Aalto University

Brown Stock Washing Efficiency - Past, Today and Future

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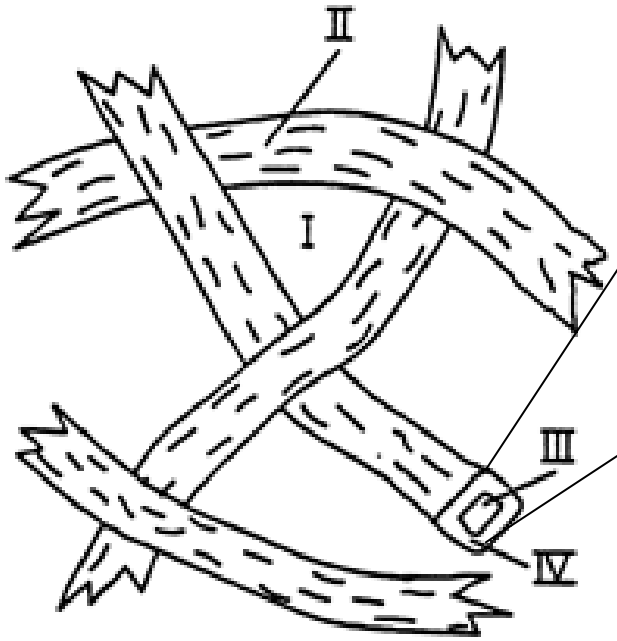
Outline

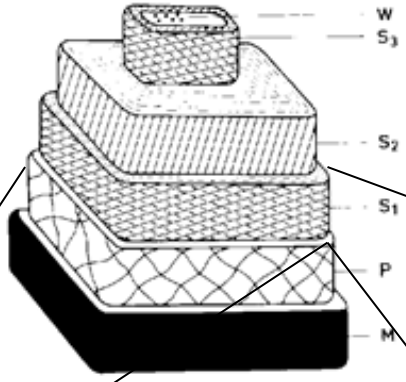
- Background
- Measuring of washing performance
- The situation before
- The situation today
- Needs in the near future
- Benefits of the better washing?
- Conclusions

Background – which are washed and where?

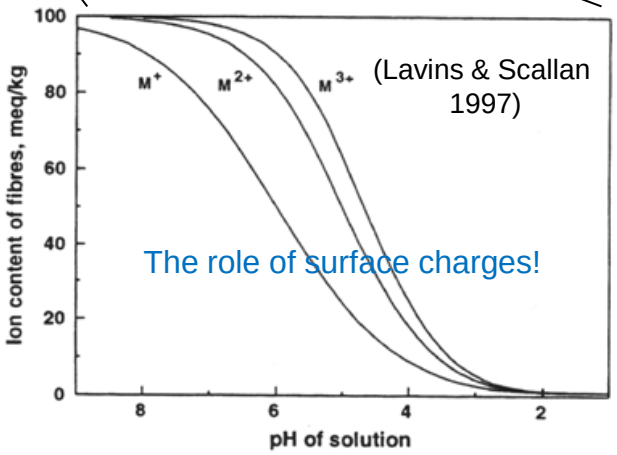
- Water, the essence of fiber suspensions - what and where?



(Eklund & Lindström 1991)



