Title	Foam formed wood-based thermal insulation materials
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Citation	9th Global Insulation Conference & Exhibition 2014, 30 - 31 October 2014, Copenhagen, Denmark Proceedings. Pro Global Media Limited (2014)
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Foam formed wood-based thermal insulation materials

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Outline

- Introduction
- Important foam characteristics
- Foam forming research facilities at VTT
- Properties of foam formed cellulose insulation materials
- Summary

Background

History

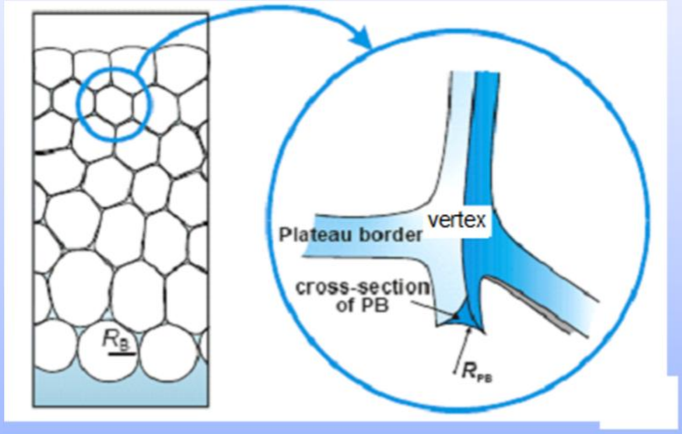
- Foam forming technology has been studied already in 1970's but implemented in some extent only in nonwoven and tissue industry.

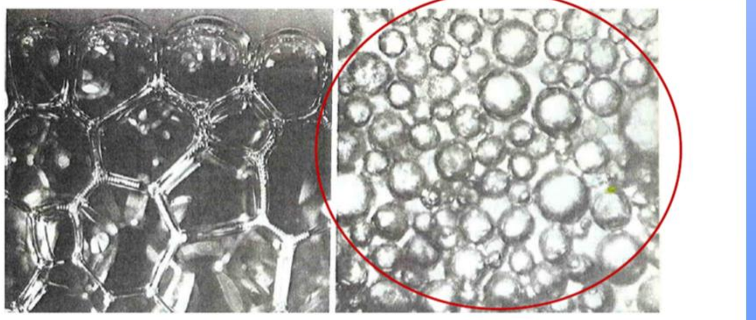
Foam forming research at VTT

- First laboratory scale projects started in the mid of 2000
- Earlier research focused mainly on paper and packaging board applications, but nowadays more and more also on other fibre based products
- Paper and board facilities have scaled up recently; big investments to novel research environments, annual research volume several M€

Basics of foam forming

- Fibres and other raw materials are mixed with aqueous foam instead of water
- Foam consists of water, foaming agent and air
- Typical air content 50 – 70 %
- Material is located in “bubble pockets”
- Fibres are ”frozen” in their dispersed state leading to uniform material distribution



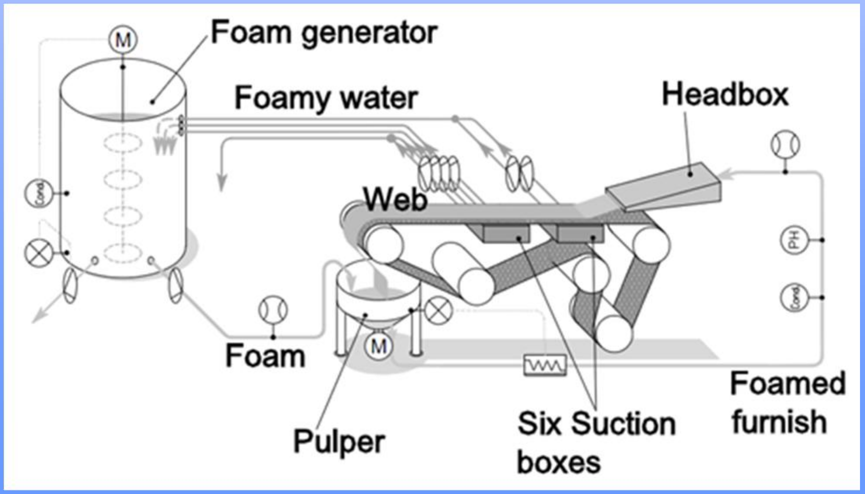


Froth, 2-4 mm bubbles
'Fairy foam, dish washing'

Foam, 20-100 μm round bubbles
Dense foam

Main process phases and features

- Generation of foam and mixing of raw materials in the foam: In tank or on-line in tube
- Web forming: Foam removal with vacuums
- Wet pressing: Not used if aiming to highly porous structures
- Drying: With contact or non-contact techniques
- Process can be batch or continuous process



