ADVANCES IN DRYING AND PRESERVATIVE TREATING OF WOOD

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Summary

Creosote treating of wood has seen a renaissance in Europe with the introduction of new plant designs, processes and creosote oils that reduce the risk of bleeding and keep the content of benzo-a-phyrene below the EU defined maximum level of 50 ppm. Simultaneously the introduction of a new process of drying wood with super-heated steam at temperatures below 100° has lowered the cost of pre-drying by decreasing energy consumption and reducing the drying time 3 - 7 times.

1. Introduction

Wood treaters in Europe generally use 3 different types of preservatives: creosote, water-borne salts, and light organic solvent preservatives.

For creosote a number of improvements have been seen both with regard to the preservative, the treated product, and the market for the past 4 to 5 years.

Water-borne salt impregnation, which is by far the most important type of industrial wood preservation in Europe, has experienced a very positive development with regard to increased turn-over and profits, but also great difficulties with the authorities in many European countries, who are, among other actions, trying to ban the use of arsenic and chromium. On the subject of fixation, regulations have become ever more strict in Western Europe, but industry has generally coped reasonably well with this by introducing various types of steam and vacuum-steam fixation systems. The only sad thing about this is the fact that the currently used processes for accelerated fixation, such as steam and vacuum-steam (table 1), are not suitable for the new types of preservatives without chromium that are being introduced on the market, and many treating companies risk to find themselves in a position where they have invested heavily in new technology that becomes obsolete after perhaps only 2 to 3 years.

But the worst problem really is that most of the new preservatives without chromium - generally with copper as the main, or perhaps the only fungicide - are performing more poorly than even the worst expectations. The treating industry, in those European countries which have been forced to use the new preservatives, is experiencing major problems with penetration, filtration, leaching, pre-mature failure after 2 - 3 years service life, and heavy discoloration due to mould-growth on the freshly treated timber, just to mention a few of the draw-backs. In Sweden, where chromium free preservatives were introduced at the beginning of 1994, the wood treaters like to say that their country is the biggest field test ever in the world with perhaps 100.000 - 200.000 m3 of wood being sold and used every year with a range of new preservatives where the formulations have been changed perhaps 3 - 4 times during the past 18 months. Who will pay the cost of this, the greatest field test in the world, when some of the wood starts to fail after perhaps 2 - 3 years, nobody knows at present. Since the title of this paper starts with "advances", it will not deal any further with the new chromium free preservatives.

But the situation for light organic solvent preservatives, which are mainly used for treatment of joinery products such as doors and window frames, is also bad, as no important product developments have occured, and the market has shown a downward trend for quite some years now. This type of wood preservation again simply falls outside the title of this paper.

On the positive side, pre-drying of timber before impregnation has finally seen the break-through of a novel drying-process that was introduced a few years ago. The process is using super-heated steam at temperatures below 100° centigrade, and among the advantages is rapid drying, which is 3 - 7 times faster than conventional methods, improved penetration even into the heartwood, and a reduction in the total energy-cost of about 50%.

2. Creosote impregnation

Creosote seemed almost moribund as an important wood preservative in Europe 5 - 10 years ago. It was under attack for being carcinogenic, a major pollutant of lakes and rivers in several countries, unacceptable for labor-unions because of the dirty wood surfaces, and impossible to dispose of.

But all that has changed, due to efforts from a younger generation of wood treaters and from more flexible creosote manufacturers. At present, in most countries, creosote is a bright star on the wood preservation sky, and appears to be a product for the future.

On the subjects of toxicology, the European Union (EU), after much discussion, finally approved creosote as a preservative for industrial use on condition that the benzo-a-phyrene content was kept below 50 ppm. At the same time the manufacturers of creosote were successful in developing creosote oils that not only meet this requirement, but also contain decreased amounts of aeromatic substances.

The enclosed pressure vessel plant

At the same time, a new type of creosote impregnation plant was introduced. The major feature of the plant is the design, where the cylindrical pressure vessel is put inside a square pre-heater. This ensures that the working temperature can always be kept at a high level in all parts of the plant and also inside the wood. Before impregnation the creosote in the pre-heater will keep the autoclave heated to about 110°, when the wood is put inside. The short pipe-lines between the preheater and the autoclave result in a limited heat-loss during the process, and the creosote is maintained constantly at temperatures above 100° C inside the plant. The high temperature is essential for rapid penetration with a homogeneous creosote oil, which again is most important to ensure a surface-dry creosoted timber by the end of the process, and timber that will not bleed after being put into use.

