Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Plate pattern, plate clearance and pulp quality

*Lars-Åke Hammar*

2005

According to Innventia Confidentiality Policy this report is public since 2011-02-04
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Plate pattern, plate clearance and pulp quality

Lars-Åke Hammar

Report no. 108, 2005

Cluster: Mechanical pulp
Distribution restricted to: Eka Chemicals, Holmen Paper, Norske Skog, Stora Enso, Södra Cell
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

2 (29)

Acknowledgements

Thanks are due to Holmen Paper for help and support of the pulp taken out in the mill for use in these trials. This research has been performed within the cluster research program of Mechanical pulp 2003 – 2005. Additional funding from STEM is gratefully acknowledged.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Summary</td>
</tr>
<tr>
<td>2</td>
<td>Introduction</td>
</tr>
<tr>
<td>3</td>
<td>Experimental</td>
</tr>
<tr>
<td>3.1</td>
<td>HC pulps</td>
</tr>
<tr>
<td>3.2</td>
<td>LC refining</td>
</tr>
<tr>
<td>3.3</td>
<td>Instrumentation</td>
</tr>
<tr>
<td>4</td>
<td>Refining trials</td>
</tr>
<tr>
<td>4.1</td>
<td>Trial 1. LC refining of high and low freeness TMP at different edge loads and specific energies using two different plate sets of different edge lengths</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Materials</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Refiner plates</td>
</tr>
<tr>
<td>4.2</td>
<td>Results – trial 1</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Bauer McNett fibre fractions</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Plate gap measurement</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Strength properties</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Refining of 2nd stage pulp</td>
</tr>
<tr>
<td>4.3</td>
<td>Conclusions - trial 1</td>
</tr>
<tr>
<td>4.4</td>
<td>Trial 2. LC-refining of high freeness pulps at different speeds</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Materials</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Plate design</td>
</tr>
<tr>
<td>4.5</td>
<td>Results - trial 2</td>
</tr>
<tr>
<td>4.6</td>
<td>Conclusions - trial 2</td>
</tr>
<tr>
<td>4.7</td>
<td>Trial 3. LC refining of high freeness RTS pulp</td>
</tr>
<tr>
<td>4.7.1</td>
<td>Materials</td>
</tr>
<tr>
<td>4.7.2</td>
<td>Plate design</td>
</tr>
<tr>
<td>4.8</td>
<td>Results – trial 3</td>
</tr>
<tr>
<td>4.8.1</td>
<td>Bauer McNett fibre fractions</td>
</tr>
<tr>
<td>4.8.2</td>
<td>Plate gap measurement</td>
</tr>
<tr>
<td>4.8.3</td>
<td>Strength properties</td>
</tr>
<tr>
<td>4.9</td>
<td>Conclusions - trial 3</td>
</tr>
<tr>
<td>5</td>
<td>Overall conclusions</td>
</tr>
<tr>
<td>6</td>
<td>References</td>
</tr>
</tbody>
</table>
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4 (29)

1 Summary

The LC refining technique introduces a potential to reduce the energy consumption by applying LC refining in the production of mechanical pulp. In order to understand the mechanisms of LC refining of mechanical pulp these trials were undertaken.

Refining using the LC concept shows that it is important to combine a suitable edge load and refiner plates in the refining in order to preserve the long fibre content.

The long fibre content is better preserved if a too small plate gap in the refining zone is avoided.

Refining of a first stage and a second stage soft wood pulp with plates of medium edge length at a low edge load of 0.5 Ws/m preserved the long fibre content better than a finer plate pattern and higher edge loads,

Refining second stage pulps with ”fine” type refiner plates at a low edge load of 0.3 Ws/m was also found to be a god combination for LC refining.

The energy consumption was increased if the speed was increased from 700 to 900 rpm due to the increase of the idling power at higher speed.

The long fibre Bauer Mc Nett fraction >16 was reduced during LC-refining. At the same time an increase of the fibre fraction 16-30 and 30-50 was observed.

Sheet density increases 30-50 units compared at the same tensile index by the LC refining compared to HC refining. This is probably a result of the change in fibre distribution.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

2 Introduction

The objective of these studies of low-consistency (LC) refining was to obtain more information of what happens in the refining zone of a LC refiner. This report presents results on the development of the fibre properties obtained in the refining trials. In order to develop the refining processes of the mechanical pulp it is desirable to understand the prevailing mechanisms in the refining zones of the refiners.

