing in value, modified wood may lose some of its perceived value due to its inability to be used in structural practices.

4.4 Insects and Fungal Resistance

Like all materials exposed to the harsh conditions of the environment, it is inevitable that mould growth will be present. Bacteria in the air or dirt carried in the rain can eventually collect and build up on the surfaces. There, fungi can grow on the surfaces. However, the fungi do not penetrate down past the surface and can therefore be removed by wiping or scraping the fungi from the surface of the heat treated wood (Finnish, 2003).

4.5 Mimicking Exotic Species

With all the technologies in the world, including thermal modifying wood, that alters the appearance of a wood species to make it look more like a higher valued species, there simply is no substitute for the real product. Thermally modifying wood may be a more environmentally friendly way to obtain wood products that seems aesthetically valuable because raw materials for modified wood does not need to be transported from afar and can be from a certified forest. However, by having heat treated wood products, the end user would not have the true value of a genuine tropical wood species. At the end of the day, modified wood may resemble an exotic wood, but it is not an exotic wood.

5 Applications

5.1 Suitable

Wood that has been thermally modified has improved physical properties. They are more dimensionally stable, resistant to decay, and consistent with colour. There are many possible applications for this enhanced product. Door frames and windows which are exposed to moisture can benefit from the changes in properties. Dimensional stability minimizes or eliminates doors and sashes sticking to the frames (Christmas et al., 2007).

Modified wood can be used in interior and exterior applications. Because of its resistivity to fungi and insects, thermal treated wood can be used in places with high humidity or with high exposures to wet environments. Some internal applications consist of: Flooring, Sauna fittings, Wall and ceiling panels, and internal doors. Modified wood can also be found as some external applications such as: Cladding, siding, fascia boards, garden structures, and decking (Stora Enso, 2004).

5.2 Unsuitable

Although modified wood can be used in exterior applications and in environments with high moisture exposure, modified wood should not be used in applications in which it is embedded into the ground. "Moisture uptake of the cell walls is reduced due to the thermal treating process, but cell cavities can take up fluid water, similar to untreated wood" (Scheiding et al., 2007).

The strength properties of wood are decreased from the modifications of the structure of cellulose within the wood due to the heat treating. Because there is an increase in brittleness of the treated wood, using it as structural members in various applications is ill-advised until further testing can be carried out and the heat treated material can be approved (Forintek, 2003). The heating process yields an outcome that is a compromise between the durability of the wood and the mechanical properties. The higher the temperature used to modify the wood, the better the durability. However, mechanical properties such as the modulus of rupture are decreased which can be up to 40%, therefore causing the resulting wood to become more brittle (Vernois).

6 Future of Modified Wood

6.1 Limits

Modified wood is limited to its weakest physical aspect, its production, and its existence to the common consumer. The increase in brittleness caused by the degradation of the cellulose and lignin in the wood from the heat treating process, this restricts the use of thermally modified wood to strictly non-structural applications. The amount of modified wood manufactured is still relatively small compared to that of traditional preservation techniques such as painting or chemically preserving natural wood (Saunders, 2007). Its success is limited to its general exposure and knowledge of the common consumer.

6.2 Potential

Thermally modified wood has great potential to become a widespread highly used product. Because of its process which does not involve any chemicals to treat it so it becomes resistant to fungi and insects. During the last decade, attention has been paid to wood modification by the common consumer, and they perceived wood with chemicals as being harmful. If there is a shift in the market that moves the traditional practices of wood preservation which involve chemicals towards thermal modification of wood which only requires heat and steam, it would be a great increase for the demand of the thermally treated products (Saunders, 2007).

Since there are many hues that can be produced with a consistent colour throughout the entire thickness of a board, modified wood can become a major substitute product for tropical wood species. With the correct marketing and exposure, low value products that closely resemble high value products such as modified woods can become popular to consumers.

6.3 Future markets

Upon further research to fully determine the true performance of modified wood, decisions can then be made to see what changes can be done to adapt it to certain markets. If future research proves that thermal treated wood can in fact be used as a structural material, then there can be a possibility to enter the market as a product which is resistant to rot and fungi and will not shift due to its dimensional stability.

Another potential market thermal wood can enter is the interior décor market. With the procedure of thermally modifying the wood changing its colours to resemble those of valuable species, many wood products can be made out of modified wood such as wall panels, and furniture. Thermal treated wood could also continue to push its current exterior products such as siding, cladding and fascia.

7 Case Study

To gain the perspective from a manufacturer standpoint, a case study was performed. An interview was conducted with a local woodworking company that has worked with thermally modified wood to gain insight on how the product performs. The interview was conducted with Phil Walton, the owner of Walton's Woodworking. The company had a project in downtown Vancouver for a retail store- *Aritzia*.

7.1 Company Background

Walton's Woodworking is a woodworking manufacturer that is a member of the AWMA-BC and is based out of Surrey, British Columbia. They have been in operation since 1986 specializing in custom projects. The company services residential, commercial, and corporate clients, focusing on high end projects such as offices desks, entryways, kitchens and other wood projects such as furniture and entertainment units made out of various types of woods.

7.2 What they did with Modified Wood

The project for the retail store was to manufacture and install new wall panels, shelves, and doors for the store. A compact disc rack was also built into a wall panel. The thermally modified woods were machined, glued, finished with a clear coat. The aim was to use the thermally modified maple to achieve a high end look similar to that of an exotic species.

7.3 Performed to their needs

The company was “able to work with it no problem”. For the purpose of interior decorative panels, the modified wood performed to the requirements necessary to machine and install the project components. Due to the intense heat, the company “anticipated more waste due to the end checking and cracks” and ordered extra material to compensate for the ends that were to be cut away. However, the cost of purchasing modified wood was significantly cheaper than purchasing the darker exotic woods. The difference was significant enough to purchase more modified wood and still have it be more worth while than to purchase and use exotic woods.