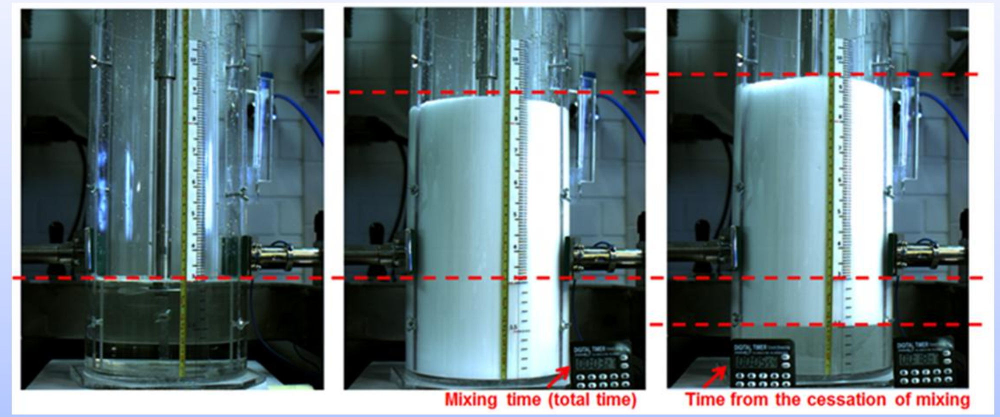
Potential of foam forming

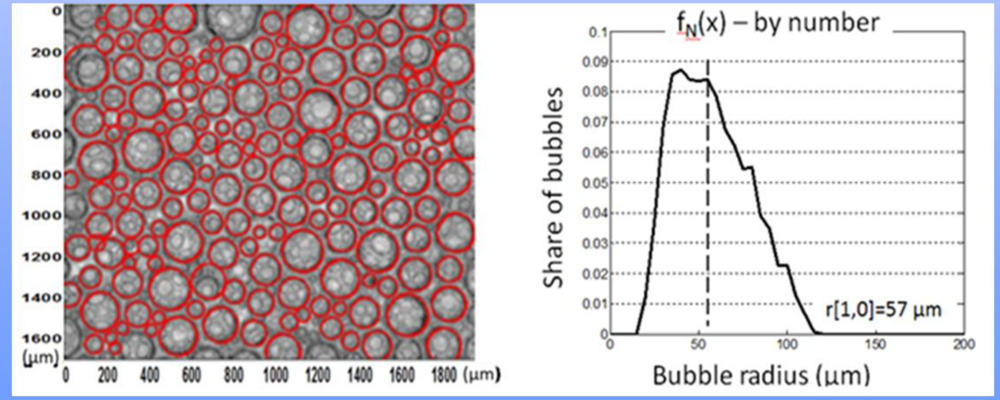
- Possible to produce highly porous structures
- Possibility to get very uniform structures even with several centimetres long fibres
- Foam allows utilization of raw materials from long fibers to nanoscale particles as well as particles lighter than water
- Possibility to produce layered products with excellent layer purity
- Technology can be resource efficient and cost competitive compared to many other manufacturing methods

Important foam characteristics

… which effect on the product properties and controlling of processes

- Foam density
  - air content
- Foam stability
  - Half life time (liquid volume reaches half of its initial height)
- Bubble size distribution





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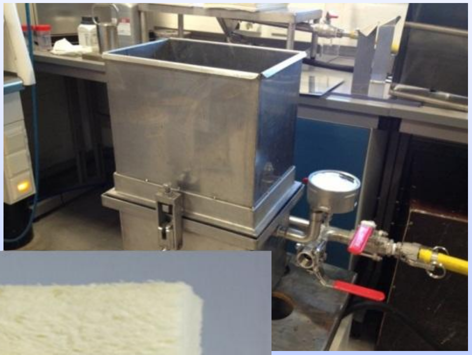
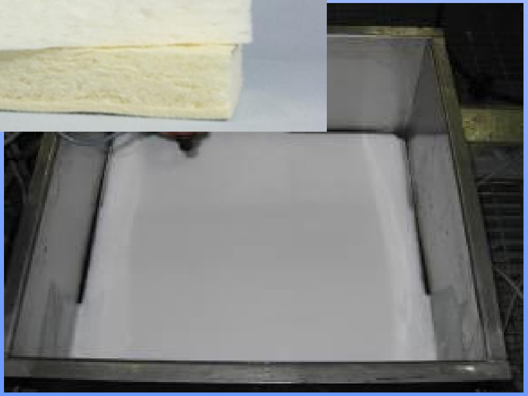
Handsheet moulds in laboratory