Low-consistency (LC) refining is well established as apart of the chemical pulp fibre development processing. LC refining is considered as an intensive process but also an energy-effective technique for fibre processing. LC refining of mechanical pulps is less understood than high consistency HC refining. LC refining of mechanical pulps is, however, often applied as post-refining before the paper machine. The post-refining is an efficient tool for the papermaker to reduce the shives content and increase the production of low freeness pulp. It is also used to change the fibre distribution to improve the formation of the paper on the paper machine.

Research in order to develop a more energy effective process for the production of mechanical pulps has been carried out for some decades at STFI-Packforsk. The refining concept developed at STFI-Packforsk is a combined two-stage HC-LC process (Hammar et al. 1997). The process combines effective defibration of chips to fibres in a high-consistency refiner and further refining of the defibrated fibres at low-consistency conditions. To reduce the heat losses an intensive LC refining is chosen as a secondary refining in contrast to the use of two high-consistency stages in a conventional mechanical pulp mill. The low-consistency (LC) refining offers a potential way to save energy. It is important in the LC stage to soften the fibre material by heat to avoid severe fibre shortening. The structure of the rigid lignin is softened if the temperature is high enough. It is recommended that the temperature approaches 100 °C. Low-consistency refining of high freeness mechanical pulp is an unconventional technique applied in the mechanical pulping process. Since most of the conventional refiner plates for LC refining are designed for chemical pulps more knowledge is needed to optimise the refiner plates for mechanical pulp, in order to improve the pulp quality. In order to increase this knowledge it is necessary to have knowledge of what happens in the refining zone. The development of different sensors and equipment that has increased during the last decade offer here an opportunity. Different sensors as plate-gap sensors, fibre-optics pressure sensors, sensors for vibration analyses, speed and temperature sensors have thus been used in this project.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

3 Experimental

Pilot trials have been performed on the EuroFEX facilities at STFI-Packforsk at three different occasions. The trials are reported as trial 1, trial 2 and trial 3. The softwood pulps of Norwegian spruce used in the trials were taken from two different mills most often from first stage refiners and once from a second stage refiner.

3.1 HC pulps

The pulps were taken out from mill refiners in both primary and secondary positions. The pulps were blown out from the sample valve of the refiner into big sacks and transported to the EuroFEX facilities at STFI-Packforsk.

3.2 LC refining

The LC refining studies were carried out on a Beloit 4000 DD Duoflo refiner, an upgraded version, which means that the rotor floats on the refiner shaft. The stocks were prepared by taking the mill pulp and dilute it in hot water at a temperature of 95 °C. The set point of the consistency was 3.5%. The stock was stirred in order to disintegrate the fibres. After 20 minutes of stirring the refining was started and the pulp was pumped from one chest to another chest. Thus a one-passage refining was applied. Samples of the pulps were taken out from a sample-valve during the refining. Figure 1 shows the LC refiner loop.

Figure 1. LC refining loop
3.3 **Instrumentation**

Plate gap sensors were placed on the front and drive side through the plate segment of the refiner, measuring the two different refining gaps on this Beloit refiner. Fibre optic pressure sensors were located in the drive side through fine holes in the plates (Eriksen 2005).

Accelerometers were attached on the refiner housing while speed sensors measured the speed variations of the refiner shaft. The measurement equipments are described more in detail in reports from this project by Eriksen;

Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

- part a no. 114) Pressure measurement in the refining zone,
- part b no. 115) Vibration measurements of the refiner housing.

In addition conventional sensors measured the inlet and outlet temperature and pressure of the pulp suspension.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4 Refining trials

4.1 Trial 1. LC refining of high and low freeness TMP at different edge loads and specific energies using two different plate sets of different edge lengths.

4.1.1 Materials

High and low freeness softwood pulps were collected from a first stage Twin refiner and a second stage single disc refiner respectively. Table 1 shows the actual pulps and refining conditions.

Table 1. HC refining (line S1 and S2)

<table>
<thead>
<tr>
<th></th>
<th>First stage TMP (S1)</th>
<th>Second stage TMP (S2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific energy, [kWh/t]</td>
<td>1190</td>
<td>1190+800 = 1990</td>
</tr>
<tr>
<td>Consistency, [%]</td>
<td>~42</td>
<td>~42</td>
</tr>
<tr>
<td>Casing pressure, [bar]</td>
<td>~4.5</td>
<td>~4.5</td>
</tr>
<tr>
<td>Rotational speed, [rpm]</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Shive content (SW 0,15 mm), [%]</td>
<td>4.1</td>
<td>0.49</td>
</tr>
<tr>
<td>Freeness, [ml]</td>
<td>450</td>
<td>150</td>
</tr>
</tbody>
</table>

The first stage and second stage pulps were further refined in the low-consistency refiner loop in one-passage at different edge loads and flows. Two different refiner plates were used. Table 2 shows the operating conditions.

