4 Process/ Durability

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Summary
This chapter gives an overview of the most common methods in the world to raise the durability of wood. There are three main groups of wood modification. In this chapter an overview is given of the methods and a few examples of processes are treated in detail.

Goals

At the end of this module students are able to describe:

- the basic principles of wood modification
- the main groups of wood modification
- the process of thermal wood modification
- the differences and similarities between the different heat treatment procedures
- the process of chemical wood modification
- the main characteristics of modified wood
- the potential market of modified wood products

Background

All over the world timber is a ubiquitous and dependable material for construction works in a very broad range of applications like building, road works, water works etc. The economic impact of timber products is considerable. At this moment it represents the world's second largest flow of goods.
Changing political and economical conditions paved the way for more attention towards close to nature forestry. As a result a new silvicultural approach, called Integrated Forest Management (IFM), was developed in the Netherlands in the first half of the 90s. In IFM all functions (timber production, nature and recreation) are pursued, and the use of natural processes is stimulated. Keywords are natural regeneration, native timber species, mixed, uneven aged stands, small-scale or selective cuttings, presence of dead wood, thick stems, no biocides. In a couple of provinces with an active political attitude towards forests and forestry, the introduction of this kind of forest management is stimulated, with good results: i.e. a growing percentage of mixed forests with a great percentage of native timber species.
However the wood of most of the native species does not have the quality demanded by the timber industry.

In Europe huge volumes of timber are imported from around the world, including many tropical timbers. There is an enormous range of timber species that vary in density, colour, strength and durability. Part of the high quality imported timber species are especially appreciated because of their high durability. Many European grown species have excellent properties but many species tend to deteriorate under biological and physical influences. In particularly the sapwood of most species has a low durability. Many factors can contribute to the degradation of timber with low durability especially water, UV radiation, oxygen and temperature. The most important biological decay is caused by fungi. Fungi can attack timber with a moisture content over 20% and mainly at temperatures between 2°C and 40°C.

Import of high quality wood is not a sustainable solution for this durability problem. The growth of the human population is causing an increasing pressure on forests with high quality timber. The results are deforestation and erosion of fertile soil and a declining stock of high quality timber. As a consequence restrictive government regulations protecting the environment will reduce the availability of this high quality timber.

A solution to this problem is using the adequate reserve timber of less quality native species. The durability of wood is determined by intrinsic biological factors, but technologies exist that can improve the durability of timber substantially and prolong the product service life. The natural durability of some well known species is given in table 1.

Table 1. Classification of durability
In Europe, wood materials are ranked into five classes according to their durability.

Class 1 Highly durable	Class 2 Durable	Class 3 Moderately durable	Class 4 Slightly durable	Class 5 Not durable
Tropical timber: Teak Merbau Greenheart Kapur	Juniper (Juniperus ssp.) European oak (Quercus spp.)	Douglas fir (Pseudotsuga mensziesii) Thuja (Thuja ssp.)	European larch (Larix decidua) Spruce (Picea ssp.) Pine (Pinus ssp.) Red oak (Quercus rubra)	Maple (Acer pseudoplatanus) Ash (Fraxinus ssp.) Beech (Fagus sylvatica) Montery pine Poplar (Populus ssp.)

At present traditional biocidal wood preservative treatments are used to improve the durability of the timber. Typical wood preservatives, however, tend to contain for example: arsenic, zinc, copper, chromium, or creosote oils etc. The use of traditional wood preservatives and the use of tropical timber species are both being subjected to increasing environmental, legislative and consumer pressure in Europe. There are even legal bans on the use of selected chemicals within some European countries.

Considerable improvements have been made in the formulation and fixation of traditional wood preservatives to prevent them leaching into surrounding soil or water. However, there is still no real solution to the disposal of biocide treated wood at the end of its life. There have also been improvements in forest certification and logging practices for tropical timbers. Despite these improvements both of these issues are complex and remain controversial in Europe.

The use of European species with enhanced durability and qualities, without the need for biocides, would be an ideal solution to this problem. This would be good for the environment. It would create new jobs, new exports and replace imports. In this chapter a description will be given of a number of methods to raise the durability of wood.

Wood preservation and modification

There is a high world-wide demand for durable timber products for use in a wide range of exterior applications (e.g. bridges, scaffolding etc.) The best materials for many of these applications are- and may always be - (tropical) hardwoods. The diminishing supply of these wood species and global concern about the disappearance of forests has led to a search for alternatives.

In spite of the efforts to come to a reliable use of means of preservation, certain methods still stay problematic from an environmental point of view. For that reason alternative methods of preservation are being developed or have been developed lately. The development of especially the thermal preservation methods have been round off successfully. With this method the cellular structure of the wood is changed and the potential moisture content is brought down. Bacteria and fungi do not recognise the wood as being wood so it is not interesting anymore. New products are starting to appear on the wood market. The introduction of such new products on the market appears to be no sinecure. Manufacturers of this new preservation-technology and of the new wood products that are a result of that work hard to provide the highest quality for the market.

In The Netherlands there are products available from for example Plato Wood Products (Plato Wood), Pontmeyer (Stellac Wood), Fetim (Modiwood) and from the Finnish Thermowood Association (Thermowood).

Principles of wood modification

The wooden cell wall consists mainly of polymers (cellulose, lignin and hemi cellulose). The reactive hydroxyl groups on these polymers are responsible for many physical and chemical properties of wood.
In wood modification the basic chemistry of the cell wall polymers is altered, which can change important properties of the wood including durability, dimensional stability, hardness and UV-stability.
Controlling the moisture content of the wood is a very effective way to protect timber. In many wood applications improving the dimensional stability also helps by prevent cracking thus keeping water out of the construction. A secondary effect of dimensional stability is the improved adhesion of paint coating systems.
Within "wood modification" a distinction can be made between three main forms of modification. These are:

1. treatments in which wood is thermally modified
2. treatments in which wood is modified with a chemical
3. treatments in which wood is treated with enzymes (www.shr.nl)

Thermal-treated wood

The heat treatment technique was developed by the Vikings. Heat treatment of wood has an effect on wood’s chemical composition and through that on the properties of wood. The effect of heat treatment on wood’s properties was already known by our forefathers when heating the edges of fence poles to increase durability. In addition to better durability the advantages of heat treated wood are reduced hygroscopicity and improved dimensional stability. In today's technology, wood is heated to a temperature that may even exceed 200 degrees Celsius in an oxygen-free chamber, and thus it does not burn. The treatment breaks up cellulose chains so that decay-causing bacteria cannot feed on the wood. In a single day the wood artificially ages 200 years. At the same time, resin and excess water are expelled from the wood. Heat-treated wood is especially suitable in applications where moisture resistance and dimensional stability are essential. Heat treatment darkens and deepens the wood’s natural colour, making it a competitive alternative to tropical hardwoods. It is used for external cladding and interior panelling as well as in garden and yard fittings, floor coverings and furniture. A variety of techniques without using chemical products are available to upgrade wood for almost all tree species.

In Finland, France, Germany, the Netherlands and the USA laboratories have been experimenting with modification of wood by heat treatments. By applying heat some of the wood polymers are broken down and new water insoluble polymers are formed. Most of these processes are performed under nitrogen since the presence of oxygen can result in severe degradation of the cellulose thus considerably reducing the strength of the timber. Keeping the strength reduction under control is one of the biggest challenges of thermal treatments.
Both in Finland (Stellac) and the Netherlands (PLATO) processes have been developed coping with the problem of excessive strength loss.

