Drying of energy wood by compression

Based on: Laurila, J., Havimo, M. & Lauhanen, R. 2014. Compression drying of energy wood. Fuel Processing Technology.

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Introduction – Why to decrease the moisture content of energy wood?

- It is not wise to ”burn” water.
- The lower the moisture content of energy wood is the more energy is possible to produce.
- Heating value of dry wood is 5.3 MWh/ton and fresh wood 2.2 MWh/ton.
- Moisture content is the most important quality factor of energy wood.

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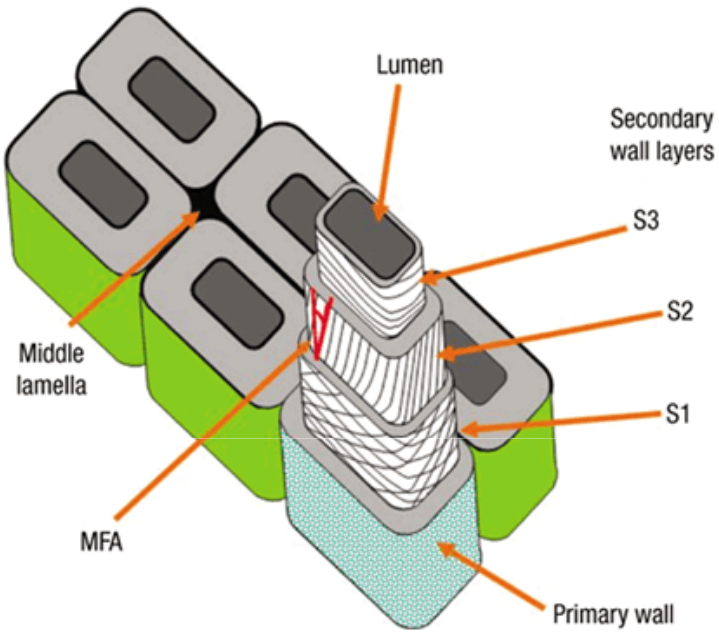
Introduction – Wood drying

- The drying of wood can be done either by using artificial drying (dryer) or by using natural conditions (solar energy and wind).
- Using the dryer is expensive.
- Using natural conditions is slow and results are not good (after 1 year in road-side storage the moisture content of energy wood is often over 40 % (wet basis)).

→ **Cheap, fast and simple drying method is needed!**

Introduction – Water in the wood

- Water is in the wood in two forms: in the cell walls and in cell lumens (so called free water).
- In the cell walls water is tightly bind by hydrogen bonds -> harder to remove.
- The free water can be removed by compressing the wood until the cellular structure collapses.



Structure of the wood. (David Kretschmann. 2003. Nature Materials 2, 775 – 776.)

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Introduction – Water in the wood

- When wood dries the free water in the lumen leaves first.
- Situation at which lumen is free of water, but the cell walls are fully saturated, is called fibre saturation point.
- The fibre saturation point differs between tree species and usually it ranges from 20 % to 25 % (wet basis).
- In theory wood can be dried by compression to the fibre saturation point.

Introduction – The aim of the study

- 1. Aim: How the pressing force and time effect on wood moisture content?
- 2. Aim: Could compression drying reduce the moisture content of wood to its fibre saturation point level (ca. 20-25 % wet basis)?

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Materials and methods - Samples

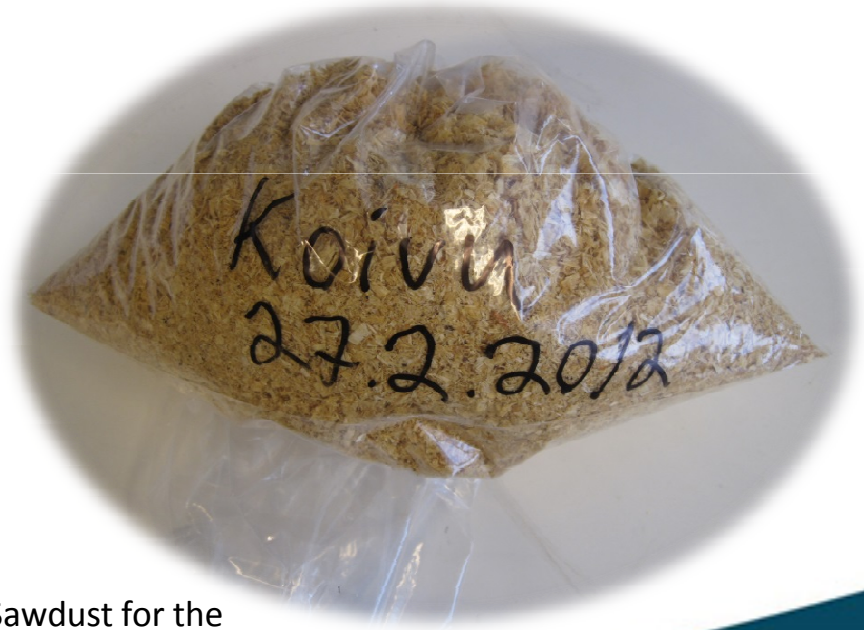
- Samples from freshly-felled Scots pine (Pinus silvestris), Norway spruce (Picea abies) and Downy birch (Betula pubescens).
- The samples consisted of chain-saw sawdust (without the bark).
- In each compression drying test 14 g of fresh wood was used.