7.4 Machining and Workability

It was found that modified wood machined as untreated wood would with the exception of “some portions of the wood would be noticeably brittle”. The machining process of manufacturing went as normal. The gluing process was found to be slightly problematic for Walton’s Woodworking. They found that “certain glues don’t work”, but after some in house testing, they realized that a certain undisclosed type of waterproof glue maintains a tight bond between the boards. Sanding and finishing of the modified wood products were simple and not problematic.

7.5 Pros

The modified hardwoods used in the project would be considered for use in the future. The uniformity, uniqueness and colour consistency throughout the cross-section of the wood makes it easy to work with. It is also an inexpensive alternative to exotic woods, while achieving the look, and not having to deal with “dust and extractives from exotics like ipé”. The product can also be promoted as being environmentally friendly which customers find attractive.

7.6 Cons

Walton’s Woodworking had to deal with some post installation issues. Some components of the compact disc rack needed to be replaced because of the rough and high usage of the rack. The ends where compact discs would come in contact with the rack would break off portions of the modified wood. The size of the component could not handle the impact because wood was just too brittle. “Places where accidental contact was made would just break the wood because it was brittle”. After replacing the problematic components twice, they resulted in replacing them with solid non-thermally modified wood.

8 Discussion

The purpose of utilizing wood preservative methods is to extend the service life of wood products. By deterring infestation and thus degradation by fungi and insects, this can be achieved. In recent history, CCA was used to preserve wood. The components contain chromium copper and arsenic. The chromium is the bonding agents for the copper and the arsenic to wood. The copper and arsenic are the fungal and insect deterrents. There have been concerns of arsenic leaching out of the wood therefore the need of a substitute product such as ACQ.

Similar to CCA, ACQ provides excellent preservation of wood without arsenic. Essentially most items that have been previously treated with CCA have been switched over to ACQ. Telephone poles, exterior products such as benches and fences are still widely made from chemically treated products which have the possibility of leaching out into the environment.

An alternative to chemically treated wood was to use thermally treated wood. Because the thermal modification process does not use any chemicals to preserve the wood, it has no chance of having chemicals leach out into the environment. The initial intent was to use an environmentally friendly wood preserved product in place of one that is chemically preserved. Both thermal and chemical treated wood products are resistant to fungi and insect infestations therefore making thermal treated wood a suitable substitute in that respect.

Though thermally modified wood can be used to replace chemically treated wood in certain applications, its mechanical properties have been changed due to the modification process. Since it is more brittle and can not be used in structural or load bearing applications, thermal treated wood has to find different markets to be used in. Exterior applications such as playground sets for children, picnic benches, or chairs can not use thermally modified wood, but non structural items such as fencing, cladding, and flower boxes can still be made out of thermally modified wood.

As a side effect of thermally treating wood as a method to preserve it, there are noticeable colour changes. With higher temperatures, the treated wood becomes darker, resembling certain higher valued woods such as mahogany or walnut. By having the ability to turn a low value wood such as pine or maple into a product that resembles a higher value product, there is a great opportunity for thermally modified wood to be used in interior and exterior applications based on aesthetics rather focusing on the preservative properties of the heat treatment.

Non-structural décor such as wall panels, flooring, and shelving units can be manufactured out of domestic wood species with the look of exotic species without the use of chemicals. The costs for such projects using modified wood would be lower than using exotic woods. Taking advantage of the effects caused from preserving the wood by heat treating and using it for a different purpose opens market segments.

From the interview with Walton's Woodworking, many of the reported properties were experienced by the wood products manufacturer. The dimensional stability of the thermally modified wood allowed for expansion gaps to be eliminated when making panels and the colour was uniform throughout the material itself and among boards. The brittleness caused by the degradation of the cells during the heat treating process posed to be problematic with the end product just as the research had suggested.

9 Summary

Wood needs to be preserved to extend the service life of the wood products. Chemicals such as CCA and ACQ are used to prevent wood from being degraded by fungi and insects. CCA was used but due to its arsenic content that could leach out of the preserved wood, ACQ was used instead.

Thermally treating wood is an alternative to chemically treating wood is an environmentally way to preserve wood. No chemicals are used to prevent fungi and insect infestation. Due to the exposure to high heat when preserving the wood, its cell structure changes and the sugars are essentially burned off, and there is very low moisture content. Without food and a hospitable environment, the conditions for insect and fungi infestation are not met therefore the method is suitable for wood preservation.

The high heat used to treat the wood changes the colour of the wood. This change in colour is similar to that of exotic species. Different in treatment temperature creates different shades of darkened wood. Colour is not the only change that occurs. Mechanical properties are also altered. Dimensional stability and durability are increased, but so is brittleness. Thus, thermally modified wood can be only used in non-structural applications for interior or exterior use.

10 Conclusion

Initially used as a preservative, thermally modified wood is a chemical free product that thwarts the infestation of decaying organisms. Comparable to chemically pressure treated wood, thermally modified wood resists the fungi and insects as effectively as CCA and ACQ treated wood.

However, due to the unique side effects of thermal modification, the future usage of the product has the potential to target the interior wood products market and move away from being solely recognized as a preserved wood product.

The process makes colour of the treated wood darker throughout the entire cross-section of the wood. These colours resemble higher value exotic woods. Since thermal treated wood becomes more brittle, but more dimensionally stable, wood that has been thermally modified can be substitutes for exotic woods.

Thermally modified wood has the potential to be a main stream popular choice as a cost effective way to achieve a high end exotic wood look for non-structural products while using domestic sustainable species without using chemicals to achieve it.

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