General process of heat treatment

All the European heat treatment processes have in common the treatment of sawn wood at elevated temperatures in the range between 160°C and 260°C. The main difference between the processes are to be seen in the process conditions. The different processes have different process steps, e.g. is it a dry or a wet process, is the wood treated with nitrogen or oxygen, is steam used in the process etc. These differences will be discussed in the next paragraph.
Next to these differences there are some things that all the products of different manufacturers have in common.

The species that can be used are mainly softwood species because hardwood species decompose more and are more likely to crack after the process. So the strength reduction is much bigger with hardwood then with softwood species.

Characteristics of heat treated wood

Durability

In general it can be stated for all heat treatment processes that the durability of wood can be improved considerably, depending on the wood species and the treatment conditions. For non-durable softwood species that normally have a durability class of 4 or 5 the improvement can range from durability class 2-4, in some cases even class 1. This depends on the treatment temperature and the process duration.

Resistance against fungi

The resistance against all kinds of fungi improves considerably after treatment. Several investigations proved that especially the resistance against brown rot fungi had improved. The resistance against white rot and soft rot fungi had also improved. The resistance against marine borers isn't improved by heat treatment of any kind.

Strength

The mechanical properties of the wood change when it is heat treated. This also depends on the temperature and the duration and it is believed that the higher the temperature during the treatment, the higher the loss in strength. Investigations showed reductions in strength of 5% -50% for several different methods.

Shrinking and swelling

The shrinking or swelling of wood is reduced by the heat treatment process. This is why heat treated wood is so dimensionally stable. It can be mounted with fewer fixtures and so it saves money in the assembly process.

Colour

Due to the high temperatures in the process all the treated wood species get a characteristic brownish colour that is comparable with the natural colour of Western Red Cedar. Like almost every effect of heat treatment this is again effected by duration and temperature. The higher the temperature and the longer the duration of the process, the darker the colour.

Smell

The smell also changes and after the treatment the wood has a characteristic caramellish smell, which is believed to be related to the release of furfural. This smell will get less after some time.

The environmental aspects should also be taken into account. The wood will become more durable and that is good for the environment of course, but during the process also energy will be consumed, waste water will be produced and gas emission can take place. The gasses that are emitted must be treated to avoid unnecessary environmental loading. This is normally accomplished by burning the gasses with a special purpose-built burner.
The process produces water that is partly acid (pH3) due to acids evaporating from the wood. The water also contains part of the evaporated resin and other solid constituents of the wood. The solid components of the waste water are separated in a special clarification basin and the rest is processed at waste water works.
The amount of energy that is consumed is only 25% higher than the amount used in an ordinary timber drying process. This is not too much when looking at the different treatments the wood undergoes.

The basic wood structure is preserved during the heat treatment, so the product can be machined in the same way as untreated wood. The natural mechanical qualities of wood stay intact. Thermally treated wood can therefore be machined and handled with the common means and techniques. No additional supplies (and costs) are necessary.

Thermal treated wood techniques

The Plato Technology

THE PLATO TECHNOLOGY IS AN EXAMPLE OF A TECHNOLOGY THAT IMPROVES NEXT TO DURABILITY ALSO THE DIMENSIONAL STABILITY OF WOOD BY A SOPHISTICATED PROCESS WITHOUT IMPREGNATION WITH CHEMICAL PRODUCTS. THE PLATO TECHNOLOGY IS PATENTED WORLD-WIDE. IT IS A (FOUR STAGE) HYDROTHERMAL TECHNOLOGY. THE ORIGINAL PLATO CONCEPT HAS BEEN INVENTED BY SHELL IN THE 1980'S. SINCE 1994 THE DEVELOPMENT CONTINUED OUTSIDE SHELL BY A COMPANY CALLED "PLATO HOUT BV", SITUATED IN WAGENINGEN (THE NETHERLANDS). THE PRODUCTION PLANT IS NOW SITUATED IN ARNHEM.

THE AIM OF PLATO HOUT BV IS TO DEVELOP AND COMMERCIALISE THE PLATO TECHNOLOGY IN ORDER TO UPGRADE FAST-GROWN SOFT- AND HARDWOODS INTO DURABLE PRODUCTS AND TO EXPLORE ITS POTENTIAL FOR MORE ADVANCED APPLICATIONS. THESE ASPECTS ARE REFLECTED IN THE PROJECT ACRONYM: PROVIDING LASTING ADVANCED TIMBER OPTION. THE PLATO TECHNOLOGY ENABLES THE UPGRADING OF NON-DURABLE WOOD SPECIES. MOST SPECIES CAN BE MADE TRANSFORMED INTO A NOBLER WOOD PRODUCT. EXAMPLES FROM SPECIES FROM WHICH PLATO WOOD IS ALREADY AVAILABLE ARE SCOTS PINE (PINUS SYLVESTRIS), NORWAY SPRUCE (PICEA ABIES), DOUGLAS FIR (PSEUDOTSUGA MENZIESSII), RADIATA PINE (PINUS RADIATA) AND POPLAR (POPULUS SSP.).

The Plato technology is based on four distinct stages:

1. Hydro-thermolysis stage: The wood is heated to 150°C - 180°C in an aqueous environment at super atmospheric pressure. This first stage selectively converts two important components of wood (namely hemi cellulose and lignin) for processing in the third stage. Polyoses are transformed into aldehydes and some organic acids are formed. The reactivity of lignin towards alkylation is enhanced. The cellulose remains intact, which is crucial for the good mechanical properties of the finished Plato®Wood.
2. Drying stage: The wood is reconditioned to a dry environment as required for the third stage. Drying is done in a conventional industrial wood kiln using common procedures.
3. Curing stage: The wood is heated once again to 150°C - 190°C, but now under dry conditions. In the third stage condensation and curing reactions set in; the aldehydes formed react with the activated lignin molecules to form non-polar (consequently water repelling) compounds cross-linked into the structure.
4. Conditioning stage: The moisture content of the wood is elevated to a level which is necessary for manufacturing. Conditioning is done in the same convential industrial wood kiln as drying.

As can be concluded from the description of the Plato technology, no chemicals are used.

Environmental aspects of the technology

Substantial effort has been made to limit the environmental consequences of the process to a minimum.
Some examples of effective use of energy are:

- a closed and circulated coolwater-system,
- isolated equipment,
- a flash-unit which makes low-pressure steam out of the condensate of medium pressure steam,
- during the winter period, heating of the buildings is done by pumping the condensate of the low pressure steam through radiators,

Even the source of the energy used for the Plato process is considered as environmental friendly.

Product characteristics

During the Plato process, the wood components are structurally modified. As a result of this structural modification the water uptake tendency is reduced and “edible” compounds (fungal substrates) are converted into “non-edible” compounds. This leads to an enhanced durability and improved dimensional stability of the wood. No toxic products are formed and a surprising finding is that the Plato product is actually less toxic to aquatic organisms than the original virgin wood!

In order to demonstrate the practical suitability of Plato Wood, a number of relevant properties of the product have been established:

Qualities of Plato Wood

- Durability throughout (class 2: durable wood)
- Lightweight
- Dimensionally stable
- Low hygroscopicity
- Good mechanical qualities
- Easy to machine and handle
- Suitable for water/soil contacts
- Environmentally safe
- Low in maintenance

Market characteristics

Production and sales

A large-scale commercial production plant is operational in Arnhem, the Netherlands. More than ten years ago the first platonised wood species were used in several waterworks projects in the Netherlands.