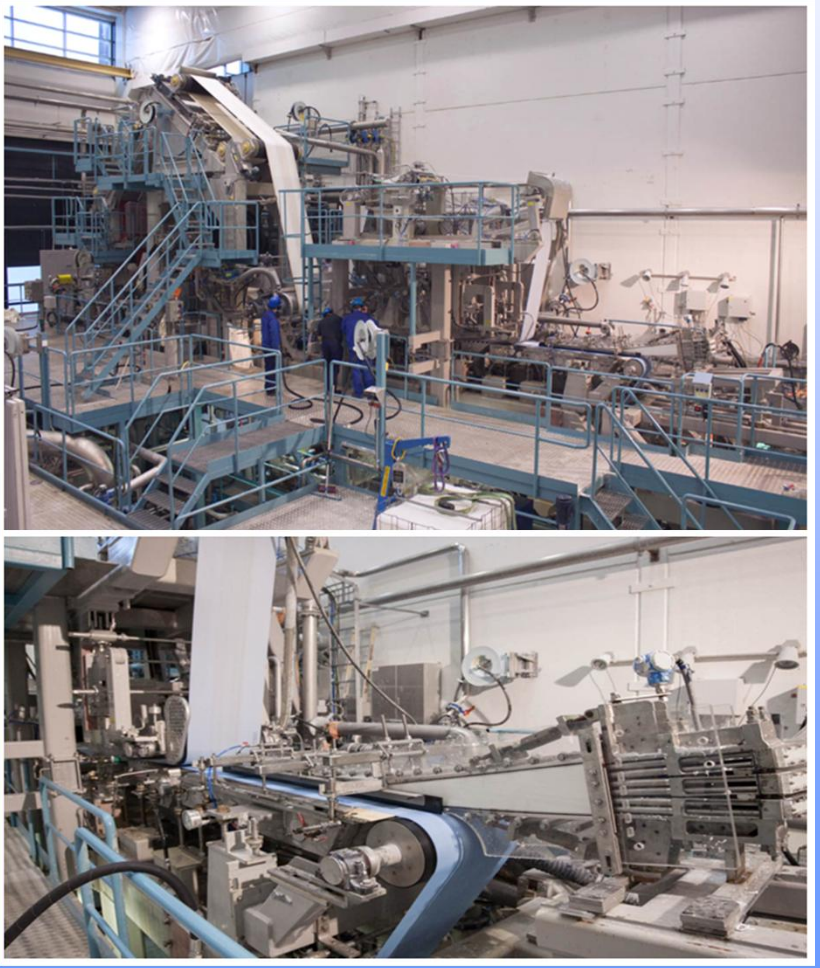
- For both paper-like and thick products
  - Sizes up to 50 cm x 50 cm
  - Underpressure up to 0.6 bar
  - Raw materials from nanoscale to several centimeters long fibers
  - Layered structures
  - Wet pressing and drying in laboratory scale





Pilot scale foam forming environment

- Technical specifications
  - Design speed 2000 m/min
  - Sampling speed <1000 m/min
  - Roll width 250 mm
  - Several forming geometry options
  - Multilayer forming possibilities
  - Two foam generation options (tank mixing & tube generation)
  - Single nip press section
  - Off-line dryer
  - For paper-like products



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Properties of foam formed cellulose insulation materials

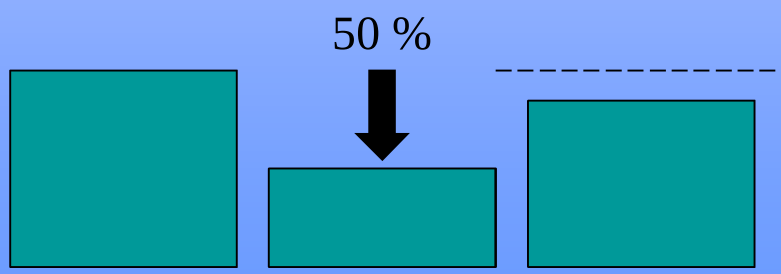
Samples and testing methods

Sample	Thickness mm	Basis weight g/m^2	Density kg/m^3
Pine	10.2	544	54
Pine + starch 4 %	9.7	525	54
Pine + MFC 4 %	10.5	548	53
Pine + starch 2 % + MFC 2 %	9.7	528	55

