R&D challenged by resource efficiency

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Kari Edelmann
VTT Technical Research Centre of Finland
Out-line of the presentation

- Challenges for forest industry
  - Profit in forest industry
  - EU Energy policy
- Improving resource efficiency
  - Available technologies
  - Emerging technologies
- Integration of emerging technologies in a case mill
  - Assessment of resource efficiency improvement
  - Research and development challenges and outlook of funding
- Summary
Profit before taxes in selected forest industry companies relative to turnover

SOURCE: Finnish Forest Industries Federation
EU energy and climate change policy

Targets for 2020

- Mandatory -20% target for CO₂ emissions compared to 1990
- 20% directive target for energy efficiency improvement
- Mandatory 20% share for renewables in final energy consumption
- Mandatory 10% target for renewables in transportation

National RES Targets by 2020
Challenges

Profitability development of forest industry

EU's Energy and climate change policy

- Calls for a large reduction of CO\(_2\) emission, efficient use of energy, increased use of renewable energy (RES) in energy production and transportation

EU's emission allowance price and subsidised national energy tariffs

- Increasing cost of energy and wood
- Demand for reduced energy and raw material costs
- Demand for new processes and products with higher added value
Improving resource efficiency

- Raw material efficiency
  - Lighter printing and writing papers
  - Lighter packaging materials
  - More income from raw material
  - Less waste
  - Recyclable paper

- Energy efficiency
  - Less purchased electricity
  - Less purchased fuels

- Resource Cost $C = \left( \frac{\€_{\text{raw materials}} + \€_{\text{energy}}}{a} \right)$

- Efficiency improvement potential $EIP = 1 - \frac{C}{C_{\text{ref}}}$
Improving energy efficiency
examples on emerging technologies

- Energy efficient mechanical pulping
- Low quality raw material for energy or chemicals
- Improved drainage properties
- High consistency processing
- Lighter paper and board products
- Forward looking process control methods
- Wet end hood to reduce heat losses and steam consumption
Reference mill (LWC)

- Capacity 1350 t/d
- Basis weight 67 g/m² (base paper 49 g/m²)
- Furnish: 38 % TMP + 27 % Kraft + 35 % filler
- TMP plant capacity 530 t/d peroxide bleached pulp (90 % DS)
- Average amount of broke 10 %
- Recovery of coating colour with UF
- Dry debarking process
- Closed cooling water system
- Activated sludge treatment for effluent
- Sludge is pressed to 40 % DS and burned in power plant
Water balance of the model mill

Raw water mechanical purification

Raw water chemical purification

TMP-plant

Papermaking line

Debarking

Effluent treatment

In 10.1 m³/t

Out 10.1 m³/t

Air 0.30 m³/t

Chemicals and chemical pulp 0.35 m³/t

Wood 0.59 m³/t

With bark 0.06 m³/t

1.89 m³/t

0.55 m³/t

With paper 0.04 m³/t

Clean water out 7.44 m³/t

Water to powerplant 0.61 m³/t

Evaporate 1.95 m³/t

Steam 0.21 m³/t

Condensate 0.07 m³/t

Power plant

Blowdown 0.33 m³/t

With sludge 0.04 m³/t

0.41 m³/t

1.17 m³/t

4.70 m³/t

0.27 m³/t

6.83 m³/t
# Energy use in the model paper mill

<table>
<thead>
<tr>
<th>Category</th>
<th>kWh/t</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TMP plant (total)</strong></td>
<td>1280</td>
<td>71561</td>
</tr>
<tr>
<td>Main refiners</td>
<td>924</td>
<td>51642</td>
</tr>
<tr>
<td>Reject refiners</td>
<td>274</td>
<td>15318</td>
</tr>
<tr>
<td>Other (pumping pulpers and drives)</td>
<td>82</td>
<td>4601</td>
</tr>
<tr>
<td><strong>Paper machine (total)</strong></td>
<td>689</td>
<td>38525</td>
</tr>
<tr>
<td>Refining, pumping, broke and approach system</td>
<td>250</td>
<td>13958</td>
</tr>
<tr>
<td>Vacuum system</td>
<td>80</td>
<td>4467</td>
</tr>
<tr>
<td>Paper machine drives</td>
<td>100</td>
<td>5583</td>
</tr>
<tr>
<td>Ventilation</td>
<td>90</td>
<td>5025</td>
</tr>
<tr>
<td>Finishing</td>
<td>125</td>
<td>6979</td>
</tr>
<tr>
<td>Other</td>
<td>45</td>
<td>2513</td>
</tr>
<tr>
<td><strong>TOTAL (electricity)</strong></td>
<td>2057</td>
<td>114986</td>
</tr>
<tr>
<td>TMP-plant</td>
<td></td>
<td>71561</td>
</tr>
<tr>
<td>Papermaking line</td>
<td></td>
<td>38525</td>
</tr>
<tr>
<td>Other (wood and water handling, power plant)</td>
<td></td>
<td>4900</td>
</tr>
<tr>
<td>Purchased fuel</td>
<td>945</td>
<td>52815</td>
</tr>
<tr>
<td>Grammage</td>
<td>67</td>
<td>g/m²</td>
</tr>
<tr>
<td>Production</td>
<td>55.9</td>
<td>t/h</td>
</tr>
<tr>
<td>Fresh water (total water consumption)</td>
<td>8.6</td>
<td>m³/t</td>
</tr>
</tbody>
</table>
Cases for resource efficiency improvements

- Mechanical pulping that uses 50% less electricity
- Technologies for 25% lighter products
- Wet end heat recovery
- High consistency papermaking
Energy efficient mechanical pulping