Today, in the Netherlands, Belgium, Germany, Japan and more, Plato wood is applied and is promising for more.

Developments on panels and boards.

The two most important development-projects next to Plato timber is first the use of Platonised chips, strands, and fibres for water-resistant particleboard OSB and MDF; and second the Plato veneer and plywood.

This application of the Plato process can result in an add-on device to existing panel product factories that will Platonise the feedstock (strands, chips). Factories can then produce water-resistant panel products at a limited investment. Other future developments that are anticipated are fire retardation, colouring and process variations focussed on improving specific wood properties.

Applications.

The Plato process will be used in the supply chain of timber producing and processing industry for products such as garden furniture, fencing, claddings, window frames and doors. Due to its high durability, Plato Wood is especially suitable for exterior applications and might replace materials such as PVC or aluminium in certain products.

Road works

Garden design

Construction

Water works

References

Source: www.platowood.nl

Finnforest ThermoWood

Finnforest ThermoWood is produced by passing timber through a cycle of heat and moisture changes involving exceptionally high temperatures. The intensive heat treatment transforms the structure and properties of the wood itself. The wood's original natural susceptibility to warping, swelling or shrinking in different conditions of humidity is reduced by as much as 50 %. The resulting ThermoWood is thus much more stable than normal wood in changeable climatic and environmental conditions.

The equilibrium moisture content of ThermoWood is considerably lower than that of ordinary wood and its resistance to rot-producing fungi is equal to that of larch, oak or even teak, depending on the degree of heat treatment. The ThermoWood production process also improves the wood's insulating properties and removes resin from coniferous softwoods.

Description of the technology

The process used for the Finnish treatment method can be divided into three different steps:

1. temperature rise period (preliminary warm up (_ 100°C) + kiln dry at hot temperatures if needed (100 - 150°C) + temperature rise period (150°C _)), up to 48 hours
2. actual heat treatment (constant temperature of between 150-240°C), 0,5…4 hours
3. cooling + stabilising, up to 24 hours

During the temperature rise period the temperature of the oven is raised to the temperature at which the actual heat treatment occurs. If the moisture content of the material is too high (> 10 %) before heat treatment a lot of splitting and colour differences may result. The kiln dry period can be integrated to the temperature rise period. The temperature rise period can take up to 48 hours.

The temperatures used for the actual heat treatment period range from 150 °C to 240 °C and during the actual treatment the temperature of the oven is kept constant. In heat treatment both the time and the temperature affect on the quality of the heat treated timber. The actual heat treatment takes from 0,5 hours to 4 hours.

During cooling and stabilising the temperature decreases to normal. Cooling and stabilising takes about 24 hours. During all these periods it is important that the temperature differential between the wood and the air is not too large. If the temperature difference is large the quality of treated wood is not good. It is also important that there is water vapour in the oven during whole treatment. The water vapour affects the quality of heat treated timber and it also acts as a protective atmosphere to prevent the material from burning.

Environmental aspects of the technology

Finnforest's ThermoWood production process is based on the carefully controlled use of heat and steam. ThermoWood production does not involve chemicals that pollute the environment, and no other substances are added or applied to the wood during the treatment process. ThermoWood thus has no adverse effects at all on the environment. The total energy consumption of the ThermoWood production process only slightly exceeds that of normal timber drying.

Any waste resulting from ThermoWood can be harmlessly burnt or otherwise destroyed without risk to the environment. Another important benefit from the environmental point of view is that timber from almost any tree species can be used as raw material for ThermoWood. Sustainable managed softwood from Finland that has been processed to ThermoWood displays properties that are remarkably similar to those of many tropical hardwoods.

Product characteristics

In Finland the most common wood species used for heat treatment are pine (Pinus Silvestris), spruce (Picea Abies), birch (Betula Verrucosa/Pubescens) and European aspen (Populus Tremula) although other species are also treated. The heat treatment process is different for each wood species and the final result is different because of the different chemical compositions and cellular structures. Usually softwoods are treated more strongly and hardwoods are treated more lightly. This is because of the different usage of the heat treated species.

The quality of wood which is going to be heat treated must be good. For example the knots are a problem if they are dry and they drop out or crack. Also decayed wood may cause colour differences after treatment. The final result is also affected by how the log is sawn. The conventional simple cut

may result especially for softwoods a lot of peeling off and peeling of annual rings. In this case the annual rings are nearly horizontal to the surface. If the wood pieces are sawn so that the annual rings are at least in 45°_ angle to the surface the deformations will be smaller, the hardness of the surface will be stronger and the "general looks" after heat treatment is better.
Usually softwoods are treated more strongly and are used in constructions which need moisture protection, for example in outdoor constructions. Hardwoods are treated more lightly
and usually the most important property is the colour or good surface quality. Heat treated hardwoods are used in doors, for example in kitchen furniture, panelling and parquets.

The extent of the change in timber properties during heat treatment depends on:

- the maximum temperature and the maximum length of the actual heat treatment period
- the temperature gradient
- the maximum length of the entire heat treatment
- the use and amount of water vapour
- the kiln drying process before the actual heat treatment
- the wood species and its characteristic properties

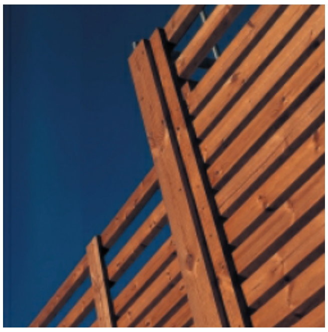
Temperatures over 150°C alter the physical and chemical properties of wood permanently. Heat treatment darkens the colour of the wood. The colour of wood changes easily and colour changes do not tell anything about how much the other properties have changed compared to untreated wood. It reduces the shrinkage and swelling of the wood and improves the equilibrium moisture content of the wood. At the same time the strength properties start to weaken. Very high temperatures improve the resistance to rot and also reduces the susceptibility to fungal decay.
The improved characteristics of heat treated timber offer the timber product industry many potential and attractive new opportunities. Also wood species having no commercial value as such can be heat treated and in this way new uses can be found for these species.

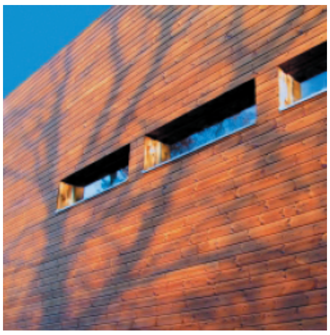
- Reduction of equilibrium moisture content of wood by 50 %. Heat treatment slowers water uptake and wood cell wall absorbs less water because of the decrease of the amount of wood's hydroxyl groups.
- Reduction of shrinking and swelling 50 - 90 % As a consequence of the reduced number of hydroxyl groups the swelling and shrinking are lower.
- Improvement of biological durability.
- The resistance in ground contact is not acceptable. The improved biological durability is based on the chemical degradation in wood components and formation of new compounds. The essential changes in wood chemistry are not exactly known.
- Decrease of wood mechanical properties by 0 - 30 % The higher is the treatment temperature the better is wood's biological durability. But at the same time more weakened are wood's mechanical properties. A negative consequence is that the wood becomes more brittle, and bending and pulling strength decrease by 10 % to 30 %.
- No changes were found in compression and impact strengths and surface hardness. As also the dry knots are loosened, the use of heat-treated wood in load-bearing constructions is restricted.
- Heat conductivity decreases by 10 - 30 %
- Resin flows out of wood: wood looses some of it's weight (5 - 15 %)