For countries with colder climates where it might be difficult to heat the timber before impregnation, it is normal practise with this type of plant to enter a charge of wood by the end of the work-day, fill the autoclave with creosote oil to just below the level of the wood packs, and let the creosote oil and vapours inside the autoclave be heated by the surrounding preheater for up to 8 hours. This will partly dry wood with a high moisture content, and furthermore heat it in preparation for the actual impregnation process to prevent the temperature to drop too low during the initial stages of the treating process.

The plant is well suited for the recently introduced creosote oils with benzo-a-phyrene contents below 50 ppm which are not allowed to come under 40° at any time during the process in the plant as well as in the wood.

This type of creosote plants are always fitted with an incineration system which keeps all emmisions, whether in vapour-form or in liquid form, from the plant itself, below the toxic values, and the plants are considered to be emmission-free, which makes the approval procedure simple and quick.

During the past 2 years, new plants have been equipped with a cooling-cylinder at one end of the pressure vessel. The purposes of the cooling-cylinder are several. The main purpose is to cool down the wood after the impregnation process, to limit emmissions of vapour from the treated wood to the environment. During the cooling-phase, which lasts about 3 hours, the temperature in the cylinder drops to about 40°. The actual effect of the cooling is presently being investigated and will be reported later at different conferences. But one main effect of the cooling-cylinder is to let the final vacuum take its full effect in the wood to permit any surplus creosote on the surface of the timber to be sucked into the outer few millimeters and prevent any dripping outside the self-contained plant. A third advantage is to collect any dripping of creosote from the trolleys and other iron parts that have been inside the pressure vessel during the impregnation process and is not influenced by the final vacuum. A typical creosoting process including after-cooling is shown in table 2.

Double butt-end treatment of poles

In Europe, creosote impregnation is also becoming more important as new, less effective water-borne salts are introduced. Utility poles are being impregnated with water-borne preservatives without arsenic and perhaps subsequently without chromium in their full length, whereupon the butt-end of the poles are being treated in a tilting autoclave. The height of the butt-end treatment corresponds to the part of the pole that goes into the ground afterwards. The advantages are poles that will last longer and are more safe due to the double-impregnation, and at the same time they are pleasant to climb as the part of the poles outside ground-contact is impregnated only with a clean, water-borne preservative. This keeps the labor-unions happy and the utility companies more confident. For the butt-end treatment, the same design is used as for horisontal impregnation plants, as the surrounding pre-heater follows the pressure vessel. During impregnation, partly due to the surrounding pre-heater, vapours at high temperatures evaporate from the lower part of the pressure-vessel to the top-end and lead to instant fixation of the water-borne salt in the whole length of the pole.

Selective treatment

An alternative to the double butt-end treatment of poles was introduced as an idea in Europe in 1983 but only recently implemented at an industrial scale. Instead of impregnating the poles in the full length with water-borne preservatives, they are treated with creosote in a plant in horizontal position at a retention of 75 kg/m3/sapwood, lower than normal (135 kg/m3/sapwood), in the full length, whereupon the impregnation plant (table 3) with the poles is raised to an almost vertical position and the lower part of the poles are exposed to a second pressure-phase and impregnated to a high retention of 150 kg/m3/sapwood in the part of the poles which is later to have ground contact.

The advantage of the so-called selective treatment is to limit the risk of bleeding in the part of a pole which is climbed afterwards, and to assure sufficient service-life in the part of the pole with ground contact. The reason for increasing the retention to 150 kg/m3/sapwood instead of 135 kg/m3/sapwood is to compensate for the normal downwards movement of creosote in poles during their first years of life.

Disposal

One of the great advantages of creosote impregnation is the easy disposal of residues from the treatment plant itself, as well as disposal of the treated timber at the end of its service-life.

Most of the modern creosoting plants in Europe are equipped with a closed tightening system for the vacuum pumps, and the plants then do not produce any waste water. All vapours from the plant itself are being incinerated in the boiler system attached to the plant and transformed into non toxic substances. Any contaminated water that may arise during treatment are heated to above 100° inside the plant, and the vapours are eventually incinerated.