Table 2. Conditions in the LC refining

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency, [%]</td>
<td>~3.5</td>
</tr>
<tr>
<td>Temperature, [°C]</td>
<td>~90</td>
</tr>
<tr>
<td>Rotational speed, [rpm]</td>
<td>700</td>
</tr>
<tr>
<td>Edge load Bs, [Ws/m]</td>
<td>0.3, 0.5, 0.7 and 0.9 Ws/m</td>
</tr>
<tr>
<td>Edge length Ls, [km/rev]</td>
<td>(&quot;medium&quot;) 8.4 and (&quot;fine&quot;) 15.7 km/rev</td>
</tr>
</tbody>
</table>

4.1.2 Refiner plates

The plate design from GL&V used in this trial is shown in Figure 2. The plates are called “medium” type and “fine” type characterizing the large difference in edge lengths (Ls). The average angle of the bars was similar for both sets.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 2. GL&V “medium” and “fine” type refiner plates

4.2 Results – trial 1

4.2.1 Bauer McNett fibre fractions

The challenge of the LC-refining process is to preserve the long fibre content. The Bauer McNett analysis shows a good picture of the development of fibre distributions; it signifies what happens during the refining. In particular the coarse long fibre fraction from the Bauer McNett reflects the refining action. By utilization of the right combinations of power input, refiner plates and increased temperature, it is possible to avoid severe fibre shortening and keep the long fibre content high.

Figure 3. Bauer McNett fraction >16 vs. CSF
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 3 shows that refining with “medium” edge length plates (Ls 8.4 km/rev) gave a higher content of the fraction >16 compared to refining with “fine” type segment (Ls 15.7 km/rev). The content of the fraction >16 was highest after refining with a combination of “medium” refiner plates and low edge loads (0.5 Ws/m). Refining at higher edge loads of 0.7 and 0.9 Ws/m with fine segments gave the lowest content of the long fibre fraction >16. However, the level of the fraction >16 was highest for a two-stage HC refining mill pulp.

Figure 4. Bauer McNett fraction 16-30 vs. CSF

Figure 4 shows that the development of the Bauer McNett fraction 16-30 first increases during refining but then drops when reaching low freeness. This effect obtained by the smaller plate gap in the LC refining is opposite to what occurs in the HC refining where the 16-30 fraction generally decreases progressively somewhat by increased energy input. This decreased content of the 16-30 fraction by increased energy input has earlier been observed studying defibration at different energy input however at a freeness of 150 ml the amount of the 16-30 fraction is similar for the two types of refiners.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 5. Bauer McNett fraction >30 vs. CSF

Figure 5 shows that using “fine” type plates in the LC refining the long fibre content >30 decreases more than refining with “medium” type plates. Refining at higher edge loads than 0.5 Ws/m also decreased the long fibre content compared at the same freeness. If the right combination of refiner plates and edge loads is balanced it is probable that the fibre development could be the same as for a second stage HC refining.

Figure 6. Bauer McNett fraction vs. 30-50CSF

Figure 6 shows that the middle fraction 30-50 is increased by 5% using “medium” type plates in the LC refining compare to a second stage HC refining. The increased content is about 10% using “fine” type plates compare at the same freeness as second stage HC pulp. The increase of the middle fraction 30-50 is a result of the lower content of the fraction >16.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4.2.2 Plate gap measurement

Figure 7. Bauer McNett >30 vs. plate gap (mean) from refining with “medium” plates

Figure 7 shows that by increasing the edge load also the plate gap decreased and with that the content of the long fibre fraction >30. The plate gap decrease about 0.15 mm by increasing the edge load from 0.5 to 0.9 Ws/m compared at the same content of the fraction >30.