Market characteristics

The improved characteristics of heat treated timber offer the timber product industry many potential and attractive new opportunities. The most important property compared to untreated wood is that the equilibrium moisture content of the heat treated wood is reduced
and as a consequence of this shrinkage and swelling of the wood is also reduced. The best way of utilising heat treated timber is to make use of these improved properties. Wood species having no commercial value as such can be heat treated and in this way a new use found for these species.
Heat treated pine and spruce are mainly used for outdoor constructions, for example garden furniture, windows, doors and wall or fence boarding. Excellent heat insulation and the absence of resin also make ThermoWood's properties ideal for

warm and damp interiors such as saunas or washrooms. Its low moisture content, too, means that sauna benches made from ThermoWood are hygienic and less burning to the skin than those made from ordinary wood. In flooring applications, ThermoWood's advantages include its outstanding dimensional stability as well as its beautiful colour. Intensive heat treatment imparts a whole range of attractive brown shades and tones to ThermoWood. In general, the higher the temperature of the treatment, the darker and richer the colour.
When better weather and decay resistance is desired the temperatures used for the heat treatment process must be over 200°C. At these temperatures the strength properties also decrease, a factor which has to be taken into account. Although the rot resistance improves when the timber is heat treated strongly it is not recommended to use heat treated timber in ground contact.
Heat treated birch and aspen are used indoors. The most important property of heat treated birch and aspen is dimensional stability (due to moisture content changes) but also very beautiful but selectable shade of colours varying from light brown to almost black. For indoor use the treatment temperatures are under 200 °C. Birch and aspen are used for furniture, kitchen furniture, parquets, panelling and sauna furnishing





References

www.finnforest.com

New Option Wood (Retitech)and Le Bois Perdure

Mainly two processes are in use at the present time in France. The first one called Retification (Retified wood) has been developed by Ecole des Mines de Saint-Etienne and operating licences and patents have been acquired by the Company NOW (New Option Wood) (Also known as RETITECH).
The second Process is named "Le Bois Perdure" and the oven has been developed by the Company BCI-MBS.

Description of the technology

The Retification process consists in starting from wood previously dried around 12 % in humidity and to heat slowly in a specific chamber up to 210 – 240°C in a nitrogen atmosphere with less than 2 % in oxygen. The Industrial oven has been developed by the Company Four et Brûleurs REY, near Saint-Etienne.
Three Industrial Units are already in operation with a capacity of 3 500 m_/year for each corresponding to a heat chamber of 8 m_. A few plants are operational since 2002.

Instead of starting from dry wood the "Le Bois Perdure" process allows to use fresh wood. The first step of the process consists in an artificial drying in the oven. Then the wood is heated up to 230°C under steam atmosphere (steam generated from the water of the wood).

In both cases there is a compromise between durability and mechanical properties-higher the temperature, the better the durability and lower some mechanical properties as strength to rupture. The treated wood at 230 – 240°C is much more durable but can loose up to 40 % in Modulus of rupture and is more brittle. At 210°C, the material, depending upon the species, can be less brittle with mechanical characteristics close to the original values but the durability could be improved only slightly.
It means that the heat treatment shall be adjusted in terms of rate of heating, duration of treatment and maximum temperature to reach according to the application on usage.
The processes are very sensitive to slight changes in temperature which shall be controlled with accuracy. For example, in the Retification Process it has been observed and published recently that 230°C corresponds to a define modification of the lignin leading probably to crosslinking. Under such a temperature the treated wood does not show the same behaviour, in terms of durability, that at a temperature above 230°C.

The Retified wood is processed under inert nitrogen atmosphere, with the residual content of oxygen lower than two percents. The "Bois perdure" is processed under saturated water vapour atmosphere.

Environmental aspects of the technology Product characteristics

All properties are very dependent upon the wood species, the type of process, the final temperature reached. However, in all cases, the material turns brownish in color, the higher the temperature reached, the darker the final product. As mentioned above, mechanical properties are very dependent upon the control of the process, the final temperature, the wood species etc. The parameters to take into account are numerous and very sensitive to slight modification. In any case, the material becomes more brittle. At 230°C, quite often, a decrease of MOR in the range of 30 to 40 % can be measured with a very brittle behavior. (Catastrophic failure, without creep).
According to previous testing, mechanical properties after heat treatment are not strongly affected for poplar as they are for other species like pine trees. This means that the density is not the only parameter involved. Surface tension of the wood is drastically affected after heat treatment. Any kind of painting and finishing usually used for untreated wood cannot be used. However, it is possible to find some formulation and paints adequate on a surface of heat treated wood. If needed surface tension can be adjusted by additives. The main problem can arise from exudation of the resin from the resinous species.
Wood treated at high temperature turns grey in colour after exposition to sun and UV, for few weeks. It is generally assumed that such grey colour is more homogenous than for untreated wood. Cracking, due to dimensional motion is reduced in comparison with natural wood.
Wood treated at high temperature has less hygroscopicity than natural wood. It stabilises around 4 – 5 % in humidity instead of 10 to 12 %. This low hygroscopicity is of importance on biological durability (rot, stains, mould).
However, the material presents a certain porosity and when dipped in water it can absorbe more than 20 % of water. But when dried again the water can take out quite easily. Such behaviour is of importance for building materials.
It is known that heat treatment at a temperature above 200°C reduces by factor two dimensional movements. However, dimensional stability is largely dependent upon the process, the final temperature, the wood species.

Species of high density are more difficult to process than low-density species. With species of high density (mostly hardwood) heat treatment has a tendency to induce cracking lowering drastically mechanical properties. Poplar seems to be interesting to process giving good results in terms of physical properties and durability. A large study on maritime pine has been carried out in France and the main results will be commented.

Market characteristics

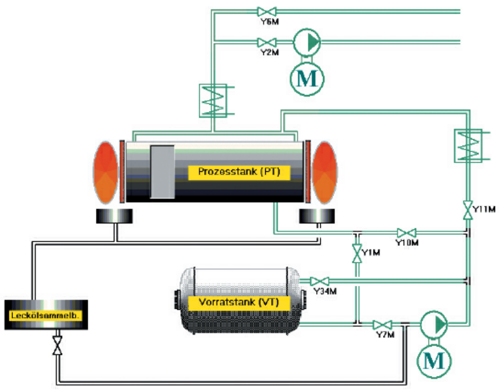
At this moment there is not known about the market characteristics, but the wood can be utilized in the same way as the Thermowood procedure.

Oil Heat Treatment

Heat treatments usually take place in an inert gas atmosphere at temperatures between 180 and 260°C. The boiling points of many natural oils and resins are higher than the temperature required for the heat treatment of wood. This opens up the option of the thermal treatment of wood in a hot oil bath. Improvements in various wood characteristics can be expected from the application of oil-heat treatment as compared with heat treatment in a gaseous atmosphere, due to the behaviour of oils in conjunction with the effect of heat.