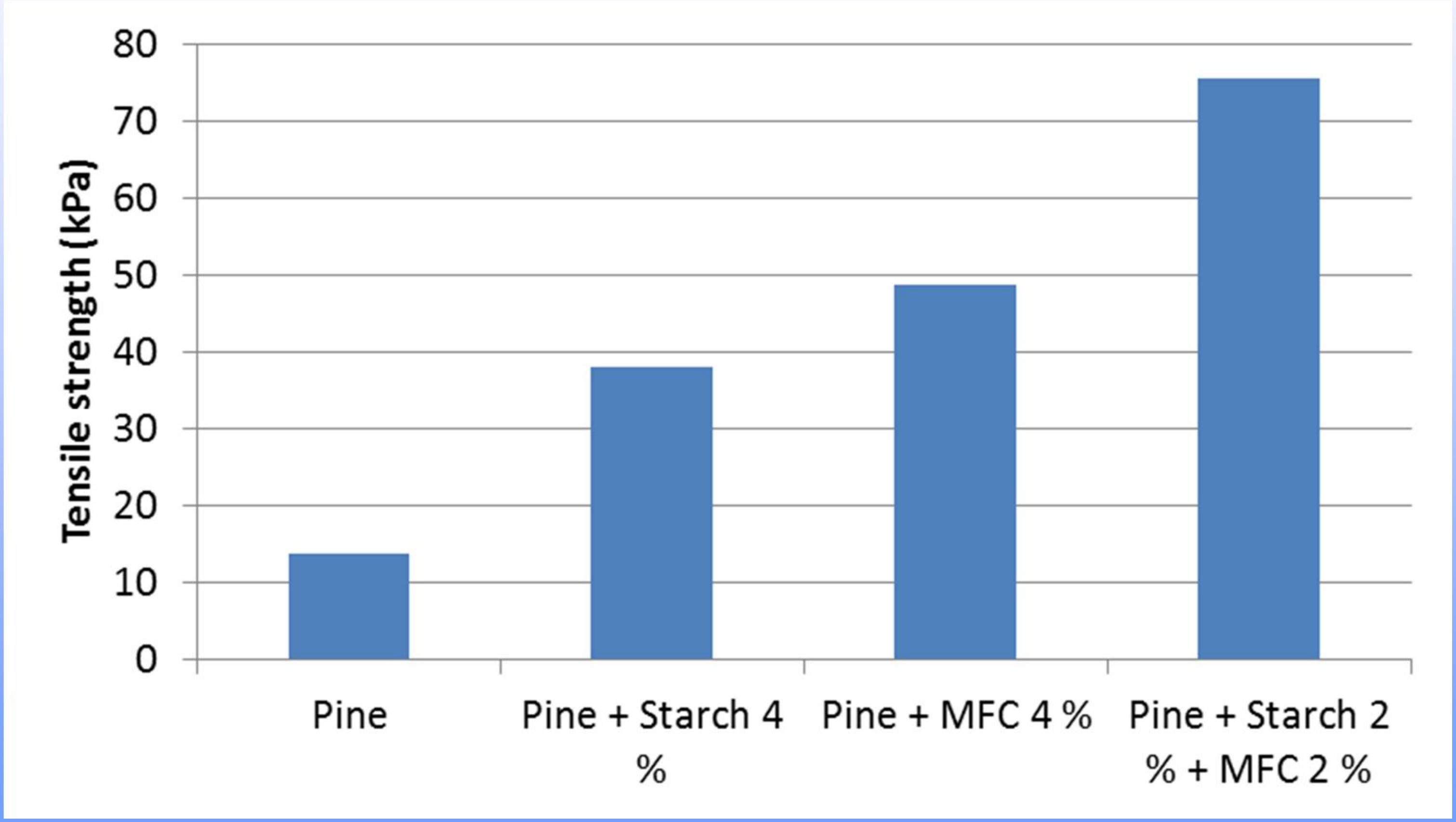
Pine: Chemical Softwood Pulp
MFC: MicroFibrillated Cellulose

- Tensile strength: EN 1608
- Bending strength: EN 12089
- Compression strength: modified EN 826
- Water absorption ISO 17190-6 (immersion + centrifuge)