At the end of its service-life, creosoted timber can be collected by the treating companies, and after being transformed into chips it is also incinerated at temperatures above 800°. The energy produced exceeds the need of the treating and drying plant and is sold to local communities close to the treatment plants.

The last recognized problem in Europe today, which needs to be finally solved is the fumes from the timber right after the impregnation process. The cooling system does minimize the amount of vapours that are emitted to the environment. The total effect of the cooling system must be investigated further and improvements can certainly be found.

2. Accelerated pre-drying

The main softwood-species used for treated timber is scots pine in Northern and Southern Europe. It is easily permeable in the sapwood, provided it has been dried down to below 25% moisture content. In Central Europe, large quantities of refractory spruce are also being impregnated. For spruce, it is generally a requirement that it should also be dried down to below 30% moisture content if special impregnation processes which are suitable for wet timber, such a sap-displacement or OPM/APM, are not being employed.

A problem with roundwood, and in less developed timber countries like Poland also with sawn wood, is pre-drying. It takes long time and costs a lot of energy in conventional heat-and-vent dry kilns, and the manufacturers of treated wooden products find it difficult to wait the necessary time for air-drying to take place.

Drying with superheated steam under vacuum

Som years ago, a new process for drying wood with super-heated steam under vacuum was introduced. The advantages are rapid drying, for many dimensions of timber and poles 5 - 10 times as quick as in a conventional heat-and-vent kiln, and low heat energy costs.

The original system, called the Moldrup-process after the inventor, employs a vacuum autoclave (table 4). After introducing the wood into the autoclave on trolleys, an almost complete vacuum is established in the autoclave and the wood. Due to the vacuum, small amounts of humidity are released from the wood in vapour-form. The water-vapours are then circulated by fans inside the autoclave through heating coils that increase the temperature of the vapours to between 60° and 80°. The hot vapours are then circulated through the stacks of wood, which must have sticks between each layer for an easy transfer of heat-energy inside the packs, and the wood is heated through its full thickness to the wanted working temperature, which must be between 50° and 90°. During the heating phase, the relative vapour pressure inside the autoclave must be kept as close to 95% as possible to avoid any premature drying that could provoke case-harding and tension.

After the wood has reached the desired working temperature, steam is extracted from the autoclave and condensed, which causes the relative vapour pressure (table 5) to drop below 95% inside the autoclave and the actual drying of the wood commences. The wood humidity is released in the form of vapour, and by controlling the amount of steam that is extracted from the autoclave, the relative vapour pressure inside the autoclave can be precisely controlled to suit the appropriate drying programme. Due to the evaporation of the wood-humidity by pressure differences, and the rapid contribution of necessary heat-energy through circulation of the water-vapour, the drying is 3 - 7 times more rapid than with conventional heat-and-vent kilns. The control of the climate inside the autoclave with the relative vapour-pressure, the quality of drying can be improved compared to conventional drying systems.

The drying time for pine-wood with an initial moisture content of about 80% to a maximum of about 30% is approximately 24 hours for 100 mm thick material and 48 - 60 hours for 180 mm poles.

Due to the extremely favourable conditions for heat transfer inside the autoclave with steam as the transfer medium, the consumption of heat energy is only about 30% of that of a heat-and-vent conventional kiln. The eletricity consumption is slightly higher, and the total energy consumption is less than 50% of even the best of the heat- and-vent kilns.

The Moldrup-process has many similarities to high temperature drying with super-heated steam above 100°, but not some of the disadvantages, such as discolouration of the wood.

One feature which needs further investigation to be finally confirmed concerns a markedly improved penetration of preservative into the heartwood. Wood that has been dried with super-heated steam under vacuum shows considerable heartwood penetration as well as good penetration in the sapwood even if the moisture content is between 25% and 35% in some pieces. During the drying, large amounts of resins are extracted from the wood, where some of the harder components are deposited on the surface but the more volatile parts evaporate together with the wood moisture. One explanation for the improvement in heartwood penetration is that the preservative quickly and easily enters the wood through the now empty resin-tubes.