Figure 8. Bauer McNett fraction >30 vs. plate gap (front and drive side)

Figure 8 shows that the two plate gaps are not equally divided when the edge load is increased. The gap on the drive side seems not to move as easy as the front side when the edge load is increasing.
4.2.3 Strength properties

Despite the fact that the same tensile index can be reached using different segments and edge loads the best combination of refiner plates and refining load to preserve the long fibre fraction >30 and keep the tensile index high was to use “medium” type plates and an edge load of 0.5 Ws/m in the LC refining. Figure 9 shows that with a low edge load of 0.5 Ws/m applied by the medium edge length refiner plates approximately the same long fibre content compared to the HC refining was possible to reach. However in this case the tensile index was reduced by approximately 4 (units) Nm/g compared to the tensile index of the HC pulp.

Figure 10 shows the electrical energy consumption of the HC–LC refining concept compared to the HC–HC two-stage process. About 300 kWh/t less electrical energy is needed compared to the HC refining to reach the same tensile index.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4.2.4 Refining of 2nd stage pulp

Figure 11. Bauer McNett fraction >16 vs. CSF

Figure 11 shows the development of the content of the long fibre fraction of a LC refined second stage HC pulp. Similar trends as shown in Figure 3 for the first stage pulp were obtained. The combination of low edge load and medium type refiner plates resulted in the highest content of the fraction >16 compared to refining using fine type refiner plates.

Figure 12. Bauer McNett fraction 16-30 vs. CSF

The Figure 12 shows that the fraction 16-30 increased in content to some extent in the LC refining using medium type refiner plates while the fine pattern reduced the content somewhat.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 13. Bauer McNett fraction >30 vs. CSF

Figure 13 shows that the content of the long fibre fraction >30 decreased if the edge length was increased. Refining with the medium type refiner plates preserved the fibre length better than the long edge length plates compared at the same freeness.

Figure 14. Light scattering coefficient vs. tensile index

All the combinations of edge loads and edge lengths, plotted in Figure 14, used for the LC refining of second stage pulp increased the tensile index. The combinations using “medium” type refiner plates and an edge load of 0.5 Ws/m and “fine” type plates at the edge load of 0.3 Ws/m respectively gave to some extent also increased light scattering to the pulp.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

16 (29)

4.3 Conclusions - trial 1

These refinings in trial 1 showed that it is important to combine a low edge load and refiner plates with relatively short edge length in order to preserve the long fibre content of the pulp.

The long fibre content is also better preserved if a small plate-gap is avoided.

Refining of first and of second stage pulp with “medium” type refiner plates at a low edge load of 0.5 Ws/m showed to be the best combination for preserving the long fibre content. Refining of second stage pulps with “fine” type plates at a low edge load of 0.3 Ws/m was also noticed as a good combination.

The long fibre Bauer Mc Nett fraction >16 was reduced by LC refining which instead increased the fractions 16-30 and 30-50.

4.4 Trial 2. LC-refining of high freeness pulps at different speeds

4.4.1 Materials

High freeness pulp from a high consistency first stage Andtriz Twin refiner was the original pulp for this trial. Table 3 gives the data of the pulp.

Table 3. HC refining (line S1)

<table>
<thead>
<tr>
<th></th>
<th>First stage TMP (S1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific energy, [kWh/t]</td>
<td>1250</td>
</tr>
<tr>
<td>Pulp consistency, [%]</td>
<td>~ 42</td>
</tr>
<tr>
<td>Pressure, [bar]</td>
<td>~ 4.5</td>
</tr>
<tr>
<td>Speed, [rpm]</td>
<td>1500</td>
</tr>
<tr>
<td>Shive content Sommerville, [%]</td>
<td>4.2</td>
</tr>
<tr>
<td>Freeness, [ml]</td>
<td>450</td>
</tr>
</tbody>
</table>

4.4.2 Plate design

The plate design used for the LC refining is shown in Figure 15. These plates were, based on previous experience, considered too coarse for the trial pulps that were used. Evaluation of the pulp properties was thus limited. Notable is that the plates had full surface dams.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 15. J&L coarse segment with full surface dams

<table>
<thead>
<tr>
<th>Bar width [mm]</th>
<th>Groove width [mm]</th>
<th>Depth [mm]</th>
<th>Angle</th>
<th>Ls [km/rev]</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6</td>
<td>5.2</td>
<td>7.9</td>
<td>10.0</td>
<td>6.126</td>
<td>Full surface dams</td>
</tr>
</tbody>
</table>

4.5 Results - trial 2

Figure 16. CSF vs. specific energy gross

Figure 16 shows the freeness as a function of the specific energy consumption at two different rotational speeds. At a freeness of 180 ml the energy consumption increased with 30% as the speed increased from 700 to 900 rpm.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

18 (29)

Figure 17. Bauer McNett fraction >30 vs. specific energy

Compared at the same content of the Bauer McNett fraction >30 the specific energy consumption was much higher if the refiner speed was increased from 700 to 900 rpm, see Figure 17.