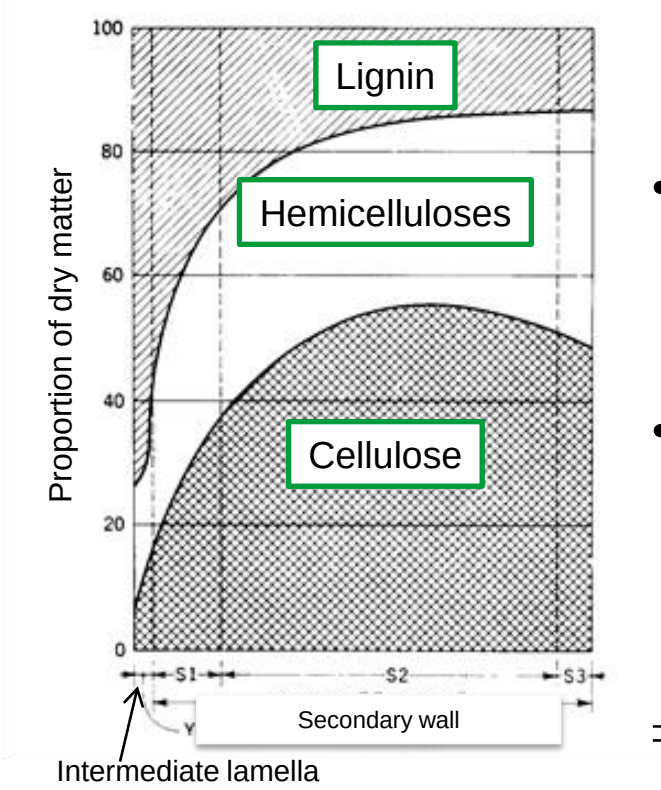
(Ilvessalo-Pfäffli 1977).



(Lavins & Scallan 1997)

Background – what are washed - boundary conditions?

- Organics in fibers



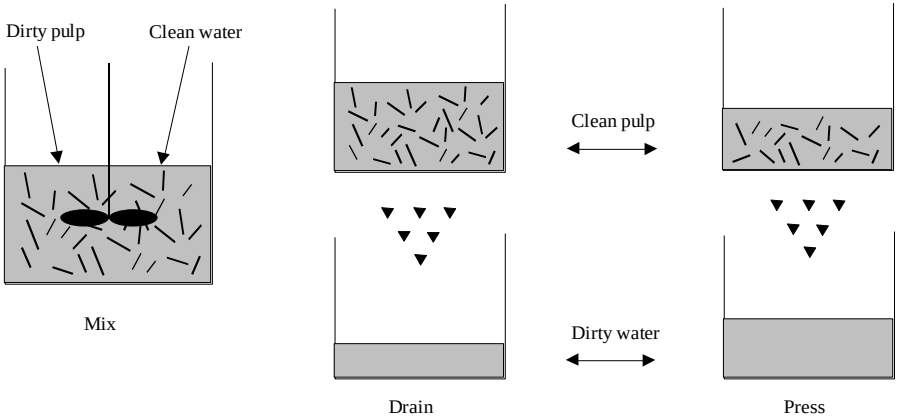
(Ilvessalo-Pfäffli 1977).

- Basic assumption: all materials should be in dissolved form in the pulp suspension ⇒ can be washed out
- Otherwise, the materials will remain and will be found in the next stage or final product
- We know very well the solubility of inorganics and basics of solubiity of organics, but theirs interaction is unknown

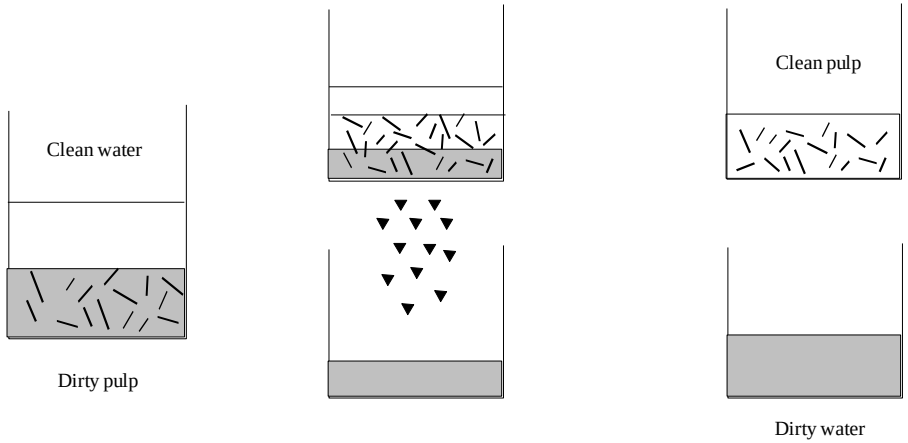
⇒ no additional information by modelling

⇒ more experimental studies will be needed

Background – how to wash?