Accelerated fixation

Apart from being used for pre-drying, the Moldrup plants are also employed for accelerated fixation of the chromium containing water-borne preservatives after impregnation. With this plant it is possible to transfer larges amounts of heat to the treated wood and thus provoking a fixation at 60° after 1 - 2 hours, depending on wood thickness.

Note: Temperatures are always quoted as ° celcius.

3. Literature

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Figure 1

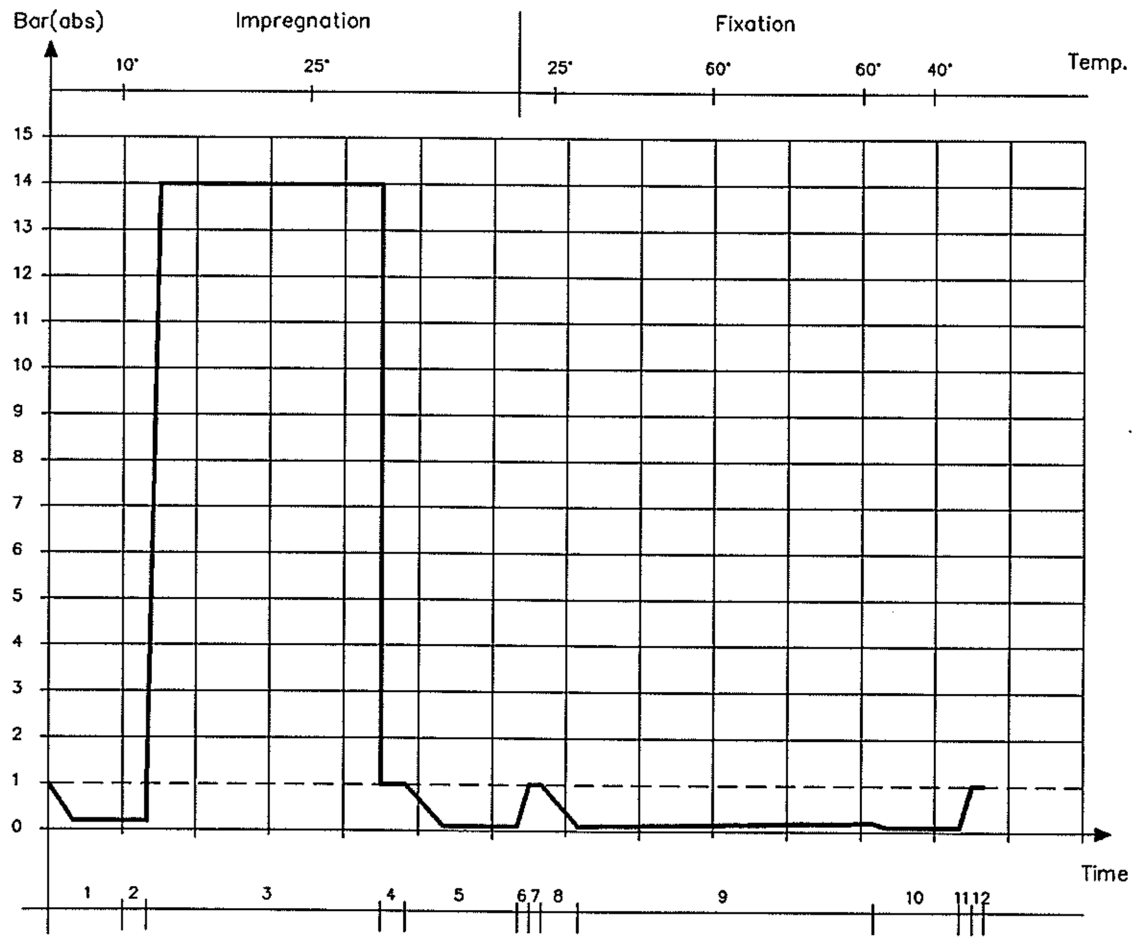
IWT Vacuum – steam fixation

	Time	Pressure
1. Initial vacuum	30 min.	0.20 bar
2. Filling	10 min.	
3. Pressure phase	95 min.	14 bar
4. Emptying	10 min.	
5. Final vacuum	45 min.	0.10 bar
6. Air equalization	5 min.	
7. Final emptying	5 min.	
8. Initial vacuum	15 min.	0.10 bar
9. Vacuum–steam fixation	120 min.	0.20 bar
10. Final cooling	35 min.	0.10 bar
11. Air equalization	5 min.	
12. Final emptying	5 min.	
Process time	380 min.	

