Effect of consistency and refiner speed on bar coverage in refining

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Mat thickness, $i$ and bar coverage, $f$ - refining variables

**Mat thickness**
- No of fibres trapped under each bar segment, $i$
- Thickness of mat - first takes compressive load: $g_o$
- For given specific energy, $g_o \propto i$

**Bar coverage**
- Fraction of rotor bar with compressed fibre mat
- Labelled $f$

Not considered in current refining theories
Experimental

- ProLab refiner with LM conical fillings
- Speed range 600-4000 rpm
- 6%, 4%, 3% consistency examined here
- Dried, bleached Finnish softwood reinforcement kraft pulp
- More details- see Tom’s talk
Nominal and Effective Specific Edge Load

- Nominal Specific Edge Load ($SEL_n$) - normal SEL calculation. Intrinsically assumes: $f = 1$

- Effective Specific Edge Load ($SEL_e$) - If $f < 1$, more energy applied to bar areas with a mat and

$$SEL_e = SEL_n / f$$
Theory: effect of $f$ and $i$ on refining

$F \propto \frac{SEL_n}{f}$

$N \propto Ei \frac{SEL_n}{f}$

- $F$ is force per fibre, $N$ is the number of impacts, $E$ is specific refining energy
- Equivalent refining treatment when $N$ and $F$ are equal.

- **Lower $f$:** harsher refining
- **Lower $i$:** less efficient refining
Reduction in $f$- less Power/thrust/SEL to obtain a given gap

![Graph showing reduction in bar coverage only](image)

- 6%
- 4%
- 3%
- $f=1$
- $f=0.8$
- $f=0.6$
- $f=0.4$
- $f=0.2$
Reduction in $i$-gap at which first draw net power ie have SEL is reduced.

Reduction in mat thickness
3% consistency curve
Complete data set

- 600-4000 rpm

Data at different speeds not directly comparable as data collected sequentially- 600 rpm then upwards

- 600 rpm: specific energy $\approx 0$
- 4000 rpm: specific energy $\approx 500$ kWh/t
600 rpm

The graph shows SELn values for different gap (mm) at 600 rpm. The graph includes data points for 6%, 4%, and 3% with distinct markers for easy differentiation.
4000 rpm

Graph showing the relationship between SELn (J/m) and Gap (mm) for different frequencies (f) and percentages (6%, 4%, 3%). The graph includes lines for f=1, f=0.8, f=0.6, f=0.4, and f=0.2.
4000 rpm - SELn vs strain - adjusts for different $g_o$
Values of $f$ and $g_\circ$ from these experiments

<table>
<thead>
<tr>
<th>RPM</th>
<th>6% consistency</th>
<th>4% consistency</th>
<th>3% consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f$ $</td>
<td>g_\circ$ (mm)</td>
<td>$f$ $</td>
</tr>
<tr>
<td>600 rpm</td>
<td>1.0*</td>
<td>1.11</td>
<td>1.0</td>
</tr>
<tr>
<td>1000 rpm</td>
<td>1.0*</td>
<td>0.55</td>
<td>1.0</td>
</tr>
<tr>
<td>1500 rpm</td>
<td>1.0*</td>
<td>0.45</td>
<td>0.7</td>
</tr>
<tr>
<td>2250 rpm</td>
<td>1.0*</td>
<td>0.49</td>
<td>0.6</td>
</tr>
<tr>
<td>3000 rpm</td>
<td>1.0*</td>
<td>0.45</td>
<td>0.4</td>
</tr>
<tr>
<td>4000 rpm</td>
<td>1.0*</td>
<td>0.43</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* 6% consistency data is taken as reference curve and assumed that $f = 1$
Conclusions

- Bar coverage reduces with consistency
  - Small reduction at 1000 rpm
  - Large reduction at 4000 rpm
  - Explains differences: lab vs. mill refining?
- 4000 rpm - mat thickness is reduced for 3% consistency
- Mat thickness independent of consistency for other speeds