WHITE PAPER

PROFITABLE BUSINESS OPPORTUNITIES WITH WOOD MODIFICATION

JARTEK

The aim of timber modification is to increase wood usage and help it compete with other building materials such as concrete, bricks, metals or plastics. Modification improves one or more wood qualities: hardness, durability, wear and fire resistance, resistance to decay, reduced swelling and shrinking, better heat insulation or biological resistance.

Modification is required especially for wood to be used in outdoor environments, because natural wood is prone to moisture deformations and vulnerable to insects, rot and mold, making it unsuitable for a number of end-use applications.

At Jartek, we deliver wood processing equipment, line solutions, software, consulting and services for customers' needs from individual parts to complete turnkey mills. We have accumulated know-how by developing wood processing technology already since the late 20th century, and have delivered near 100 thermal modification kilns.

This technical overview explains the different wood modification methods and technologies that are commercially available to increase the profitability of wood. We shortly go through the benefits and suitability of these methods to produce wood for different applications and use cases. The main focus of this overview is ThermoWood®, the optimal solution for increasing wood profitability through wood thermal modification.

What to consider when selecting the best modification method for your business?

More and more interest is shown to reduce the environmental impact of wood modification. The challenges in developing modification technologies arise from the vast amount of wood species available, the differences between their characteristics, versatility of their end-use applications and environments, and the differing legislation in the end-markets.(1)

Because any modification always increases wood price, the end-customer should consider the benefits and costs of a modification method throughout the whole lifetime of the material. This means considering the costs incurred during the wood material's uselife, but also costs related to its eventual disposal. Health and ecological aspects should also be considered.(1)

As a producer, you must consider the costs incurred throughout the whole production chain: raw material costs, process equipment purchase and maintenance prices, energy prices, transportation costs and the environmental regulations that apply to the end-product you produce.(1)

It is important to understand that no wood modification method can be used to improve raw material quality - natural wood must be of high quality to ensure a profitable end-product after modification. By using qualified and graded wood you can ensure it reacts to the modification in the intended way, and you achieve the desired characteristics in the process.

Understanding different wood modification methods and technologies

A number of different wood modification methods have been developed in search for a solution that is both economical and ecological, while producing the best possible end-product quality. Different modification methods influence wood characteristics in different ways, so not all methods are suitable for all end-use applications.

There are three main methods for wood modification: thermal modification, furfurylation and acetylation, all of which modify the wood characteristics by using heat. Another method for modifying wood characteristics is traditional preservation.

Next, we go through these modification methods in more detail.

Thermal modification of wood

Wood thermal modification is a relatively low-cost method and requires no chemicals or harmful substances. Its energy costs are only slightly higher than for traditional kiln drying. The method's benefits are environmental friendliness and the possibility to produce near unlimited colour options for versatile end uses. Thermally modified wood is also used to substitute tropical wood species. In general, it has become more popular in the recent years.(1)

Thermally modified wood is suitable for use in e.g. decking, garden furniture and building exterior cladding, where moisture, rain, warmth, frost and sunlight are the main sources of strain. In flooring, the appearance and hardness along with wear resistance, bending strength and rigidity are desirable characteristics. It is suitable for terrace planks that must endure bending stress and mechanical wear in addition to weather conditions. It is also suitable for piers.(1)

Darker, thermally modified wood is a suitable material for façades.

Thermally modified aspen, pine, or spruce are well suited for decorative use in interiors, including saunas, because they are resin-free and water-resistant. The thermally modified surface is easier to clean and more hygienic, because it contains less nutrients for bacteria to grow on. When used in moist conditions, the ends of the bench wood should be treated with oil wax or lacquer to prevent moisture from absorbing into the wood.(1)

The benefits of thermally modified wood are good dimensional stability, dark colour, water resistance and reduced thermal conductivity. Thermally modified wood has lesser moisture deformations than natural wood, resulting also in less cracking.(1) To be able to reach stability in its destined use, thermally modified wood's moisture content should be matched with its end-use environment conditions.

Thermal modification can be done in open, closed or vacuum systems, the differences of which we will go through in the following chapters.

Showcasing the colour of thermally modified wood.

Wood thermal treatment in an open system

An open system uses a high-temperature modification method where the wood is heated and dried inside a kiln. Process temperatures range from 185-225°C - the higher the temperature, the darker the wood becomes. Depending on the wood species, the process takes from one to a few days. During the process, the hemicellulosas crystallise, improving the biological durability of the wood.