Energy consumption : 4.5 kW/m³

Water consumption : 300 L/m³

Heat consumption : 41 kW/m³



2000562–PBP/24.10.1991

Figure 2

IWT Creosote process

	Time	Pressure
1. Initial filling	5 min.	1.00 bar
2. Initial pressure (Air)	15 min.	5.00 bar
3. Filling	10 min.	5.00 bar
4. Pressure (Liquid)	30 min.	13.00 bar
5. Emptying	10 min.	
6. Final vacuum	100 min.	0.10 bar
7. Air equalisation	5 min.	
8. Final emptying	5 min.	
9. Cooling	180 min.	1.00 bar
Process time	360 min.	

Electricity consumption: 4.5 kW/m³

Heat consumption: 99.8 kW/m³

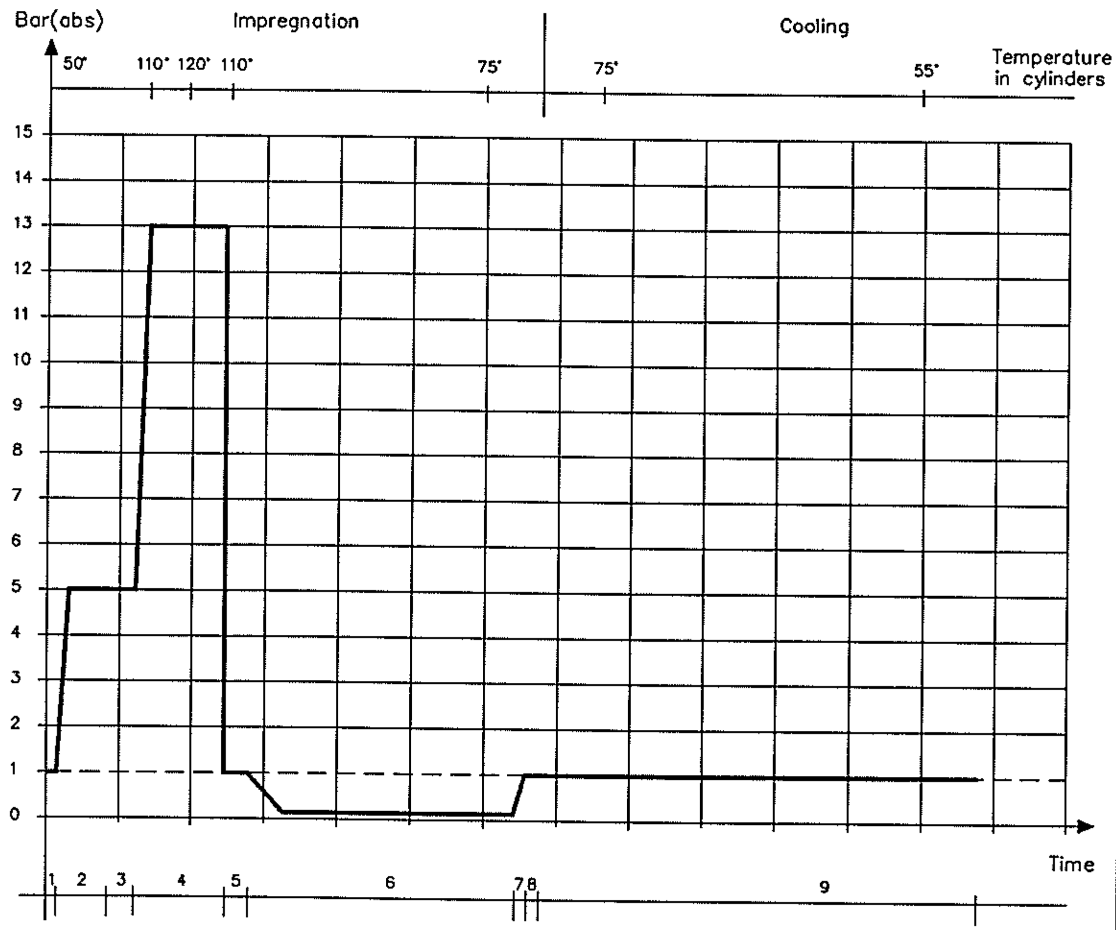


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Figure 3 IWT Selective Creosoting plant.