Compression strength and reversibility

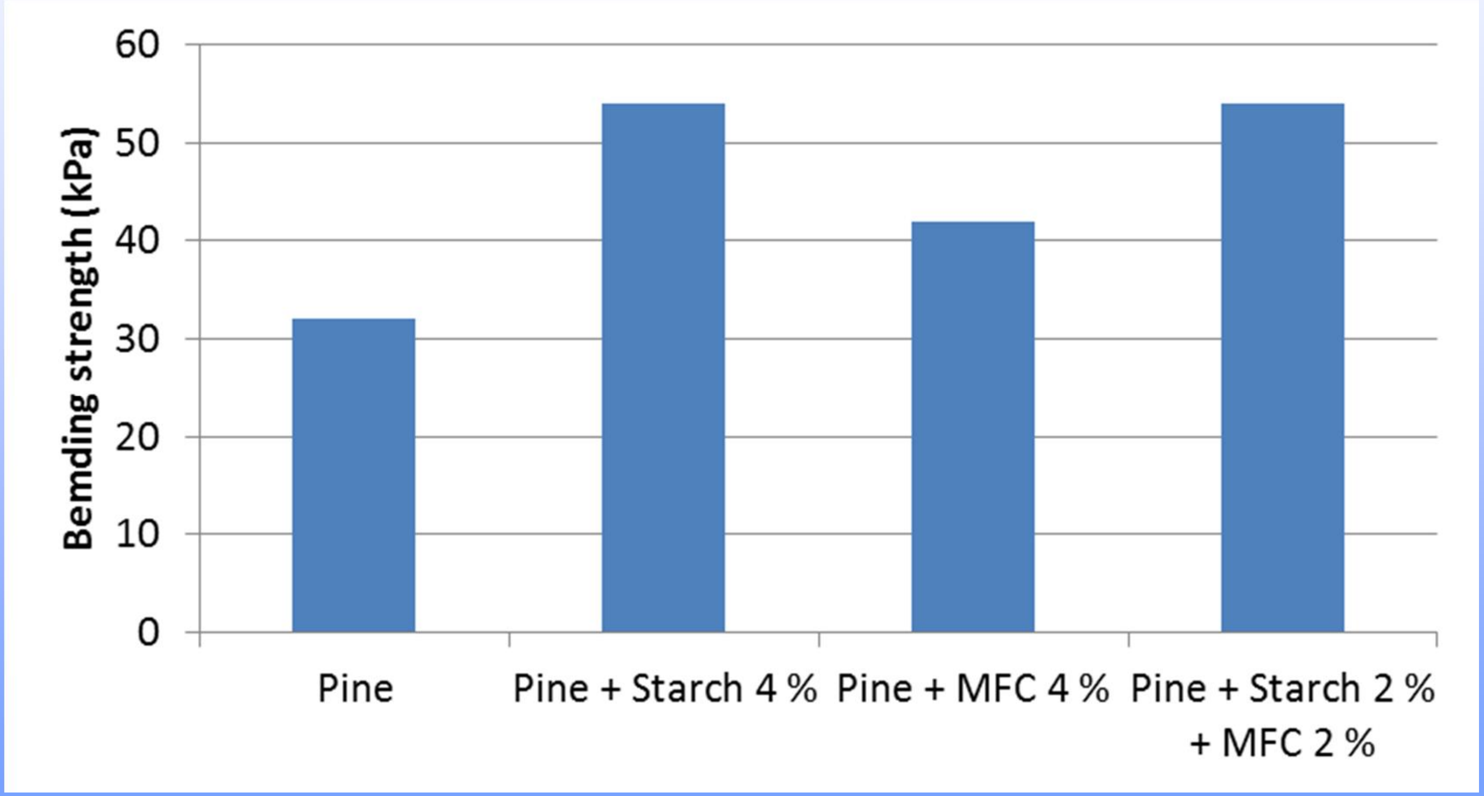


Tensile strength



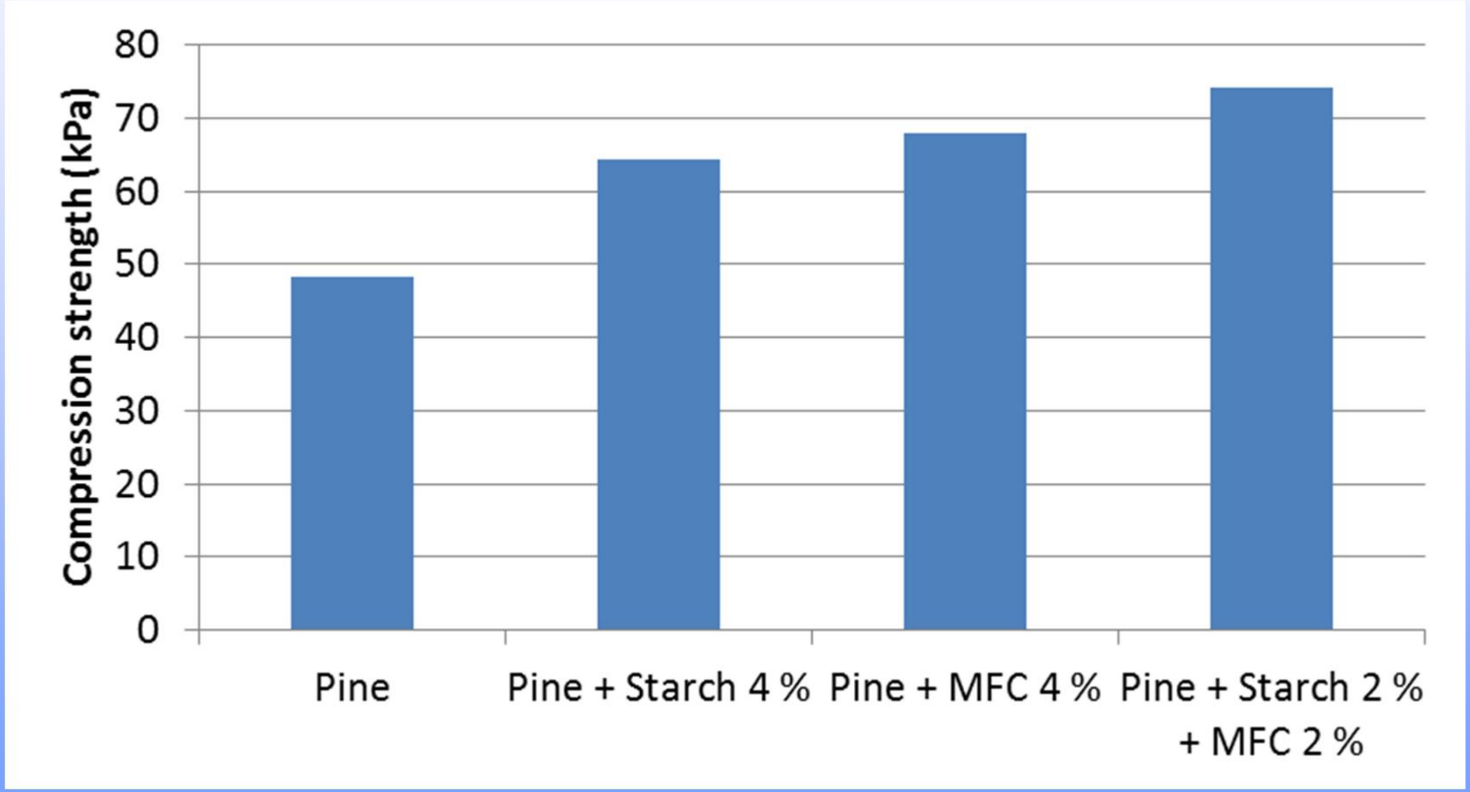