Dilution-thickening-washing (Turner et al. 1996).

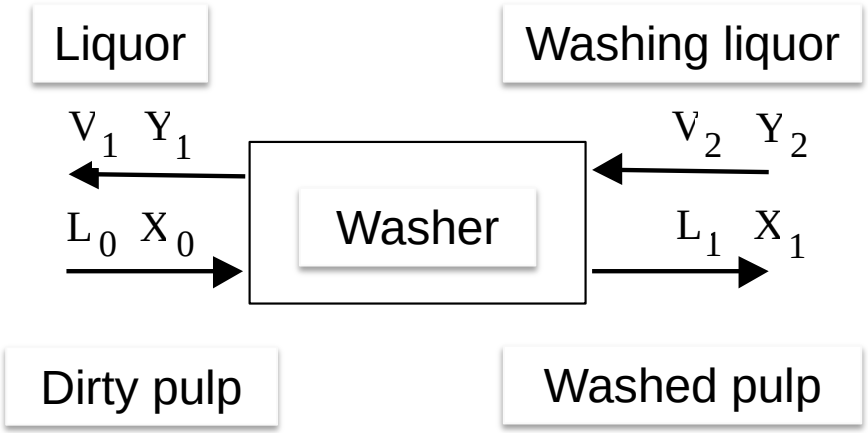


Displacement washing (Turner et al. 1996).

Measuring of washing performance

- Efficiency of washing can be estimated by the washer's ability to remove the impurities carried over in the pulp and the amount of used wash water
- The parameters describing the washing procedure can be divided into three categories:
  - Amount of the water used
  - Impurities removed in the washing stage
  - Washing efficiency measured with standardized feed-in and feed-out consistencies

Measuring of washing performance



Amount of water used

$$DF = V_2 - L_1 \qquad R_W = \frac{V_2}{L_1} \qquad W = \frac{V_1}{L_0}$$

Removal of dissolved components

$$DR = \frac{X_0 - X_1}{X_0 - Y_2} = \frac{C_0 - C_1}{C_0 - C_2} \qquad Y = 1 - \frac{L_1 X_1}{L_0 X_0} = \frac{V_1 Y_1}{L_0 X_0}$$

V_1, V_2 = flow of liquors
L_0, L_1 = flow of pulp
x_0, x_1 = concentration of dissolved solids in pulp suspension
y_1, y_2 = concentration of dissolved solids in liquids

DF = Dilution Factor
RW ja W = wash and weight liquor
DR = Displacement Ratio
Y = Washing Yield
E = Nordénin efficiency factor
Est = Modified Nordén efficiency factor
EDR = Equivalent displacement ratio

Washing efficiency

$$E = \frac{\log \frac{L_0}{L_1}\left(\frac{X_0 - Y_1}{X_1 - Y_2}\right)}{\log(V_2/L_1)} \qquad E_{st} = \frac{\log \frac{L_0}{L_1}\left(\frac{X_0 - Y_1}{X_1 - Y_2}\right)}{\log(1 + (DF / L_{st}))}$$

$$(1 - EDR) = (1 - DR)(DCF)(ICF)$$

Measuring of washing performance

- **Wash loss** reports the amount of alkali loss with washed pulp (per tonne of pulp) in other words alkali which can not be found from black liquor.
  - kg Na_2SO_4/ADt $\Rightarrow$ after O-stage$\Rightarrow$ kg COD/ADt

- **Dilution factor** reports the dilution of black liquor occuring due to the addition of wash water. H_2O m^3/ADt