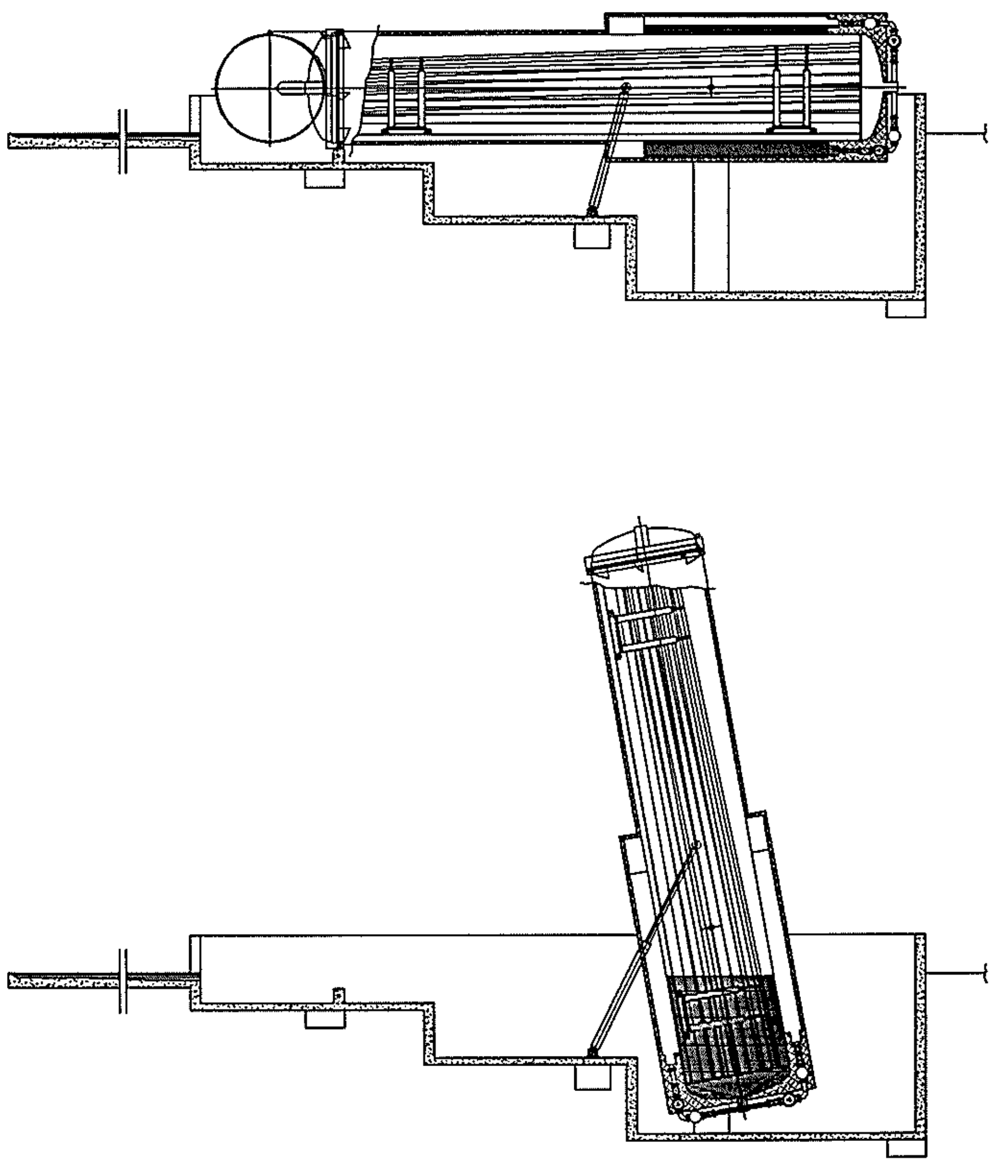
