IR BELT DRYER

~~A.Technology page 1-19~~

B. Drying Theory page 20-26

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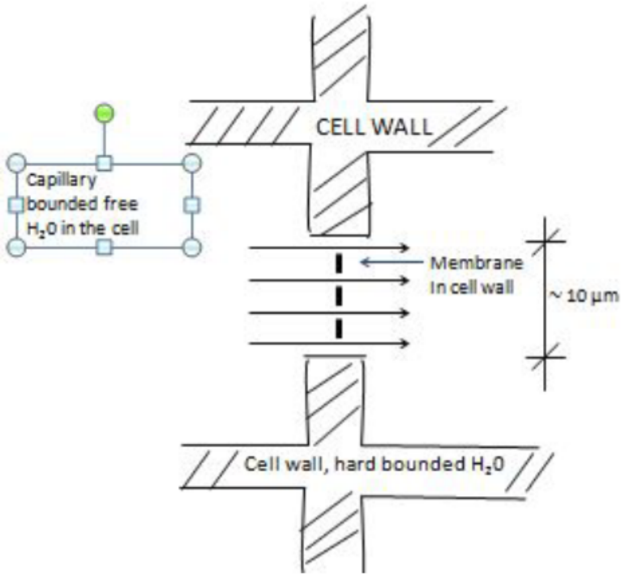
IR-belt dryer
Theory

Examples of material we dehumidify on the belt are sludge, sawdust, lignin and potato peel, potato chips, all of which are permeable cell structures.



95% of the product's granular size are in the 100-1,000µm range. The drying material, approximately 750kg lying on the conveyor belt, has a surface area that is much greater than the total surface area of the Netherlands.

The volume of the drying material remains constant throughout the drying process, i.e. dV=0.

IR-belt dryer

Theory

The most prevalent wavelengths are λ_{max} = 6-8 µm at a drying temperature of approx. 500K.
Shorter wavelengths λ penetrate the cell membranes more easily and are also carrying more energy according to

$$E = h \times f = \frac{h \times c}{\lambda} \text{ ; } c = \text{speed of light}$$

The tests done by Södra it is evident the core temperature of the drying material is higher than on the surface. That also means the pressure is higher inside the drying material. At a raised diffusion pressure the moisture evaporation increases, kg/m^2s, and thereby the drying capacity of this drying process in comparison to a dryer that works with thermal conductivity with the opposite direction of pressure and temperature compared to the direction of the moisture diffusion.

IR-belt dryer
Theory

With a elevated core temperature in the drying material the disorder within the water molecules increases, i.e. the enthropy (S) increases.
Dehumidifying is a chemical thermodynamic process, which is the sum of the altered bindings n enthalpy (I) and altered disorder n enthropy (S).
When a mol (18.02g) H_20 evaporates at 100^oC the following formula ΔS=S(g)n S(l)=109J/mol K is known.

H_20 (l) $\rightleftharpoons$ H_20 (g)
Liquid Steam

These reversible arrows symbolise that the evaporation (dehumidifying) is never complete, 100%.

The outlet temperature of the product is approximately 60^0 C.

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The enthropy change in the drying material:
T_1 = the surface temperature of the material, approx. 373K. T_2 = the core temperature of the material, approx. 378K.

We end up with

$$S_2 - S_1 = \int_1^2 \frac{dQ}{T}$$

dQ = dU + dW
dU = $mc_{(s)}$dT and dW=pdV
but dV=0 → dW=0 →

$$S_2 - S_1 = mc_{(s)} \int_1^2 mc_{(s)} \frac{dT}{T}$$

S_2-S_1 = 18.02 x 2257 (In378-In373)
S_2-S_1 = 542 J/mol K
(S_2-S_1) > 0 which means the heat must be taken from the surrounding area, i.e. from the outer parts of the drying material.
I.e. the radiation only needs to be applied to the surface, and the drying process is driven by the enthropy.

(S_2-S_1) / 5 = 542 / 5 ≅ 109 J/mol K as above.

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Date
2009-02-16

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Test drying with TDS drier in Aurland

TDS drier

During this test, 10m^3 was dried and the energy consumption was registered. After this, the drier was run empty in order to determine the losses, with the same programme as used during the drying process.

A full drier, as per the size in Aurland, can dry 48 m^3 per load and the reference data was scaled up to simulate a full drier load. The loss was split across 48m^3 as this is more or less constant regardless of amount being dried.

The timber was measured for moisture content both before and after the drying process and density was established. The amount of water that had evaporated could then be determined and the energy consumption per kg evaporated moisture was calculated.
The energy consumption turned out to be **0.8kWh/kg evaporated.**

Chamber drying at Södra Timber Värö (STV).

The energy consumption in a progressive drier has been estimated to 80% of the energy consumption of a chamber drier and the production per year for a chamber drier at STV has now been set at 24,000 m^3. Production and energy data from 2007 was used for the calculation.
Inlet moisture content was established at 80% and outlet at 18%. Energy consumption is then **1.1 kWh/kg evaporated**.

Conclusion:

Nearly 30 % less energy per kg evaporated water is used by the TDS drier. A condensate of approximately 85°C is also obtained and if this heat is utilised, the overall efficiency increases even further.

SÖDRA

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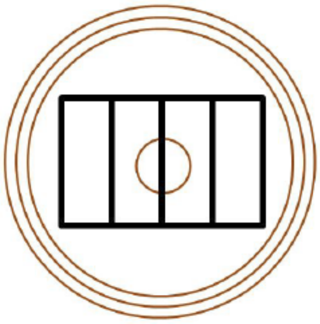
TEMPERATURE PROFILE IN THE TIMBER DURING THE DRYING PROCESS

Time	T centre	T surface
42	52	40
55	63	53
78	78	78
192	103	98
768	115	110
840	116	116
1080	124	121
1090	121	121
1120	69	74

IR-belt dryer



Test drying programme

White pine 47 x 200 [mm], 4-log

Step		Time (min.)	Medium	Moisture content (%)
I.	Heating	0-40	Steam	80
II.	Drying	-840	IR	10
III.	Equal.	-1090	Steam	18
IV.	Cooling	-1120	Air	18

The drying process finishes in step II with an average moisture content of approx. 10%, but with a significant standard deviation as the timber is part of individuals that have grown in soil of varying nutritional value.

In step III we add steam to equalise variations in moisture content.

The driest planks soak up more steam, so that the drying rate gets a standard deviation of 1.