Measuring of washing performance – wash loss

- Na_2SO_4/ADt, no longer describes the current situation (due to oxygen delignification stage) (slow method)
- kg COD/ADt, does not describe wash loss accurately (slow method)
- kg TOC/ADt, good description/estimate of wash loss (slow method)
- Conductivity, describes well in certain cases, with restrictions (fast method)
- Total amount of dissolved components, good description of wash loss, with large amount of dissolved lignin (fast method)

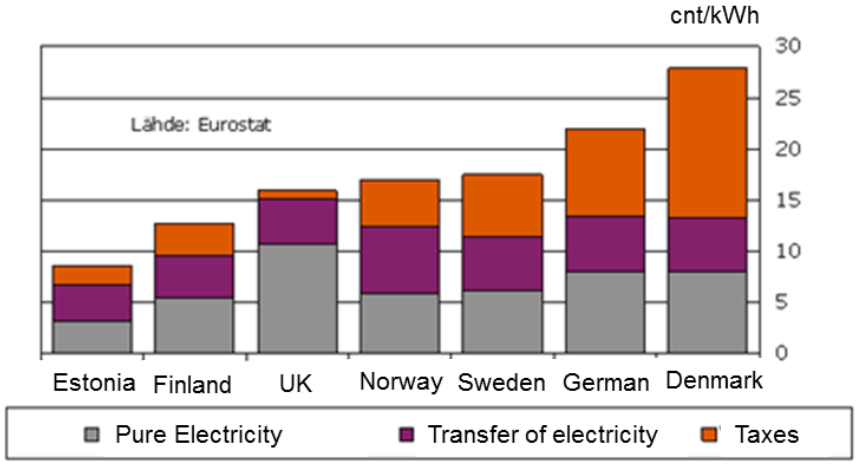
The situation before

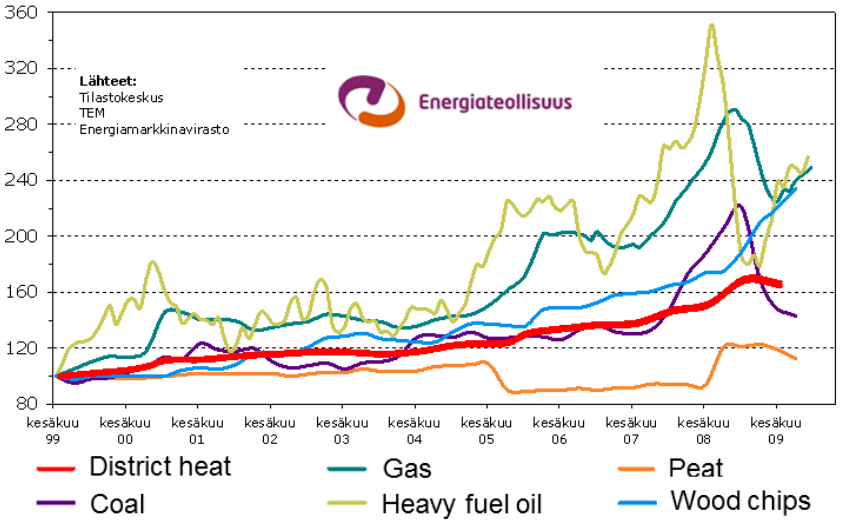
- Brown stock washing efficiency is not typically measured at mills (neither mathematically nor analytically)
  - With the exception of water amount and conductivity
    - These are not controlled actively(?); washing is mainly controlled simply by observing the chest levels in mill
  - The driving forces to improve brown stock washing did not exist!
- WHAT ABOUT NOW?

The situation today

Driving forces are coming!