There is currently one plant in commercial use in Germany. The plant is operated since August 2000 by MENZ HOLZ in Reulbach, 30 km east of the city of Fulda. MENZ is intending to cover the German marked segment of oil-heat-treated wood for garden furniture and wood for gardening. The company is interested to find partners for licensed production of oil-heat-treatment wood for different market segments in all European countries. The existing vessel has a capacity of 2900 m_/a. The future vessels planned by MENZ have typical capacities of 8500 m_/a

Description of the technology



The principle design of the plant can be seen from Fig. 1.(Diagram designed by MENZ HOLZ Germany)

The process is performed in a closed process vessel (PT). After loading the process vessel (PT) with wood, hot oil is pumped from the stock vessel (VT) into the process vessel (PT) where the hot oil is kept at high temperatures circulating around the wood. Before unloading the process vessel (PT) the hot oil is pumped back into the stock vessel (VT).

Temperatures used during the process

For different degrees of upgrading, different temperatures are used.
To obtain maximum durability and minimum oil consumption the process is operated at 220°C. To obtain maximum durability and maximum strength temperatures between 180°C and 200°C are used plus a controlled oil uptake.

Process times

It proved to be necessary to keep the desired process temperature (for example 220°C) for 2-4 hours in the middle of the wooden pieces to be treated. Additional time for heating up and cooling down is necessary, depending on the dimension of the wood. Fig. 2 gives an example of the a heating up phase for logs with a cross section of 90 mm by 90 mm. Typical process duration for a whole treatment cycle (including heating up and cooling down) for logs with a cross section of 100 mm x 100 mm and length of 4 meters is 18 hours.

Heating medium

The heating medium is crude vegetable oil. For example rape seed, linseed oil or sunflower oil. The oil serves for both, fast and equal transfer of heat to the wood, providing the same heat-conditions all over the whole vessel perfect separation of oxygen from wood.
Natural plant oils lend themselves to the oil-heat improvement of wood from an environmental point of view and because of their physical and chemical properties. As renewable raw materials they are CO2 neutral. The use of other plant oils, such as rape seed oil, sunflower oil, soybean oil or even tall oils or tall oil derivatives in addition to drying oils such as linseed oil, is also conceivable. Linseed oil proved to be unproblematic though the smell that develops during the heat treatment may be a drawback. The smoke point and the tendency to polymerisation are also important for the drying

of the oil in the wood and for the stability of the respective oil batch. The ability of the oil to withstand heating to a minimum temperature of 230°C is a prerequisite. The consistency and colour of the oil change during heat treatment. The oil becomes thicker because volatile components evaporate, the products
arising from decomposition of the wood accumulate in the oil and change its composition.
This obviously leads to improved setting of the oils.

Product characteristics

Fresh, untreated pine (Pinus sylvestris L.) and spruce (Picea abies L. Karst.) was used in a test for the oil-heat treatment. The specimens with a wood moisture content of 6% were heated at three temperatures (180°C, 200°C and 220°C) unpressurised and with exclusion of oxygen in an oil bath of refined linseed oil. On the oil reaching the desired temperature, the wood specimens were immersed in it for 4.5 hours. Virtually no oil was absorbed during the actual heat treatment. To achieve the desired oil loading, the specimens cooled off in the oil bath for 15 minutes. Reference samples were also treated for 4.5 hours at corresponding temperatures in a drying chamber in an air atmosphere.

Rot

A noticeably lower loss of mass was determined for oil-heat treated specimens than for airheat treated specimens.

Stains and mould

Weathering tests in the field have shown, that superficial treatments are necessary to prevent
the nice brownish coloured wood from bleaching and staining.

MOE, MOR, Impact bending strength, brittleness

The MOE and MOR was determined in a three point bending test with medium force applied on 150x10x10 mm3 treated and untreated wooden slats parallel to the grain on a universal testing machine. Tests of the impact bending strength provide information on the dynamic stability of wood specimens. They were performed using a Louis Schopper pendulum impact
machine. The changes in the impact strength due to oil-heat or air-heat treatment were calculated in relation to untreated specimens of the same type of wood

The highest MOE of more than 11,000 N/mm2 were achieved at 200°C in the case of oil-heat treated specimens (Fig. 3). There was no reduction in the values for the MOE of elasticity of untreated coniferous wood with either heat treatment process.

The MOR of wood which was oil-heat-treated at 220°C was about 70% of the value of untreated controls. The impact bending strength is the most critical value for all kinds of heat treatments. It declines considerably and the wood becomes brittle. Oil-heat-treated wood achieved a 51% and air heat treated wood only 37 % of the impact bending strength of untreated controls as the treatment temperature increased (Fig. 4).

Smell

Like all heat treated woods also oil-heat-treated wood has that initially typical smoky smell. This could lead to limitations in use in internal areas, though this smell evaporates after some time. In any case this should hardly be a problem outdoors.

Colour and surface properties

At the end of the treatment cycle the oil remaining on the surface of the wood was absorbed by the wood very quickly during the cooling down of the specimens so that a dry wood surface appeared a few minutes after treatment. The surfaces were light brown in colour at lower treatment temperatures and dark brown at higher treatment temperatures. Unlike the airheat treated specimens, no spotted discoloration due to the uneven distribution of exudated rosin was found on oil-heat treated specimens.

Paintability

The paintability of oil-heat-treated wood for acrylic water based paints as well as for alkyd solvent based systems proved to be good during two years of weathering. Surprisingly after two years the adhesion of the paints and varnishes on the oil-heat-treated wood was even better than on gas-heat-treated wood.

Gluability
Initial tests have been made with the following results: After planing of oil-heat-treated spruce, gluing was no problem. However for oil-heat-treated pine with higher oil uptake, only modified glues lead to good results.

Weathering properties
For heat treated softwoods its typical initial brownish colour is not UV-stable without surface treatments. After a half year of weathering in the field the colour of oil-heat-treated spruce came close to that of weathered untreated larch heartwood.

Hygroscopicity
If the oil-heat-treatment is performed for 4 hours at 220°C then the moisture content at fibre saturation was 14% whereas the moisture content of untreated controls was 29% under the same conditions.

Dimensional stability and cracking
Specimens for the examination of swell and shrink improvement (ASE) were exposed to a temperature of 20°C and a relative humidity of 35%, 65% and 85% after the oil-heat treatment. The dimensions of the specimens subjected to the above climatic conditions were determined after their masses becoming constant. The ASE was calculated from the ratio of the percentage volumetric change of the treated specimens in relation to the volumetric change of untreated wood specimens.
The improvement in the ASE of specimens that were treated at 220°C was similar for both types of treatment, at about 40%. The degree of improvement in this case depended on the relative humidity. When humidity was increased, the ASE became lower, with less difference in the specimens treated at higher temperatures than in those treated at lower temperatures
In Anglo-Saxon literature the term ASE (anti-swell efficiency or anti-shrink efficiency), coined by Stamm (1964) to describe the reduced swell or shrink of treated wood compared to untreated controls, has become established. In this case the swell or shrink characteristic of wood is determined under laboratory conditions with appropriate climatic conditions.
However, it is not yet possible to make a statement on dimensional stability under open land conditions on the basis of these values because experience shows that the behaviour of samples subject to the multi-faceted stresses of open land is different from their behaviour under laboratory conditions. But since the ASE is easy to determine, it is often ascertained and therefore offers a good means for comparison of the various wood improvement processes. It is expected that the dimensional stability of oil-heat-treated samples will prove to be better in open land than that of wood that has undergone conventional heat-treatment in an oxygen-free gas atmosphere, due to the additional water-repellent effect of the oil component.