Figure 18. Bauer McNett fraction >30 vs. plate gap (FS: Front Side DS: Drive Side)

The plate gap was almost the same comparing 700 rpm to 900 rpm, see figure 18. However there is a trend of a reduction in the >30 fraction with the small clearance in the plate gap. The content of the long fibre fraction >30 was lower running the refiner at 900 rpm. The results indicate that lower speed is preferable to preserve the long fibre content.
4.6 Conclusions - trial 2.

The main conclusion from the refinings of trial 2 seen was that the specific energy consumption increased when a higher rotational speed was applied a fact that most probably can be referred to the higher idling power at the higher speed.

4.7 Trial 3. LC refining of high freeness RTS pulp

4.7.1 Materials

A high freeness pulp was taken out from a first stage refiner Andtriz SB170-RTS-process at the Hallstavik mill for further use in this trial. Table 4 gives information of the original pulp. Special attention should be directed to the fact that the shive content of the pulp from an RTS process is lower compared to a conventional TMP process due to the much higher speed of the refiner.

Table 4. First stage HC-refining

<table>
<thead>
<tr>
<th>Specific energy, [kWh/t]</th>
<th>~1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp consistency, [%]</td>
<td>~42</td>
</tr>
<tr>
<td>Pressure, [bar]</td>
<td>5.5</td>
</tr>
<tr>
<td>Speed, [rpm]</td>
<td>2300</td>
</tr>
<tr>
<td>CSF, [ml]</td>
<td>335</td>
</tr>
<tr>
<td>Shive content (SW), [%]</td>
<td>1.4</td>
</tr>
</tbody>
</table>

The first stage pulp was refined at low-consistency in one passage in the pilot refiner. The LC refining was carried out at different edge loads and specific energy inputs. Table 5 shows the running conditions. Measurements of the plate gaps were done in each refining zone.

Table 5. LC refining

<table>
<thead>
<tr>
<th>Pulp consistency, [%]</th>
<th>~3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, [°C]</td>
<td>~90</td>
</tr>
<tr>
<td>Speed, [rpm]</td>
<td>700</td>
</tr>
<tr>
<td>Edge load Bs, [Ws/m]</td>
<td>0.5, 0.7 and 0.9</td>
</tr>
<tr>
<td>Edge length Ls, [km/rev]</td>
<td>8.54 (“medium”)</td>
</tr>
</tbody>
</table>

4.7.2 Plate design

The plate design of the plates from J&L used in this trial is shown in Figure 16. The plate design is close to the “medium” segments used in trial 1. However, the average angle of the bars was smaller compared to the GL&V refiner plates.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4.8 Results – trial 3

4.8.1 Bauer McNett fibre fractions

The Bauer McNett fraction >16 was lower for the HC-LC refining concept compared to the two stages HC refining at the same freeness, see Figure 20. Increasing the edge load from 0.5 to 0.9 Ws/m further somewhat decreased the fraction >16. Compared at the same freeness of 180 ml, the content of the fraction >16 were 10% after the HC–LC refining compared to 20% for the HC refining.

Figure 19. J&L “medium” type plate segment

<table>
<thead>
<tr>
<th>Bar width [mm]</th>
<th>Groove width [mm]</th>
<th>Depth [mm]</th>
<th>Angle</th>
<th>Ls</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>4.4</td>
<td>7.3</td>
<td>7.5</td>
<td>8.54</td>
<td>No dams</td>
</tr>
</tbody>
</table>

Figure 20. Bauer McNett fraction >16 vs. CSF
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 21. Bauer McNett fraction 16-30 vs. CSF

The content of the Bauer McNett fraction 16-30 was about the same for the HC–LC refining or slightly higher for the low edge load 0.5 Ws/m compared to HC refining at a freeness of ~150 ml, see Figure 21.