- Pre-treatment methods
  - Fractionation
  - Mechanical, chemical and enzymatic

- Novel thermo mechanical pulping
  - Different geometry, residence time and refiner plate details
  - Refining conditions
  - Steam recovery

➢ Verification of lab scale results are needed
Lighter printing and writing papers

- More coarse fibres → bulky structures
- Use of enzymes and chemicals for bulk increase
- Increase of forming consistency
- Foam forming
- Stratified forming (coarse fibres in the middle + fines on surfaces)
- Extended nip pressing
- Curtain coating
- Belt calendering
- Combinations of previous technologies
Heat recovery from paper machine

- **30 m³/s, 10 MW**
  - Exhaust air
- **85 m³/s, 20 MW**
  - Mist control and exhaust ventilation
- **25 m³/s, 13 MW**
  - Vacuum system air
- **25 m³/s**
  - Turbo blower
- **90 m³/s**
  - Exhaust air
- **1200 t/day**
- **Steam 40 MW**
- **1200 t/day**
- **Vacuum system air**
- **Clear filtrate**
- **Scrubber for heat recovery**
- **eg. clear filtrate**
- **Supply air**
High consistency papermaking

Designing the HC system

- Fibre chest
- Source of dilution water
- Screening technology
- Pumping technology
- Dosing and mixing of chemicals
- Measurements and control of pulp flow
  - Flow, consistency, pH, T, flocculation, bacteria and fibre properties measurements
  - Consistency control methods
- Fibre and water recovery
  - Production of clear water
    - Shower water and effluent
  - Water system closure possibilities

Research approach

- Consistency ranges 1-5 and 5-10%
- Short fibre furnishes
- No filler in the base paper process
- Grammage > 100 g/m²
- Modified pumping and screening technologies
- Development of HC screening is started at later stage
- Air removal is connected to pumping
## Case studies

<table>
<thead>
<tr>
<th>Raw materials (g/m²)</th>
<th>Reference</th>
<th>Lower grammage</th>
<th>Mech pulp</th>
<th>Mech pulp + high temp</th>
<th>HC</th>
<th>Mech pulp + HC + lower grammage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>67</td>
<td>50</td>
<td>67</td>
<td>67</td>
<td>50</td>
</tr>
<tr>
<td>Electricity (MWh/t)</td>
<td></td>
<td>2.06</td>
<td>2.46</td>
<td>1.43</td>
<td>1.33</td>
<td>1.95</td>
</tr>
<tr>
<td>Heat (GJ/t)</td>
<td></td>
<td>3.54</td>
<td>3.33</td>
<td>3.54</td>
<td>3.41</td>
<td>3.48</td>
</tr>
<tr>
<td>Water consumption (m³/t)</td>
<td></td>
<td>8.6</td>
<td>11.5</td>
<td>8.6</td>
<td>8.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Purchased fuel (GWh/a)</td>
<td></td>
<td>372</td>
<td>169</td>
<td>561</td>
<td>520</td>
<td>354</td>
</tr>
<tr>
<td>Purchased electricity (GWh/a)</td>
<td></td>
<td>670</td>
<td>642</td>
<td>379</td>
<td>346</td>
<td>629</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key technologies</th>
<th>Heat-exchangers, cooling towers and UF</th>
<th>Methods for bulk increase/saving and better fibre bonding</th>
<th>Chip treatments and refiner optimisation/new design</th>
<th>Air flow control and hood insulation and chemistry</th>
<th>Screening, consistency control and unit operations</th>
</tr>
</thead>
</table>

11/06/2010
### Resource cost scenarios

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchased electricity (€/MWh)</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Peat (€/MWh)</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Wood raw material (€/t)</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Pine Kraft (€/t)</td>
<td>485</td>
<td>485</td>
<td>485</td>
</tr>
<tr>
<td>Pigment (€/t)</td>
<td>190</td>
<td>190</td>
<td>190</td>
</tr>
</tbody>
</table>
Raw material and energy costs

- Pigment (M€/a)
- Pine Kraft (M€/a)
- Wood raw material (M€/a)
- Fuel (M€/a)
- Purchased electricity (M€/a)
Annual resource costs
sensitivity against changes in wood and electricity price

M€

BAT reference  Lower grammage  Mech pulp  Mech pulp + high temp  HC  Mech pulp + HC + lower grammage

Low  Medium  High
Balancing technology development

**Targets and goals for future**

- **Short term**
  - Company driven development
  - Joint applied research
  - Medium term

- **Medium term**
  - Strategic
  - Academic

- **Long term**
  - Public funding

**Programmes**
- Investments on infrastructure
- Projects
- Networking
- Training
Conclusions of the case study

- Total site approach is used to evaluate resource efficiency of various papermaking concepts
  - Efficiency of both energy use and production can be studied simultaneously
    - Opens also an opportunity to optimise heat recovery
    - Specific energy consumption values are not enough to estimate energy bill
      - Avoids the need to set a price for steam

- Raw material is the dominating resource cost
  - Reduction of grammage is the most effective way to reduce both raw material and energy costs
    - Profitability depends on pricing of the product
      - Functional based pricing €/m² instead of €/t
    - Potential is high but requires development of several new technologies
Summary

- EU's energy and climate change policy
  - Will increase the price of energy and wood raw material
- Low profitability
  - Requires new processes and products with higher added value

Resource efficiency improvements by new technologies
- Evaluate the effects at total site level by using process models
  - Benchmark with BATs and BOPs
  - Integrate new process technologies to the model
  - Screen the process alternatives
    - Use annual costs instead of specific consumption figures

Profitability
- A step change in profitability achievable by new technologies
- Investments in research infra-structure and focused R&D work is needed
- Networking and training essential
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  - Jussi Manninen
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VTT creates business from technology