Market characteristics
There are no species excluded from oil-heat-treatments. However the most experience exists for the treatment of Norway spruce and Scots pine. For most commodities in European hazard class 3 Norway spruce is suitable.

Suitable commodities
- claddings
- pergolas
- exterior joinery
- garden furniture
- decks
- fencing
- noise barriers
- wood in soil contact (treated at high temperatures and high oil loadings)

Chemical-treated wood
Chemical modification aims at the improvement of wood properties by altering the basic molecular structure of the cell wall components. The first trials in this field were made as early as the 1930's although only recently (the last decade) it has become a serious field of research. Modification implies the combination of two very different types of expertise, chemistry and wood anatomy, both of which strongly influence the final result.

- Within (organic) chemistry there is enormous diversity and many chemicals can react with wood cell wall polymers. The final result is largely influenced by the great variety of parameters of reaction-types and processes, such as: temperature, time, pH, catalysts, solvents, etc

- Within wood anatomy the nature of wood and fibres is extremely complex. Wood species differ enormously in chemical structure, ultra-structure and anatomical structure. These factors are crucial for the different reaction types.

Chemical modification of wood is therefore very complex and requires both a multidisciplinary approach and the set up of a new field of research. Only the integration of knowledge of both chemical/enzyme/kinetics and of wood will result in the most beneficial research for a successful industrial production and usage of modified wood.

In many chemical modification reactions the hydroxyl groups play the leading role. In this case wood reacts as an alcohol. Many chemicals have been used to modify wood. The main reaction types are:

- the formation of ethers
- the addition of carbonyls or acetals
- the formation of esters or urethane bonds
- oligoesterification (a combination of two or more reactions)
- chemical oxidation of the wood, or sylilation.

Ethers

The simplest ether is formed during methylation of wood with for instance methylchloride, dimethyl sulphate or methyliodide. Methylated wood is mechanically impaired because of severe reaction conditions and the by-product formed. These reactions result in good dimensional stability but they are not permanent. Another category forms the alkylene oxides. Several epoxides EO, PO and BuO have proven to be excellent modification agents.

Acetals

One of the aldehydes used and most frequently reported is formaldehyde. Sulphur dioxide was both used as catalyst and to treat wood in combination with formaldehyde at 120 °C for 24 hrs. Glyoxal, glutaraldehyde and dimethylol dihydroxyethylene urea (DMDHEU) are mentioned as cross linking chemicals.

Esters

Esters are formed by the reaction of wood with carboxylic acids or anhydrides. Many acids have been tried in laboratory experiments as well as many anhydrides. Most studied and reported by dozens of authors is the acetylation of solid wood, wood fibres, chips, veneers etc. with acetic anhydride. In Europe, SHR (the Netherlands) is developing a method to overcome the problem of the residual by-product acetic acid, while at Chalmers University (Sweden) efforts are being made to use microwave technology for fast heating during the treatment.

Urethanes

Isocyanates have been studied extensively: methyl-, ethyl-, n-propyl, n-butyl-, phenyl-p-tolylisocyanate and 1,6-diisocyanatohexane (hexamethylene diisocyanate) and tolylene-2,4-diisocyanates all have been used to modify wood cell wall polymers. 4,4'-diphenyl methane diisocyante (MDI) is frequently used in fibre technology.

Oxidation

Sodium periodate and periodic acid have been tested for oxidation of solid wood. Wood treatments with aqueous solutions (1-3%) of these chemicals at 25 °C for 4 hrs, resulted in limited oxidation of the cell wall polymers.

Silyllation

Propyltrimethoxysilane has been tested, while rubber wood was treated with g-methacryloxy-propyltrimethoxysilane. Timber is available in a wide variety of density, colour, strength and size

References

www.woodmodification-network.org

CCA-Treated Wood

The wood preservation process involves impregnating the wood with chemicals that protect the wood from biological deterioration and to delay combustion due to fire. The most common process includes pressure-treatment in which the chemical is carried into the wood by a carrier fluid under pressurized conditions. Treatment chemicals utilized during the wood preserving process are separated into four major categories (AWPI, 1994). These categories include: waterborne preservatives including CCA, oilborne preservative including pentachlorophenol, creosote, and fire-retardants. The purpose of the first three chemicals is to prolong the useful life of wood products by protecting them against insect and fungal attack. Wood exposed to the outdoor atmosphere and in direct contact with soil and water are more prone to decay and therefore usually require treatment. The fourth preservative, fire-retardants, delay the combustion process when wood is subjected to fire.

Fire-retardants represent the smallest fraction of the wood treatment market. Formulations for fire retardants include ammonium salts, borates, phosphates, bromides, and antimony oxides. Creosote is a heavy black-brown liquid produced by condensing vapors from heated carbon-rich sources, such as coal or wood. The resultant preservative is sometimes mixed with tar oils and petroleum oils. Oilborne preservatives utilize oil to carry the treatment chemical into wood. Oilborne preservatives include copper naphthenate, zinc naphthenate, and pentachlorophenol. The most common of these is pentachlorophenol which is a crystalline aromatic compound. Both pentachlorophenol and creosote impart a dark color to the wood, have an odor, and result in an oily surface which is difficult to paint. Wood treated with either chemical is flammable and contact with skin may cause irritation. Most common uses for creosote treated wood include railroad and bridge ties. Pentachlorophenol is used to treat utility poles and crossarms (Milton, 1995). Neither pentachlorophenol- nor creosote-treated wood should be used inside residences.

Waterborne preservatives utilize water as the carrier fluid during the treating process. The water is evaporated from the wood shortly after treatment leaving behind the treatment chemicals. The most common waterborne chemicals are metal oxides. These chemicals include chromated copper arsenate (CCA), acid copper chromate (ACC), ammoniacal copper arsenate (ACA), chromated zinc chloride (CZC), and ammoniacal copper zinc arsenate (ACZA). The most common of these waterborne preservatives is CCA which represents over 90% of the U.S. waterborne preservative market (AWPI, 1996). CCA is composed of the oxides or salts of chromium, copper, and arsenic. The copper in the wood serves as the fungicide whereas the arsenic protects the wood against insects. The chromium fixes the copper and arsenic to the wood. CCA can be separated into Type "A", "B", or "C" depending upon the relative proportions of metals (table I-1). The relative proportions range from 35-65%, 16-45%, 18-20% for chromium, arsenic, and copper, respectively. The amount of CCA utilized to treat the wood or retention level depends upon the particular application for the wood product (table I-2). Low retention values (0.25 lb/ft3) are permissible for plywood, lumber, and timbers if the wood is used for above ground applications. Higher retention values are required for load bearing wood components such as pilings, structural poles, and columns. The highest retention levels (0.8 and 2.5 lb/ft3) are required for wood components which are used for foundations or saltwater applications.

The primary advantages in the use of CCA-treated wood are that it produces no odor or vapor and its surface can be easily painted. At low retention values it does not change the general appearance of the wood, maintaining the aesthetic quality of natural wood. The wood is suitable for use indoors and is generally used for interior parts of a wood structure in contact with the floor. Drawbacks of the wood are a strong green color at high retention values. It should not be used in applications where it is in contact with food or drinking water. CCA is used to treat primarily lumber, timbers, posts, and plywood. Its use in treating other products, such as poles and pilings, has seen relative increases as well.