The modification is done near atmospheric pressure, and steam is used to prevent outside air from entering the system. Inside the kiln, fans transfer heat from the heat source to evenly surround the wood batch.

Finally, the wood's moisture content is matched with its end-use environment conditions, to maximise the wood's stability in use. The wood is ready for profiling immediately after modification.

The modification equipment can be provided with a boiler system heated with gas, oil or electricity, or it can utilise the by-products of your production, e.g. bark, sanding dust, wood chips (green or dry) or sawdust. Any natural substances that are released from wood during modification, are incinerated in the heater that provides heat for the process.

A number of manufacturers offer an open thermal modification system with different production phases, processes and cost structures.

Some open systems result in better dimensional stability, but certified ThermoWood® has been proven to provide the best mechanical quality. Read more about ThermoWood® in the final chapter of this document.

Thermally modifying wood in a closed system

A closed thermal modification system operates at temperatures of 160–180 °C and pressures of typically a few to several bar, using pressure-resistant cylinders to dry and heat the planks. The modification process is shorter in duration than that of an open system. In the closed system, the wood becomes darker than in an open system in the same processing temperatures.

A closed system requires minimal installation work at the site, it is delivered as a whole. Because the process requires pressure vessels, the batch size is limited by the autoclave volume. This means that smaller amounts of wood can be processed per batch, compared to the large kilns in open systems. As a result, scaling up production capacity may be more challenging or costly.

In closed systems, process parameters such as heat distribution, moisture behaviour and pressure cannot usually be controlled with the same precision as in open kilns. Air or steam circulation between and around the wood layers is more limited, meaning that conditions inside the batch may vary. This can result in uneven modification outcomes, requiring extra care during final conditioning.

For closed systems, no quality classes or specific processing temperatures are set to ensure consistency in end-products - each manufacturer has their own processes and settings.

Thermally modifying wood in a vacuum system

A vacuum system operates between 190–230 °C under reduced pressure, using pressure-resistant cylinders. The vacuum system dries the planks, but not as thoroughly as the open system. The end-product colors are also lighter than those produced inside open and closed systems.

The vacuum system improves the mechanical properties of the wood as well as the closed system. The biological durability of the wood is somewhat improved during the vacuum modification, but the results are not as good as in the open system.

Also the dimensional stability is poorer for vacuum modified wood than for that modified in open systems.

Acetylation and furfurylation – modification of wood with chemicals

Examples of chemical modification are acetylation and furfurylation. Both acetylation and furfurylation are environmentally friendly solutions, but acetylation provides a better biological protection against insects, rot and mold.(1) However, neither technology can yet be bought for your mill's own use.

Acetylation means that the wood is modified with acetic anhydride in 100-120 degrees. The acetic acid binds to the wood resulting in very durable wood that doesn't absorb water, grow molds or decomposers, and prevents it from being eaten by insects. This process does not darken the wood like thermal modification.

Of all chemical modification methods, furfurylation is the lowest in capital expenditure, and is most advanced in its commercialization(1). Furfurylation means saturating the boards with furfuryl alcohol, which is attached to the wood structure with the help of heat and a catalyst. This results in a hard and durable wood that doesn't absorb water, grow molds or decomposers, and that insects cannot eat. This process also darkens the wood surface.

Acetylation and furfurylation both improve dimensional stability of wood and reduce cracks on the surface, forming a better surface for painting. This makes them good modification methods for building exterior cladding, flooring, windows and doors. They also work well for terraces, bridge and pier structures, because they prevent rot and provide resistance to shipworm.(1)

Preserving wood with chemicals, oil or water glass

The traditional preservation process provides good biological protection against rot and insects. It uses pressure-impregnation, copper and oil products or sodium silicate to improve decay resistance. Impregnation classes (A, AB) determine which wood product can be used for which purpose (2).

Oil impregnation, where pine oil is combined with copper or water glass, is a good solution for preserving e.g. columns and sleepers. The minus side of combining different impregnants is that the investment and modification labor costs become higher than the cost advantage from lengthening the use life of the wood.(1)

Different species of wood that have been thermally modified.

