Abstract

This thesis focuses on the electric energy efficiency of single stage double disc refining for production of printing grade mechanical pulp from Norway spruce wood chips. The thesis is based on the hypothesis, that more energy efficiency refining can be attained by balanced increases of wood softening and refining intensity. Five mill scale trials were performed where wood softening and refining intensity was varied by applying or changing the following process parameters and variables:

- Chip pretreatment/impregnation with water
- Low dosages of sodium sulfite (Na_2SO_3) added to impregnation
- Temperature and retention time in the atmospheric preheater bin
- Refining temperature (housing pressure)
- Feeding segment design combined with increased production rate

By combining suitable increases in wood softening and refining intensity, it was possible to reduce the specific electric energy consumption in refining by 15% (~290 kWh per bone dry ton (bdt)) while preserving important pulp properties within ±5%, compared to the standard double disc refining process. This was done by combining chip impregnation, using an addition of 0.36% (on bone dry basis) sodium sulfite, with a new feeding segment design which enabled 25% higher production rate.

When using the new feeding segment design at an increased production rate at unchanged wood softening, it led to reduced fiber length and increased sheet light scattering coefficient at certain tensile index, compared with the standard segment design at normal production rate. This is consistent with the effects normally seen when the refining intensity is increasing. The specific electric energy consumption was 8% lower at a tensile index of 43.5 Nm/g (on Rapid Köthen laboratory sheets) compared to refining at lower intensity using the standard segment design at normal production rate.

Mechanical chip pretreatment with subsequent water impregnation showed a reduction in specific electric energy consumption of 6% (~120 kWh/bdt). When chip impregnation was applied in a later trial with a milder chip compression, it led to increased wood softening seen as better preserved fiber length and reduced light scattering coefficient. This resulted in a reduction in tensile index at certain specific electric energy consumption when applied with the standard refining condition but to an increase in tensile index when applied with refining at higher intensity using the feeding segment design at higher production rate.

An addition of 1.2% sodium sulfite during impregnation led to a sulfonate content of pulps of ~0.28% (as Na_2SO_3 equivalents, including post sulfonation) and an average increase in tensile index of about 8.3 Nm/g, when compared to unsulfonated pulps at certain specific electric energy consumption. The increase in tensile index correlated with increased delamination and internal fibrillation of fibers (measured by Simon's staining), which indicate that the increase in tensile index for sulfonated pulps was a result of improved fiber flexibility and collapsibility. The reduction in disc gap at certain specific electric energy consumption in refining due to an increased wood softening after sulfonation may explain the increase in delamination and internal fibrillation for sulfonated pulps. The smaller disc gap probably led to a more intense refining, i.e. loading at higher deformation rates due to a higher degree of deformation in bar crossings.

Different temperatures (80 vs. 97°C) and retention times (6 vs. 9 min.) in the atmospheric preheater bin were studied. This showed that the lower temperature and shorter retention time was beneficial for the tensile strength and light scattering of pulp when applying low dosage sodium sulfite pretreatment. This was most likely a result of too high degree of wood softening prior to defibration in the breaker bar zone when combining low dosage sodium sulfite pretreatment with the higher preheating bin temperature at longer retention time.

Different refining temperatures (4.6 and 6.4 bar(g) refiner housing pressure) were evaluated both without and with low additions (0.6% and 1.2%) of sodium sulfite. Raising the refining temperature increased tensile index by 3.2 Nm/g and the addition of 1.2% sodium sulfite by 8.6 Nm/g. The combined increase (~12 Nm/g) was similar to the effect of increasing the specific electric energy

consumption by 380 kWh/bdt, when comparing pulps at equal tensile index. However, the pulps produced with increased refining temperature and sodium sulfite addition had lower light scattering coefficient at certain tensile index. The combination of increased refining temperature and addition of 0.6% sodium sulfite was interesting and resulted in pulp with higher tensile index, light scattering coefficient and brightness together with lower shives content at certain specific electric energy consumption, compared with pulp produced at the lower refining temperature without addition of sodium sulfite.

Finally, an implementation of the technology presented here is discussed in relation to the Braviken mill (Holmen Paper AB, Norrköping, Sweden) concerning reduction in electric energy consumption and steam recovery. The technology has potential to reduce the electrical energy use by ~100 GWh/year at the Braviken paper mill, where this study was performed.