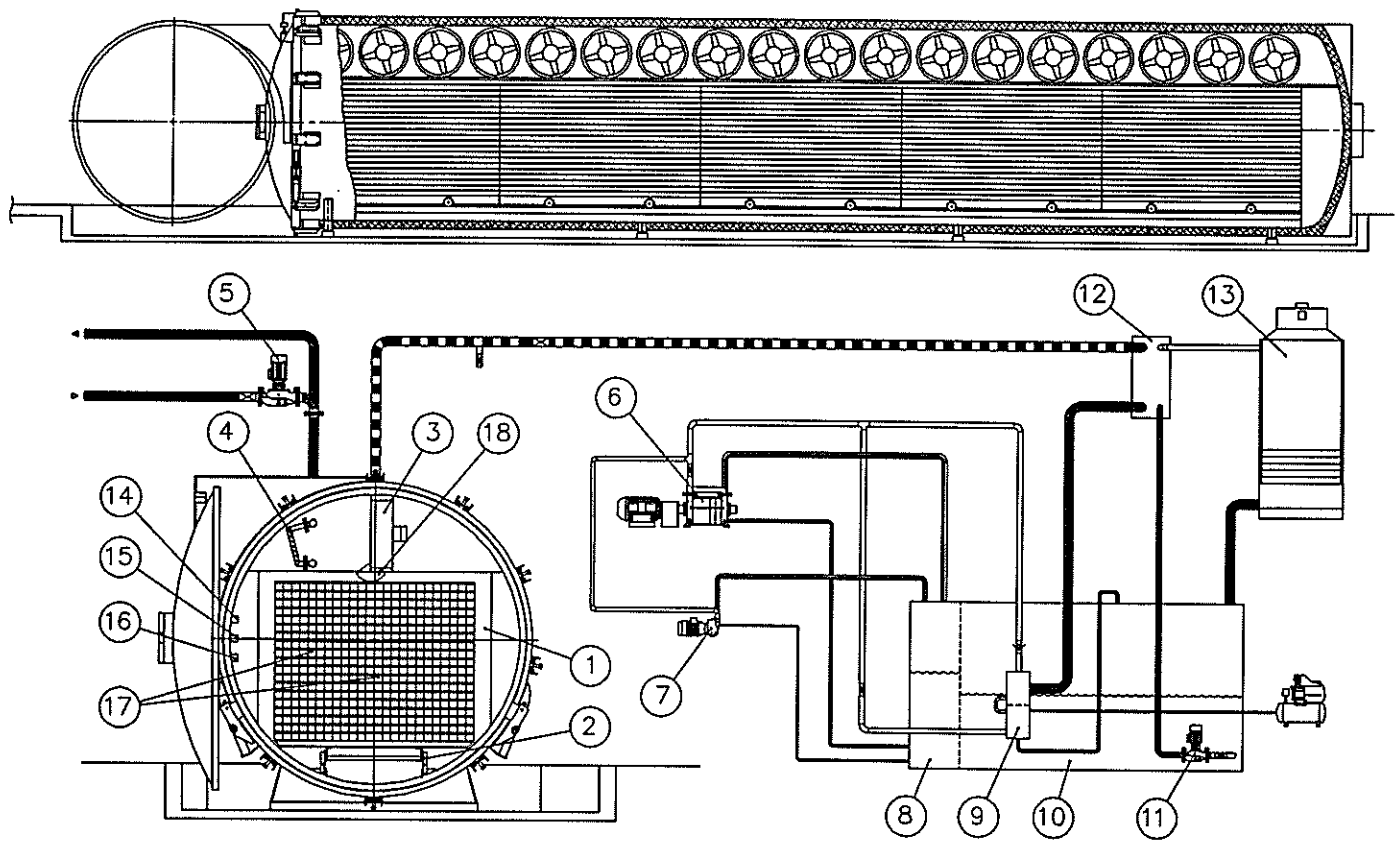