Water glass impregnated wood is an environmentally friendly method and the wood is used in building exterior cladding, windows and doors where better fire resistance is required. It is also suitable for bridges and piers, terraces and flooring, where hardness, wear resistance and dimensional stability are required. In these applications, additional thermal modification is also required to improve the characteristics, but this also increases costs.(1)

Pressure-impregnated wood is commonly used in terraces, where its lifetime is 3-5 times longer than that of natural wood. Pressure-impregnated wood use in building exteriors is justified, when the cladding is near the ground causing risk of rotting. It is not suitable for indoors use or in contact with drinking water or foodstuffs, because of the health risks involved.(1)

With impregnated wood you must also consider the end of use period, as the recycling has to be done separately (2). Tightening environmental regulations may limit the demand for pressure-impregnated wood in the future (1).

Oil impregnation of wood means thermally modifying the planks in vegetable or linen seed oil in 180-220°C. As a result, the wood softens and its impact resistance deteriorates. On the other hand the wood will become resistant to moisture and the modification time is short. Oil impregnated wood is only sold as modified wood, so the technology cannot be bought for your own production.

ThermoWood® - optimal modification technology for increased wood profitability

The wood modification process that is best established in the market is the ThermoWood® process, with its relatively low capital expenditures(1).

ThermoWood® is produced with an open thermal modification system. Each wood species is modified differently because of their differing properties: the process is carefully optimised to result in the desired characteristics of the end-product, e.g. color, minimal moisture deformations and resistance to decay.(3)

The ThermoWood® concept is owned by the International ThermoWood Association (ITWA) to ensure the technical and ecological quality of products sold under the trademark. The association also aims to enhance the use of thermally modified wood.(4)

The ThermoWood® process creates non-toxic, dimensionally stable and resinless wood that has a reduced moisture content, splitting strength, bending strength and thermal conductivity. It can be used indoors or outdoors in any climate.(3)

There are two standardised processes: the Thermo-S process creates stability and is recommended for wood that is used in e.g. furnishing and fixtures in dry conditions, sauna benches and door and window components, and hardwood used in e.g. furnishing, fixtures, flooring, sauna structures and garden furniture.(3)

The Thermo-D process improves biological durability and weather resistance and is recommended for wood used in e.g. cladding, outdoors, shutters, environmental constructions and flooring, and hardwood in use in e.g. furnishing, fixtures, flooring, sauna structures and garden furniture where a darker colour is desired.(3)

In both the processes, 80% of the energy is needed mainly for drying. The total energy consumption is only approximately 20% higher than that of drying ordinary wood to 18% moisture content. The low-emission process is based only on high temperature and steam, so no harmful substances leach to the ground.(5)

When you use additional coating on ThermoWood® surfaces, the wood remains in good condition for even longer. This reduces the consumption of substances needed for coating manufacturing.

Longer service life also reduces transportation needs and related emissions. The disposed ThermoWood® can be used in energy production or recycled normally like natural wood.(5)

Get to know ThermoWood®: https://www.thermowood.fi/

How you can produce and sell ThermoWood® to increase your profits

Only the members of the International ThermoWood Association have the right to manufacture and sell wood under the ThermoWood® trademark (4). The raw materials must originate from FCS, PEFC or similarly certified forests and the production must pass third party audits every six months.

The ITWA defines quality classes and processing temperatures for each wood species to ensure material durability and other characteristics. You can read more about the classes in the ThermoWood® handbook.

Jartek's are the only kilns available in the market to produce certified ThermoWood® - investing in our technology you make sure your end-product meets the strict quality demands of the brand. Jartek kilns can also be used to modify wood from green.

Jartek kilns are known for their precise controllability and consistent high quality of the end-product. They are always tailored to fit the most common loads and dimensions that you produce. This helps you avoid bottlenecks and unnecessary work in production. We also help you find the right parameters and formulas for modifying different types of wood.

We are here for you every step of the way to ensure uninterrupted operations with continuous improvement and preventative services: from customer support to spare parts, updates and modernisations, maintenance and repair, service contracts and training and consultation.

Contact us to start your own ThermoWood® production!

https://www.jartek.com/

This white paper has been written based on interviews with Jartek experts and the following sources:
(1) History, current state and future of wood modification, Antti Aimala, South-Eastern Finland University of Applied Sciences, February 2018
(2) Impregnated wood, Puuinfo.fi, cited 15th April, 2025, https://puuinfo.fi/puutieto/processed-sawn-timber/impregnated-timber/?lang=en
(3) ThermoWood, thermowood.fi, cited 4th April, 2025, https://www.thermowood.fi/1
(4) ThermoWood Concept, thermowood.fi, cited 4th April, 2025, https://www.thermowood.fi/konsepti
(5) ThermoWood Environmental aspects, thermowood.fi, cited 4th April, 2025, https://www.thermowood.fi/ymparisto