Figure 22. Bauer McNett fraction >30 vs. CSF

The long fibre content of the Bauer McNett fraction >30 was 10% lower for the HC-LC refining compared to HC-HC refining at freeness levels of CSF around 150 ml. A higher edge load in the LC refining further decreased the content of the long fibre fraction, see Figure 22.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

4.8.2 Plate gap measurement

Figure 23. Plate gap vs. specific energy

Figure 23 shows that the plate gap (mean) was affected both by the edge load and by the specific energy input. The plate gap decreased when increasing the edge load and the specific energy. If the plate gap becomes too small this affects negatively the fibre properties. It is possible to avoid a small plate-gap by increasing the flow through the refiner at low edge load.

Figure 24. Bauer McNett fraction >30 vs. plate gap mean
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 24 shows that a larger plate gap by approximately about 0.10 mm could be used when refining at 0.5 Ws/m compared to 0.9 Ws/m to obtain the same content of the long fibre fraction >30.

![CSF vs. plate gap mean](image1)

Figure 25. CSF vs. plate gap mean

Figure 25 shows that the difference in the mean plate gap was 0.10 mm between refining at 0.5 Ws/m and 0.9 Ws/m compared at the same freeness in the interval between 150-200 ml. A higher edge load applied results in a smaller plate gap in the refining zone.

![Bauer McNett fraction >30 vs. plate gap (front and drive side)](image2)

Figure 26. Bauer McNett fraction >30 vs. plate gap (front and drive side)
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

The plate gap in the Beloit refiner was measured in the two different refining zones which differ as seen in Figure 26. The rotor is apparently not properly floating in-between the two stator discs. The measured difference between the two plate gaps was about 0.05-0.10 mm when refining at different edge loads and energy input.

4.8.3 Strength properties

Figure 27 shows that the tensile index is more easily increased at a low edge load of 0.5 Ws/m compared to higher edge loads. An energy input of 200 kWh/t gave a pulp with almost 40 units in tensile index. The fibres were cut when the edge load was too high. Compared at the same tensile index of 40 Nm/g the energy consumption was only 200 kWh/t for the LC-refining compared to 500 kWh/t for the HC refining.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

Figure 28. Tear index vs. specific energy gross

Figure 28 shows that increased edge load decreased the tear index. Refining at a low edge load of 0.5 Ws/m was most preferable. The tear index was under these conditions preserved almost to the same level as for HC refining if an energy input not higher than 200 kWh/t was used.

Figure 29. Tensile index vs. density

Figure 29 shows that the sheet density seems to increase somewhat more by LC refining compared to HC refining. Compared at the same tensile index (~40 Nm/g) the LC refining gives a sheet of 30-50 units higher density compared to HC refining. This is
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

26 (29)

probably a result of the change in fibre distribution occurring for LC refining in comparison to HC refining.

![Figure 30. Light scattering coefficient vs. specific energy](image)

By higher edge loads the development of the light scattering coefficient is increased. The increase is due to the higher content of fines caused by fibre shortening. At an edge load of 0.5 Ws/m the light scattering develops in a similar manner as the light scattering of HC pulps, see Figure 30.

### 4.9 Conclusions - trial 3

The refinings made in trial 3 showed that an edge load not higher than 0.5 Ws/m should be used to obtain good strength properties of the pulp. Refining at higher edge loads to a large extent decreases the long fibre content.

At higher edge loads in the refining the plate gap becomes smaller. It is possible to avoid a small plate gap by increasing the flow and run the refiner at a lower edge load.

Higher energy consumption than 200 kWh/t in one passage seems to decrease the long fibre content.

At the same tensile index (~40 Nm/g) the energy consumption was 300 kWh/t smaller for the LC refining compared to HC refining.

LC refining increases the density of the sheet compared to HC refining.
5 Overall conclusions

The three refiner trials here made showed that it is important to combine a low edge load (~0.5 Ws/m) and refiner plates with relatively short edge length in order to preserve the long fibre content. Refining at higher edge loads decreases to a large extent the long fibre content due to the fact that the plate gap becomes smaller. The long fibre content is better preserved if a small plate-gap is avoided.

Refining of first and of second stage pulp with “medium” type refiner plates at a low edge load of 0.5 Ws/m was shown to be the best combination for preserving the long fibre content.

The specific energy consumption increased when a higher rotational speed was applied.

Higher energy consumption than 200 kWh/t in one passage seems to decrease the long fibre content.

The energy consumption was smaller for LC refining compared to HC refining.
Mechanisms in the refining zone for development of physical properties of TMP fibres in a low-consistency refiner

6 References

Hammar L-Å; Htun M; Svensson B
A two-stage refining process to save energy for mechanical pulps