	CCA-Type A	CCA-Type B	CCA-Type C
Chromium as CrO_3	65.5%	35.3%	47.5%
Copper as CuO	18.1%	19.6%	18.5%
Arsenic as As_2O_5	16.4%	45.1%	34.0%

Table I-1: Composition of CCA-Type A,B, and C (AWPA, 1996)

Application	Retention Value (lb/ft^3)
Above ground: lumber, timbers, and plywood	0.25
Ground/Freshwater contact: lumber, timbers, plywood	0.40
Salt water splash, wood foundations: lumber, timbers, and plywood	
Structural poles	0.60
Foundation/Freshwater: pilings and columns	0.80
Salt water immersion: pilings and columns	2.50

Table I-2: Retention Requirements for CCA-Treated Wood (AWPA, 1996)

Creosote treated railroad sleeper.

Other treatments
Tall oil impregnation

The method of using pine oil for wood impregnation has been developed in Finland by Ecopine Ltd. Ecopine produces pine oil based products like liquid pine soap, lubricants, turpentine and wood preservatives. The method is being developed further, but in Finland you can already buy products treated with pine oil.

The tall oil impregnation method is based on wood's own protective substances. In nature the wood protects itself among others by producing extractive agents in damaged parts to prevent fungal spores and other pests to enter the heart of wood. The tall oil impregnation method imitates the same natural processes. In the impregnation process tall oil is soaked into the wood so that water is replaced by the oil in the wood. Therefore, the wood becomes dry of water and water repellent. Heat and pressure are used to control the process if needed.

The tall oil impregnation process is an environmental friendly wood protection method because no chemicals or other such substances are used:

1. No heavy metals are used in the process
2. No chemical or biological active biocides are used in the oil or in process

3. No VOC - compounds are used in the process
4. Oils are separated from timber, processed and impregnated into wood by using environmental friendly methods.

The process is not under the EU's Biocide-directive, because it lacks any biological active biocide treatments or components. The process can be taken through without using any volatile solvents.

After the impregnation the wood stands better rotten, insects, dirt and stress caused by the drying and wetting movement. The strength of the wood does not suffer from the process, which enables to utilize the wood as supporting structure, and the wood is easy to work with. When needed the wood can be soaked with tall oil throughout. It is practical to handle the wood fresh, which saves time, money and energy and dry it at the same time, because oil pushes the water away during the impregnation process. The processing of both broad-leaved and coniferous wood is possible. Besides, less worthy wood, usually uncommercial wood, can be handled with the impregnation process giving rather unlimited sources of raw material. Wood with small diameter can also be utilized in the process. The impregnation of round wood is performed so that the process does not cause any crackings to the wood. Tall oil can be tinted with different colours, which enables the impregnation and colouring of wood simultaneously during the process. Tall oil impregnated wood is suitable for in-door use as well as for rooms with high humidity, e.g. bathrooms. Impregnated wood is easy and safe to dispose by composting, combusting or recycling. Additionally, tall oil impregnated wood material has a character that can be used in personal and striking design.

Market characteristics and possibilities

Decking, Garden timber and environmental building

- Decks, environmental building, garden timber, public environmental building: timber will be protected with the new Ekopine -Tall Oil Impregnation.
- There is a tremendous interest in environmental friendly methods in market.
- Even only in Europe there is a huge market area:
  - garden timber, decking, terraces, balconies, corridors, handrails, garden slabs
  - fence elements, fence boards, gates, pergolas, flower boxes
  - garden furniture
  - supporting poles, embankment timber
  - important market areas are for example Germany, Austria, Switzerland, the Netherlands, Denmark, Great Britain, Belgium, France and Sweden
- Lots of possibilities for small wood processing companies and for continuing processing of sawn timber.
- Timber can also be coloured during protective impregnation.

The oil used in fast drying causing no cracks in the wood: for example door- and window industry, log house industry and heart-centred sawing

- Timber can be dried economically in a few hours from unseasoned to room dry timber - without cracks or other drying defects.
- The oil impregnation lowers changes of moisture content in wood. In connection with drying the oil can also be absorbed in wood. Possibility to artificial heartwood or homogenization of wood.
- Using timber sawn from one piece of wood in special objects – e.g. log. Totally new possibilities for little logs and heart-centred sawing. Drying of timber for door- and window industry: for example the drying time can be shortened from two weeks to 48 hours.
- Wooden decorative materials: floors, stairs
- Log house industry: fast and controlled drying of logs without cracks.
- Timber can be coloured in connection of drying.

Fast impregnation and colouring of weather boarding

- Pigment (for example earth colour) can be added to the impregnation oil. Timber will both be coloured and get oil protection. Oil will be absorbed deep inside the wood.
- Oil impregnated surface doesn't flake, blister or peel, but it wears slowly away by chalking. Easy to maintain - no removing of old paint. In re-handling loose dirt will be brushed off from the surface and wood can be treated again with wood oil.
- New possibilities to exterior painting and industrial finishing painting.
- Log house industry - wooden weather boarding and cladding.
- Lots of potential for example in coastal areas where pressure impregnated timber has been used as a weather boarding / cladding.

Oil treatment of heat treated or other modified timber

- Oiling or even oil impregnation of heat treated timber will help it to stand weather exposure.
- Connection of heat treating and oil impregnation in the same process.
- Lots of new possibilities in connecting the Tall Oil Impregnation and other new modifying techniques.

Oil as a surface finishing material of wood products

- Surface finishing oil for treatment of oil impregnated, salt impregnated, heat treated and unprotected (oiled and transparent treated) wood products.
- Oil treated timber will be preserved longer without changes in moisture content in wood or sticking.
- Maintenance of oil impregnated wood products.
- Concentrated and long lasting oil for surface finishing. Oil content up to 50 %

New possibilities for round timber by oil impregnation

- When impregnating green round timber with the Tall Oil it can be preserved without cracks that has always had harmful effect on processing round timber.
- New possibilities will be opened for round timber in environmental building.
- Simple and economical equipment in oil impregnation - simple and economical method.
- For example, in turning wood can be machined green and impregnation will be made immediately after the machining.

Case study – Improvement of the durability of chestnut (Castanea sativa Mill.) vineyard poles by oleothermic treatment.

A. Context within EURIS

Encapsuling the general theme of "Europeans Using Round wood Innovatively and Sustainably", and in turn supporting the project's study module; this EURIS case study adhere to the following set of parameters:

- it utilize small round wood which is not high quality and without seasoned process;
- the chestnut copses are given up because the wood products have a limited market;
- the ring shake problem can be bypassed cutting young trees;
- the proposed process is innovative (dire che è stato fatto dai francesi?);
- the proposed process is sustainable, both in production and whit regard to the forest resources;
- the proposed process has good possibility to transfer and provide good potential for local added value;
- the vegetable oil should be a low environmental impact preservative;
- the oil treated wood could be used in high biological hazard class;

B. Background

Thanks to strong chestnut sucker ability and htanks to the rapid growth of its suckers, chestnut coppices produce timber for a variety of uses (poles, boards, staves, beams, etc.).

Generally chestnut coppices are cut when the suckers have reached dimensions needed by the local market demands. Short shifts are not used, currently the cutting is carried out every 15-20 years to obtain medium or big logs destined to vineyard poles, poles and stakes. To achieve assortments bigger than 20 cm diameter it's necessary to harvest 2-3 shift old sapling. Long shift are used to obtain high diameter suckers to reduce sapwood percentage respect to heartwood percentage which is more durable and resistant for poles and stakes. Thought older suckers frequently present ring shake.