- Prices of raw materials are increasing
  - (wood and chemicals)
- Price of energy will increase a lot (also for industry)
- The share of renewable energy production has to be 38 % by 2020 (2010 ⇒ 30 %) in Finland





Needs in the near future

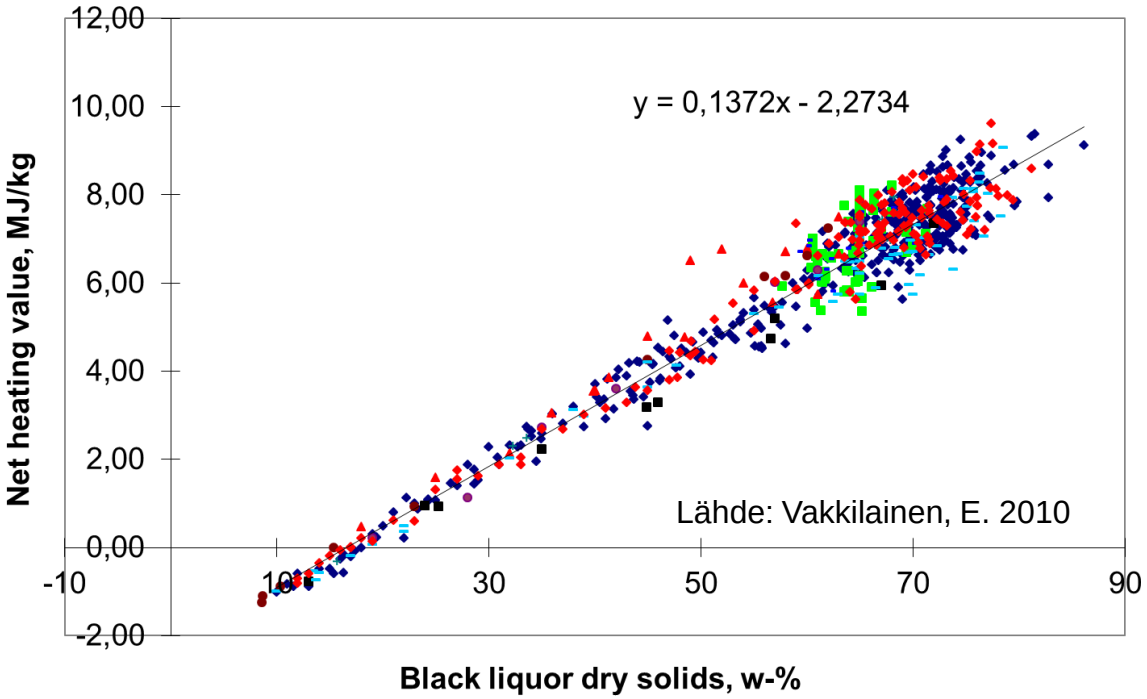
- Chemical pulp mills should concentrate more on:
  - Energy efficiency (carbon footprint)
  - Material efficiency (price increase of raw materials and chemicals)
  - Water use (water footprint)

Benefits of the better washing?

- It is possible to affect and improve the carbon footprint of the product, partially the yield, chemical consumption (material efficiency) and water footprint (at least washing stages in bleaching) by improving the washing efficiency
  - Less water to evaporate – improved energy efficiency – when integrated with municipality ⇒ additional revenue by providing electricity and steam
  - Improving yield in oxygen stage and bleaching by 0,5 % will increase income by about 1,8 milj. €/a (400 000 ts/a, wood 44 €/m^3, softwood pulp 600 €/tn)
  - Improved washing can increase the heat value of black liquor for higher final dry matter content for combustion

Benefits of the better washing? - Higher total solids in black liquor!