EN 1608

Bending strength

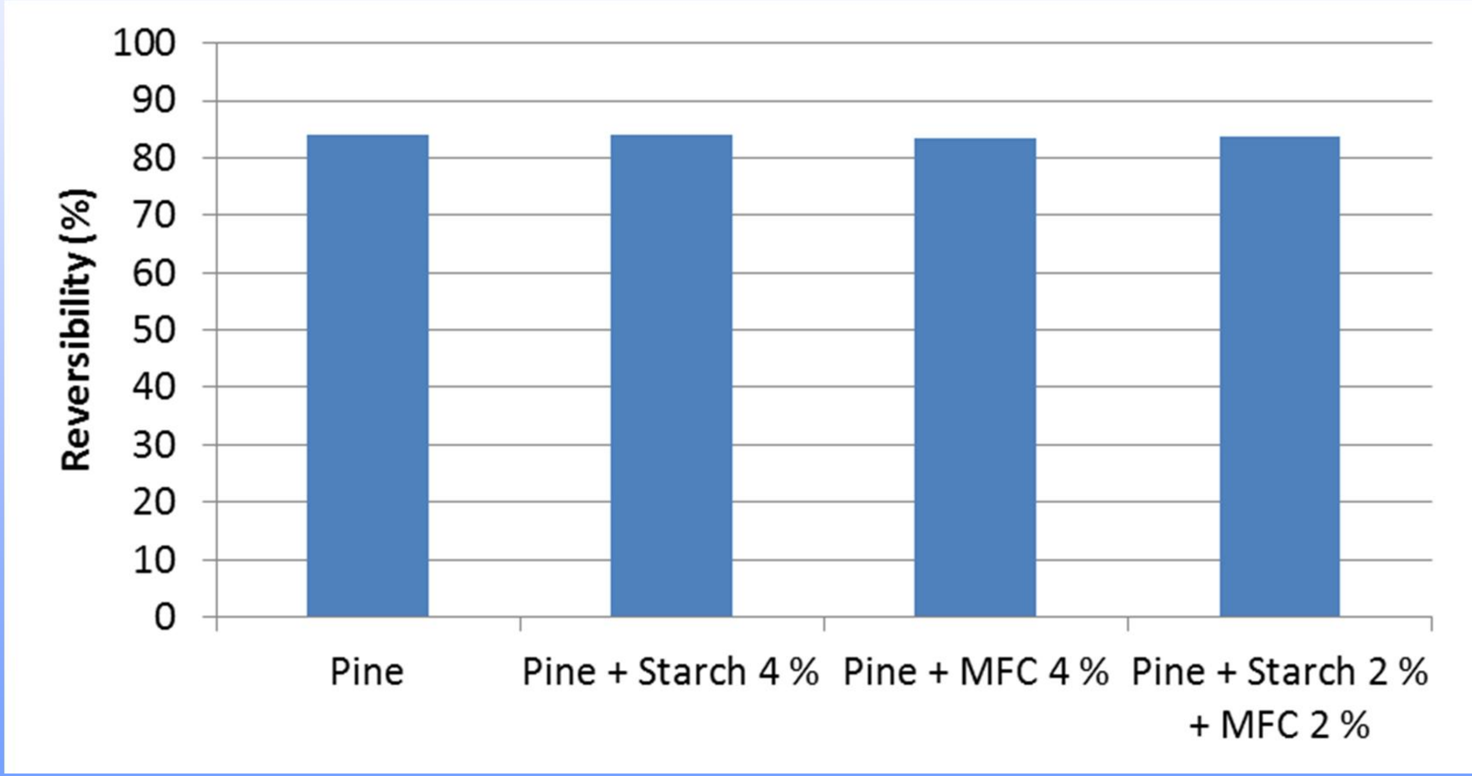


EN 12089

Compression strength