Sawdust for the samples. Picture: Jussi Laurila.

Studied tree species. Picture: Jussi Laurila.

Materials and methods - Samples

- The sawdust particle size varied from 0.5 mm to 4.0 mm for all tree species.
- The moisture content (wet basis) of sawdust before the compression was:
  - 60 % for Scots pine
  - 63 % for Norway spruce
  - 45 % for Downy birch



Sawdust for the tests. Picture: Jussi Laurila.

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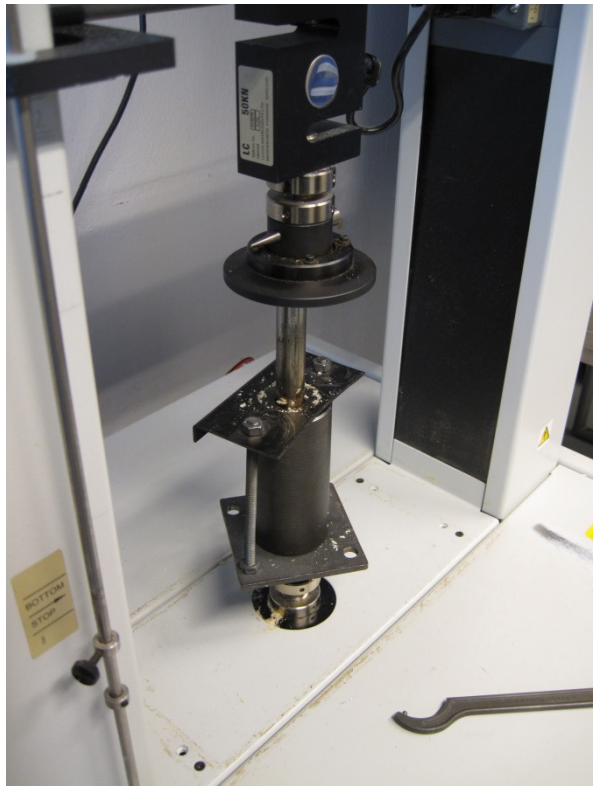
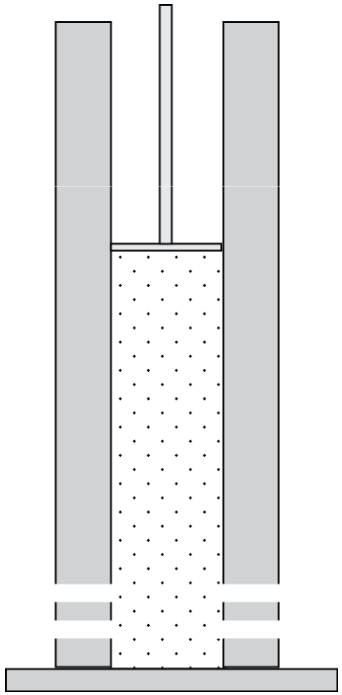
Materials and methods – Compression machine

- Lloyds EZ 50 machine with cylinder and piston was used for testing.
- Force and distance travelled by piston were used to calculate the work required in compression drying.
- The pressing range of the machine was 0 – 160 MPa with the accuracy of 0.5 %.





The drying cylinder and the piston. Pictures: Jussi Laurila.

Materials and methods – Pressing force and time

- Study included 6 momentary and 3 continuous wood compression drying tests.
- In momentary compression tests the pressure was relieved when the maximum force was reached.
- In continuous compression tests the maximum force was held 30 or 60 seconds.
- All tests were made 3 times, thus 27 compression tests per tree species were made.