Generally, the thickness of sapwood, which is not durable to biological attacks, is 3-5 grow rings so, for small diameter assortments, it is advisable a preservative treatment that increases service life.

Untreated wood products exposed for an outdoor environment easily degrades biologically. The process is accelerated especially if the wood is brought into contact with soil and infected by rot. The most common and effective preservatives used today are based on inorganic metal salts. These systems have lately questioned due to environmental reasons. There is a growing public concern and demand for environmental friendly alternatives to chemical preservatives used in the past and in the present. Hence, the interest for natural oils to serve us a wood protection is increasing. Linseed oil has since a long time found use as surface coating or additives to existing coating systems: today there is much interest on develop impregnation or similar wood treatment (Olsson, et al. 2001)

Currently CIRAD (Montpellier, France) is developing a new oleothermic wood treatment process. We think that this process could be interesting to impregnate chestnut poles for utilising them in Tuscany vineyard.

Service life poles should be increased by this treatment because the oil should confer wood water repellency. Splits and cracks on the outer surfaces of the wood increasing the tannins leaching; in order to reduce both of these phenomena, it has been envisaged to treat green chestnut small round wood with oil.

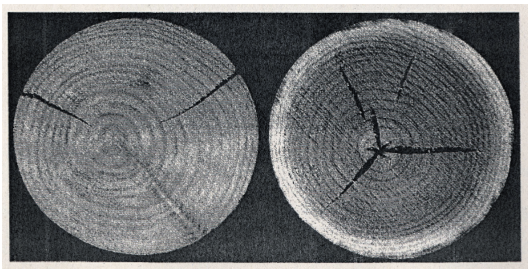


Figure 1: On the left disk of naturally seasoned wood; on the right a disk
of naturally seasoned wood after the oil treatment (Thévenon, 2001).

C. Method

CIRAD oleothermic wood treatment it is through two steps.
The first stage consists of submerging the wooden pieces into an heated oil bath. In the presence of strong heat flows, the material warms up to over 100°C. The water which is contained in the cells, evaporates creating an over pressure inside the wood. This steaming move from the surface to the centre.
There is a steam repulsion outside the wooden piece, mostly in the fibre direction. In the second stage the wood piece in soaked into an oil bath at a lower temperature than the water boiling temperature, at the pressure in the cold bath.
The wooden piece then cools down leading the water condensation. The created low pressure causes oil penetration (Grenier, et al. 2003).

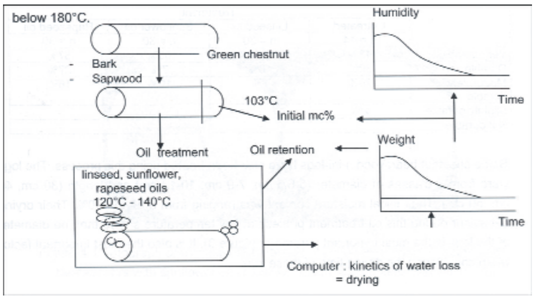


Figure 2: Steps of the oil treatment.

The process advantage are the following:

- the process doesn't need seasoned wood: a fast wood drying is performed during the first process stage whit a high thermal efficiency and without material damages;
- the process exploits the wood thermosensitive proprieties;
- in the specific chestnut case the oil treatment should prevent tannins leaching;
- the possibility to use oils as preservatives without a pressure recourse during the impregnation process;
- linseed oil could be a valid alternative to the metal salts based preservative because it could have a low environmental impact respect traditional preservatives;
- the ease of use of the equipment.

According to the protocol IVALSA started a research in order to assess, following the International standards, the real durability of the treated material.
Some chestnut poles "vineyard dimensions" and some samples dimensioned according to EN 252 standard, have been sent to CIRAD in Montpellier in order to be treated with hot linseed oil.
Poles and samples will be put in contact with the soil in a real vineyard for at least 5 years, as stated by EN 252.

Figure 3:chestnut poles treated with hot linseed oil.

D. Forest resources

Chestnut wood importance in Italy is demonstrated by the woodland area covered by this forestry specie: 650 000 ha. The chestnut woods can be split in:

- high forest, about 70% of them are used for fruit production;
- coppices, used for poles and small dimen sions round wood production.

In Tuscany chestnut woods cover 80.000 ha (36% of the total regional woodland), 93,5% of them are high forests for fruit production. Sometimes on the sidelines of chestnut coppices should be found some Quercus, Acer and Prunus trees.
Thanks to their strong mass productions, the chestnut coppices are one of the most intensive forestry farming in Italy. Where there are ideal soil and climate conditions, at the shift end it should be overtaken 20 m3/ha-year, productiveness that can suggest to utilize chestnut for arboriculture.
Basically to improve chestnut coppices management, should be considerable longer shifts and small felling of trees in order to reduce the environmental impact. Small round wood assortments should be obtained in any case from thinning.
It should be remembered that in Italy phytosanitary problems involve the chestnut trees, whit attacks on living trees due to Phytoptora cambivora (Petri) Busim. and Criphonectria (Endothia) prasitica (Murr.) Barr.

E. Suggestions of further study

We can suggest to realise laboratory tests about the accelerated evaluation of the oil treated wood resistance, and study the possibility to use this oil treatment on different wood species also hard treatable ones whit traditional systems.

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Self-assessment

Questions

1. What is the timbre trade's definition of high durability?

a. Timber with long service time;
b. Timber originated from sustainable production systems;
c. Timber produced with low environmental impact;
d. Timber with low costs of maintenance.

2. In Europe wood materials are ranked into five classes according to their durability. Place the next 10 species in the appropriate durability class.

Ash (Fraxinus ssp.)
Birch (Betula ssp.)
Black locust (Robinia pseudo-acacia)
Douglas fir (Pseudotsuga mensziessii)

European oak (Quercus ssp.)
Maple (Acer pseudoplatanus)
Pine (Pinus ssp.)

Poplar (Populus ssp.)
Spruce (Picea ssp.)
Willow (Salix ssp.)

Class 2
Durable

Class 3
Moderately durable

Class 5
Not durable

3. To what phenomenon the durability of wood is determined?

a. Environment;
b. Production systems;
c. Genes of the species;
d. Availability of water and minerals for tree species.

4. Enumerate 3 of the most common technolgies used to improve the durability of wood which fit into the European policy towards environmental protection.

5. Enumerate 3 of the most important advantages of the heat-treated timber in comparison with the traditional impregnation methods.

6. What characteristic of wood is effected most by heat treatment?

a. Bending strength
b. Compression strength
c. Stiffness
d. Weight

7. There are different heat treatment procedres. Place the heat treatment procedure in increasing order of temperature used during treatment

a. Stellac-Bois Perdure-Plato
b. Bois Perdure-Stellac-Plato
c. Plato-Stellac-Bois Perdure

8. In one of the heat treatment systems wood is heat in water before it is dry heated. This treatment system is:

a. NOW
b. PLATO
c. Thermowood
d. Oil treatment

9. In a number of heat treatment systems the timber is heated in an nitrogen environment. This is done because:

a. Nitrogen reacts with the molecules of the wood and because of that the wood is not recognized by fungi anymore.
b. In a nitrogen environment no harmful waste products will be formed.
c. At these high temperatures wood will be burnt if heated in an oxygen environment

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