Reversibility after compression



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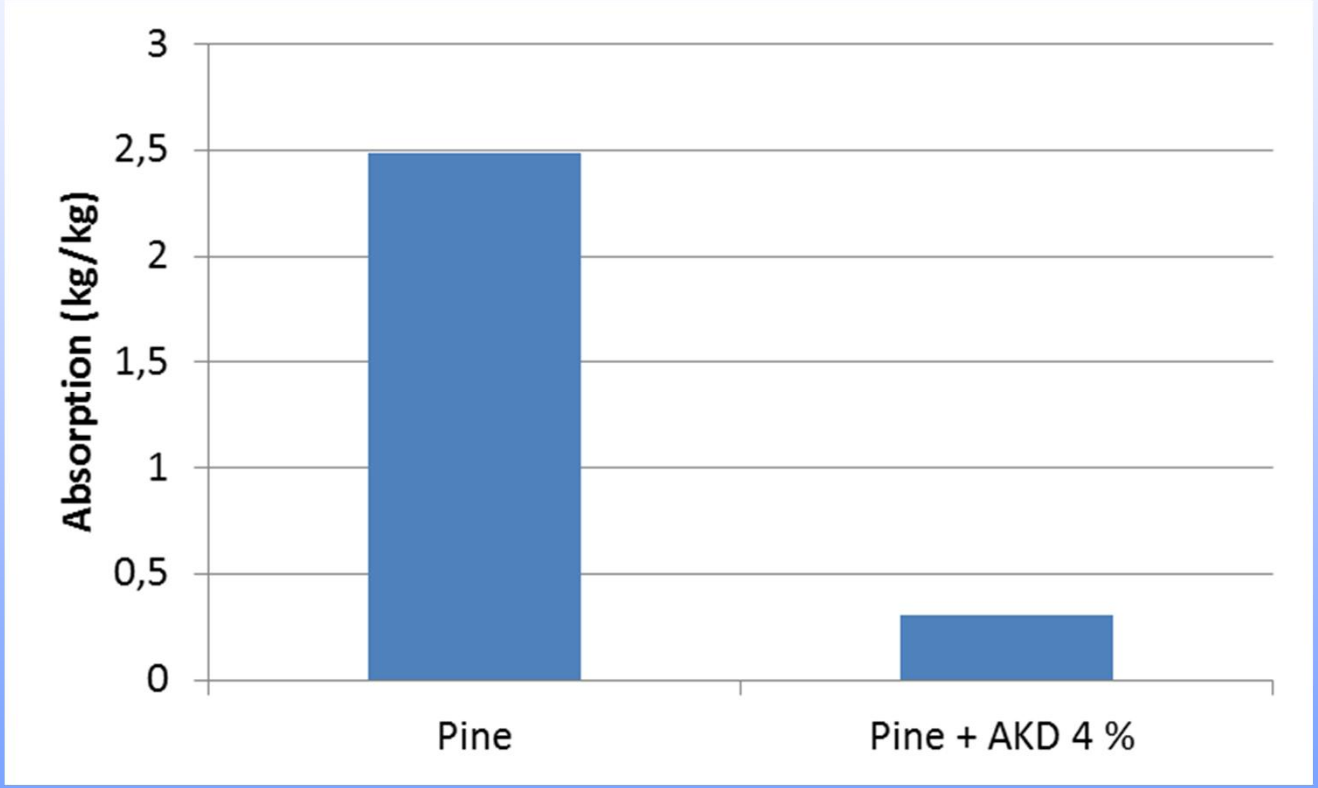
Water absorption