Momentary compressing tests			
Test number	Pressing force, N	Pressing force, Mpa	Holding time, s
1.	2000	6	0
2.	4000	13	0
3.	6000	19	0
4.	8000	26	0
5.	10000	32	0
6.	12000	38	0
Continuous compressing tests			
Test number	Pressing force, N	Pressing force, Mpa	Holding time, s
7.	4000	13	30
8.	4000	13	60
9.	12000	38	60

Compression drying tests.

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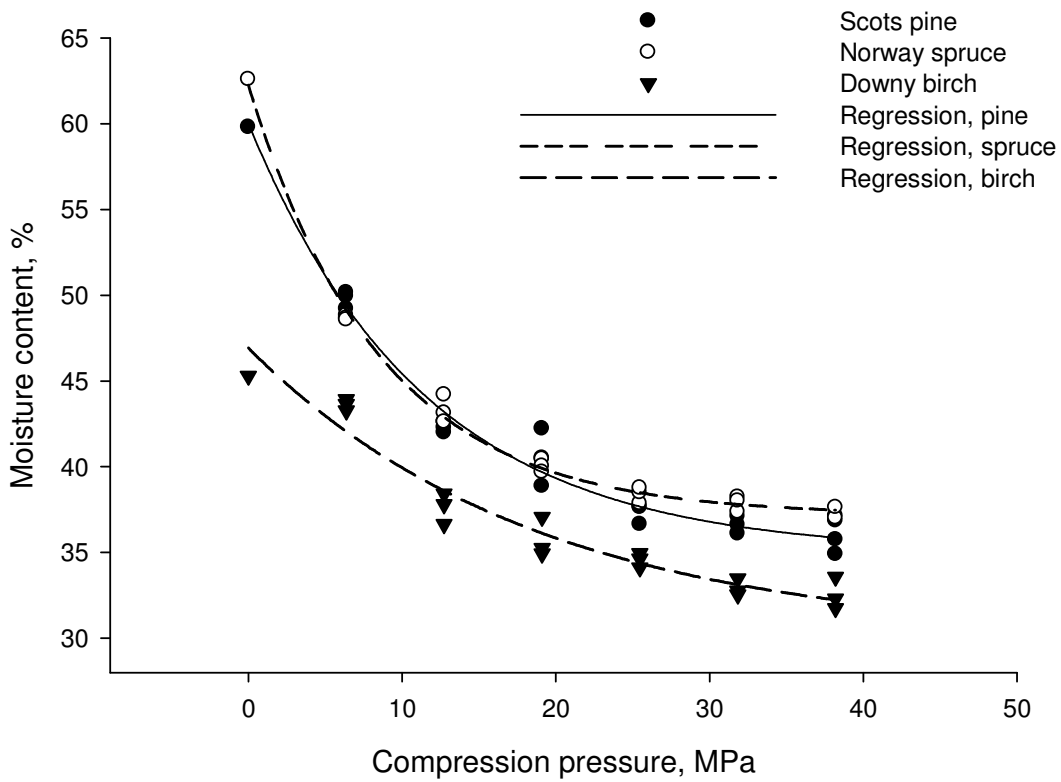
Results – Momentary compression tests

- Lowest moisture content (33 %) for birch at 38 Mpa.
- Drying rate of softwood was higher than hardwood.
- The coefficient of determination values for regression equations between 0.93 – 0.99.



Results – Compression tests with holding time

- Continuous pressing increased the wood's drying effect by 1 to 2 percentage units compared to momentary tests.
- Increase of pressing time from 30 to 60 seconds had only a marginal effect on the moisture content of the wood.
- The lowest moisture contents in this study for each tree species was achieved by using a continuous pressure of 38 MPa with 30 seconds holding time.