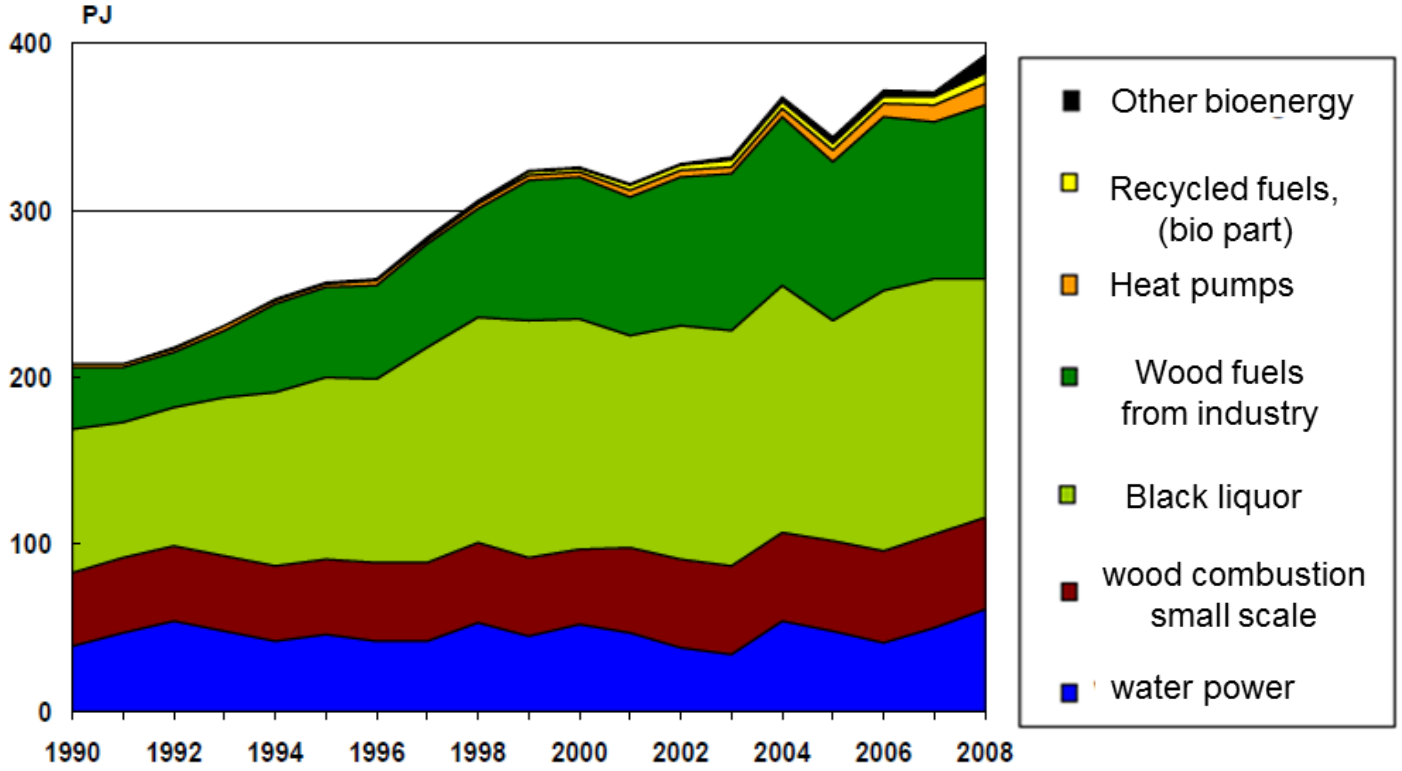
- If total solids of black liquor 72 ⇒ 74%, 7,61 ⇒ 7,88 MJ/kg (increase 3,6 %)
- 400 000 tp (softwood)/a, Heat 10 €/MWh, Electricity 50 €/MWh,



Income about
1,3 milj. €/a

Finnish pulp mills
TDS. 70 – 82 %

Benefits of the better washing? - Renewable energy sources in Finland



Lähde: Tilastokeskus

⇒ Increasing dry matter content of black liquor will directly affect demands set to Finland by EU

Conclusions

- Better brown stock washing:
  - Direct savings in chemical costs
  - Could improve yield in fibre line (oxygen delignification and bleaching) $\Rightarrow$ a significant cost advantage
  - Decrease the use of energy in a chemical pulp mill $\Rightarrow$ more "green" energy to sell to the markets (needs integration with energy grids of community)
  - If controlled washing could improve total solids of black liquor $\Rightarrow$ direct costs savings to the chemical pulp mills and great effect on the renewable energy production targets to countries set by EU