Figure 4

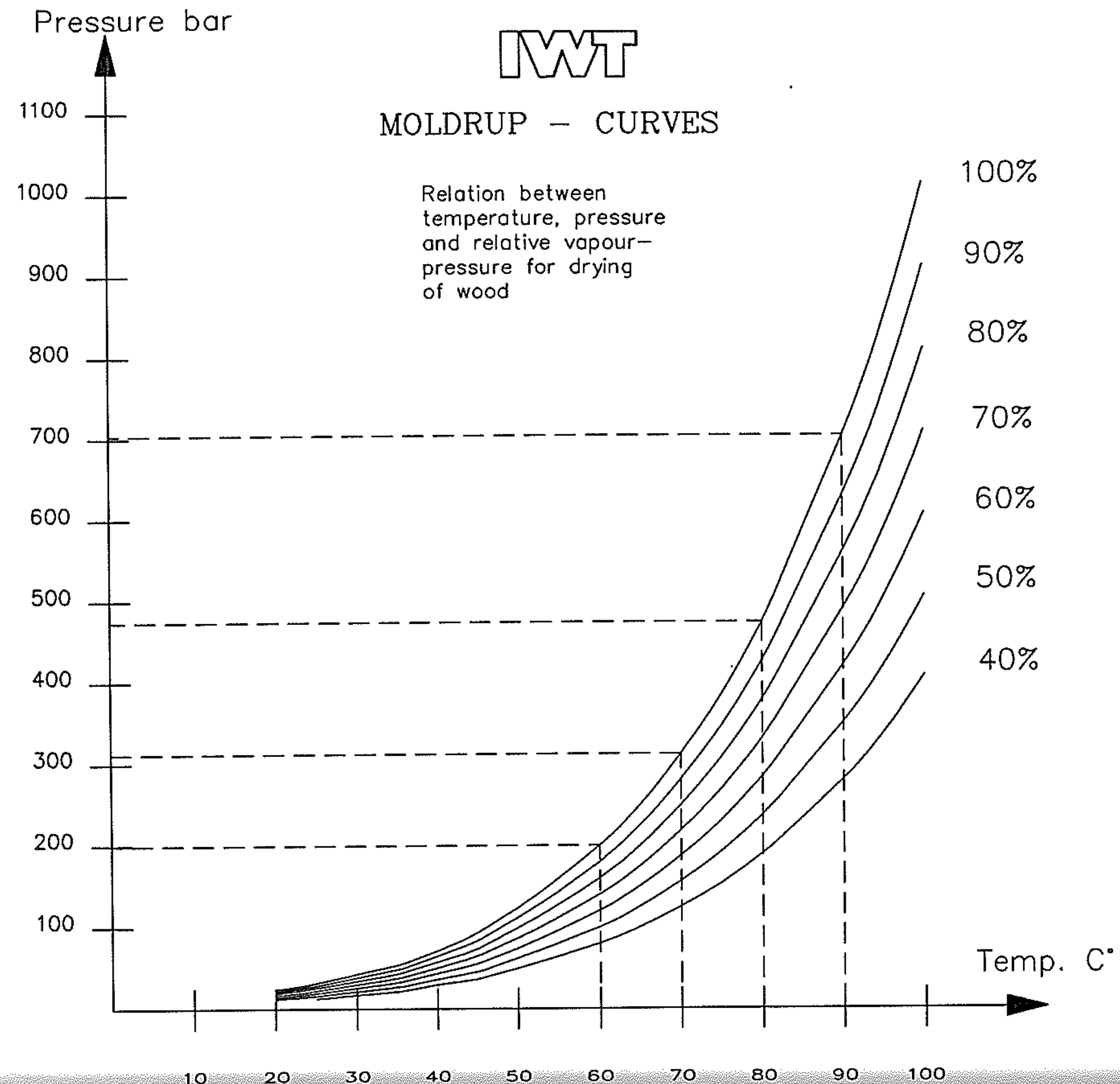
IWT

MOLDRUP DRYING KILN



1. Autoclave (ø2600x4000)
2. Trolleys
3. Fans
4. Heating coils
5. Heating circulation pump
6. Vacuum pump for initial vacuum
7. Air suction pump
8. Storage tank for tightening medium
9. Measuring tank
10. Condensate storage tank
11. Cooling medium circulation pump
12. Plate cooler
13. Cooling tower
14. Pressure transmitter
15. Equilibrium moisture sensor
16. Temperature sensor
17. Wood on 18mm sticks
18. Steam flow control

Figure 5



Pressure bar
MOLDRUP - CURVES
Relation between temperature, pressure and relative vapour-pressure for drying of wood
1100
1000
900
800
700
600
500
400
300
200
100
100%
90%
80%
70%
60%
50%
40%
Temp. C°
10
20
30
40
50
60
70
80
90
100
1002347