Super Heated Steam Drying of Wood on Industrial Scale

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• Introduction
• Drying process
• Drying schedule
• Drying quality
• Kiln
• Conclusion
Targets of super heated steam drying

- Reducing drying time
- Saving energy
- Maintaining high drying quality
Woodstructur

Annual Ring
growth ring
2 mm

Woodstructur

pits
Process Steps

- Warming up
- Steaming (optional)
- Drying above FSP
- Drying below FSP
- Cooling down 1
- Conditioning / Drying (optional)
- Cooling down 2

Drying process

Warming-up phase
- all air initially present in the kiln will be replaced by steam
- relative humidity of the air is kept at a maximum level close to 100 %
- air vents are closed
- temperature of the drying medium approaches 100°C, the climate has changed into saturated steam

Drying phase
- saturated steam is heated in the kiln, the steam will become super heated
- free water inside the boards will start to boil
- boiling effects a slight overpressure in the wood
- internal overpressure speeds up the moisture transport from the core to the surface and consequently increases the drying rate
- diffusion coefficient increases at high temperatures
Wolfgang Gard, EDG Conference Riga/Latvia, 24.04.2007                    w.f.gard@tudelft.nl

The Netherlands

Drying process

Steam

T=120°C

100% steam at 0.1 MPa

valve

Drying

T_{\text{wood (above FSP)}} = \text{max.}100°C

T_{\text{wood (below FSP)}} > 100°C

Diffusionscoefficient

T=100°C

T=80°C

moisture content [%]
### Features of the drying systems

**Conventional drying (heat/vent)**
- Mixture of air/moisture during the whole drying process
- Drying force depends on partial pressure of the air mixture
- Suck in air from outside, warming up, venting moist air
- Air temperature < 100°C

**Super heated steam drying**
- Drying in a super heated steam atmosphere
- Drying force depends on moisture pressure in the wood
- No sucking in air from outside the kiln
- Drying medium (steam) > 100°C

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### Drying schedule (28 mm Spruce)

- **Warming up**
- **Drying above FSP**
- **Drying below FSP**
- **Conditioning**
- **Cooling down**

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Equilibrium Moisture Content

![Equilibrium Moisture Content Graph](image)

Wetbulb temperature = 100°C

Drying potential = MC\text{wood}/EMC\text{air}

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<th>SHSD EU</th>
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<td>2.5 .... 8</td>
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<td>Beech</td>
<td>2.2 ..... 3.8</td>
<td>max. 2.0</td>
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<td>7 .... 19</td>
<td>3 .... 5</td>
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Timber Quality

[Images of timber samples]

Timber Quality

[Images of timber samples]
Stack

- Stickers in line
- Good stickering
- Load on top
Kiln

Stoom supply
Control parameters

- Air Temperature
- Relative Humidity
- Wood Temperature
- Wood Moisture Content
- Process Time
Sensors

- r.H.
- temperature

Sensors

- mc
- wood temperature
Control System

Summary

Conditions for good drying results

- Defined timber
- Well stickered stacks
- Suitable drying schedule
- Kiln which can stand the conditions
- Heat and water/steam supply
- Even air flow along the timber surface
- Reliable sensors
- Control system which can handle the drying conditions
conclusions

• Super heated steam drying is a good option for drying European wood species: both soft- and hardwood.
• The combination steaming and drying (mainly hardwoods), results in shorter drying times and less energy consumption.
conclusions

• Depending on the required drying quality, drying time can be reduced up to 70% and energy consumption up to 20%.

• Future work will be focused on optimizing drying schedules for hardwood (incl. tropical timber).

Thank you very much for your attention