Tree species	Moisture content, %				
	Initial	13 Mpa		38 Mpa	
		0 second	30 second	0 second	30 second
Scots pine	60	42	41	36	34
Norway spruce	63	43	41	37	35
Downy birch	45	38	37	33	30

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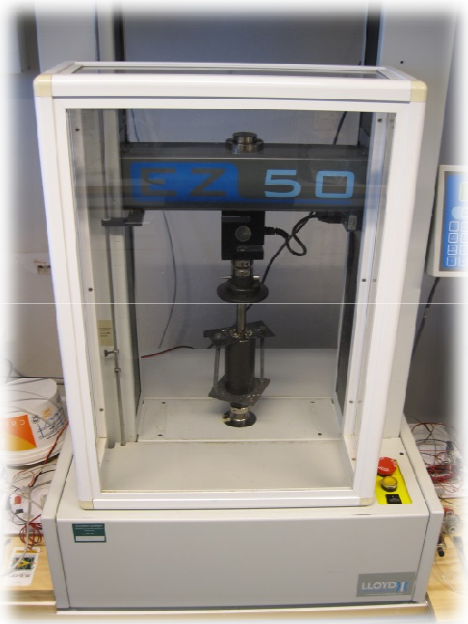
Results – Energy used in compression drying

- The energy used in the compression drying was calculated from the distance moved by the piston and the force required to move the piston.
- Energies required for the compression drying were:
  - 11 kJ/kg for pine
  - 9.7 kJ/kg for spruce
  - 41 kJ/kg for birch
- Energy requirements were calculated as an average of all the compression tests.
- These are theoretical values, since our calculation did not take into account the efficiency of the electrical motor driving the piston.



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Conclusions

- The level of the fibre saturation point was not reached in this study.
- Dewatering of wood depended mainly on the maximum compression force.
- Increasing the maximum compression force increased dewatering significantly up to pressure levels of 30 Mpa.
- Increasing of the pressing time from 0 second (momentary compression) to 30 seconds (continuous compression) increased the drying effect by 1 - 2 percentage units.
- No additional benefit when pressing time was doubled from 30 to 60 seconds.

Conclusions

- The two studied softwood species behaved similarly in the compression tests.
- Downy birch required more energy for extracting the same amount of water than softwood species.
- Compression drying is a fast and an effective method for drying wood.
- The required energy of compression drying is only a fraction of the energy required in the thermal vaporization of water.
- Large-scale wood compression product development and tests are needed.

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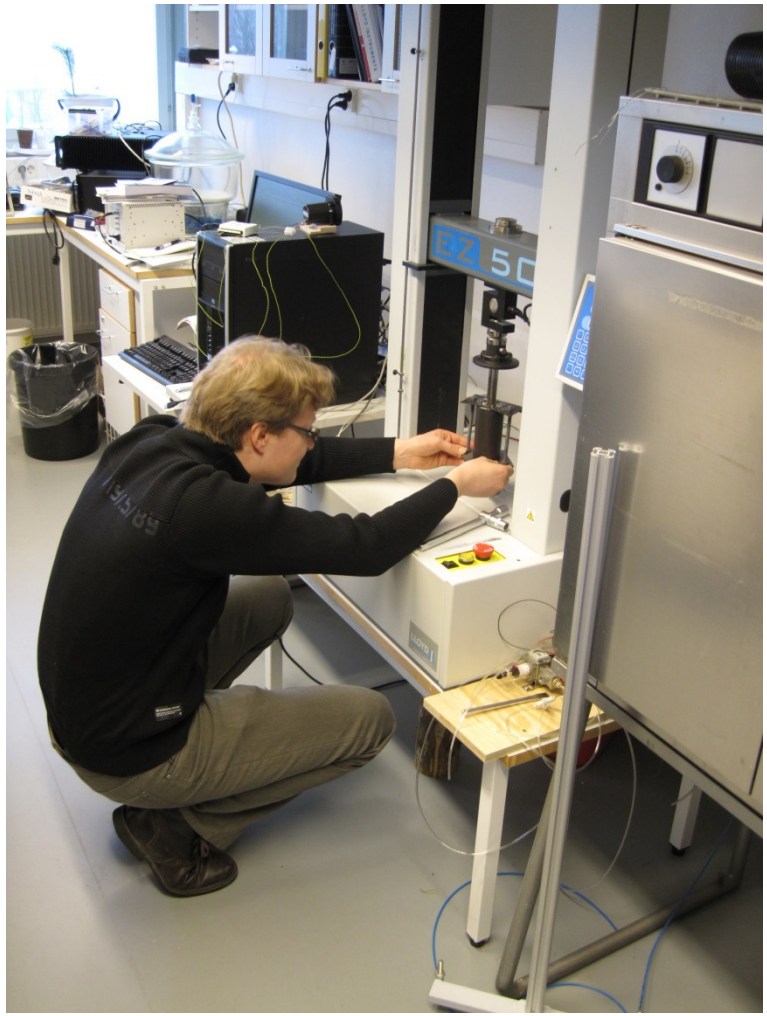

Thank you!

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