AKD: Alkylketene dimer
alkaline sizing agent synthesized from fatty acids

ISO 17190-6

Thermal conductivity

Sample	Thickness mm	Basis weight g/m^2	Density kg/m^3	Thermal conductivity W/(mK)
CTMP 100 %	30	750	25	0.040
Pine 100 %	32	800	28	0.035
CTMP/MFC 80/20 %	34	780	23	0.036
CTMP/ PCC 80/20 %	60	720	12	0.036
CTMP/Pine 50/50 %	39	780	20	0.037

EN 12667

Comparable to average values of mineral wool, EPS and XPS

CTMP: ChemiThermoMechanical Pulp
Pine: Chemical Softwood Pulp

MFC: MicroFibrillated Cellulose
PCC: Precipitated Calcium Carbonate

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Fire protection with fire retardant

Ignitability test, ISO 11925-2, surface ignition, 15 s

Flame in 3 s on 150 mm line

Reference 38 kg/m^3

Damage length 118 mm

Fire-protected 40 kg/m3

Fire class E

Potential to class D

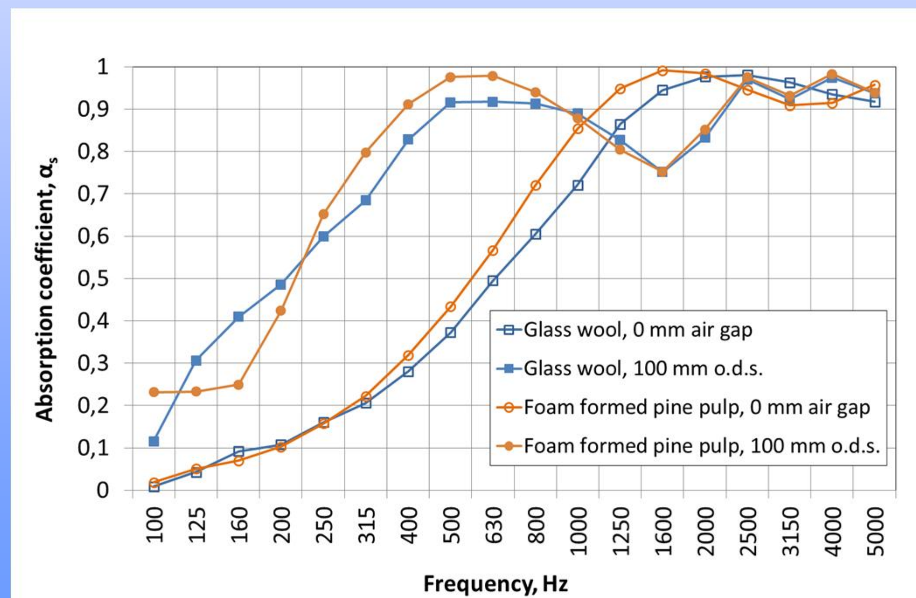
Addition of modified, nitrogen containing **phosphate salt** in fibre foam (1.2% concentration in water)

Sound absorption

Glass wool product

Foam formed pine pulp

Material	Thickness	Density	Grammage	Flow resistivity
	mm	kg/m^3	g/m^2	Ns/m^4
Commercial glass wool	30	53	1585	27300
Foam formed pine pulp	30	42	1260	23600



Absorption coefficient 0=no absorption, 1= full absorption, o.d.s.= mounting level from surface

Summary

- Foam formed materials offer a sustainable solution for thermal insulation applications
- Thermal conductivity values are comparable to average values of mineral wool, EPS and XPS
- Thermal insulation properties can be improved by closing the surfaces of insulation panels or forming closed-cell like structure in the insulation panels
- Mechanical properties can be controlled by raw material selection and processing, structure of panels and additives
- Water and fire resistance as well as resistance against microbes should be handled by additives

Acknowledgements

- Finnish Bioeconomy Cluster FIBIC Oy
- Tekes – the Finnish Funding Agency for Technology and Innovation
- European Regional Development Fund (ERDF)

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