FILLING THE GAP – IMPROVED ENERGY EFFICIENCY AND QUALITY STABILITY IN MECHANICAL PULP REFINING

Per Engstrand[1] and Anders Karlström[2]

[1)] FSCN – Mid Sweden University, SE-85170 Sundsvall, Sweden E-mail; per.engstrand@miun.se

[2)] Chalmers Industriteknik, Chalmers University of Technology, Gothenburg, Sweden

ABSTRACT

As energy prices will continue to rise long term it is very important to come up with suggestions to efficiency-improving solutions based on modifications of the existing refining technology without large investments. There are several suggestions to relatively large modifications in design of refiner plate patterns, chip pre-treatment and chip feed strategies to existing refiners, but these suggestions are difficult to implement, as the knowledge of the mechanisms prevalent in the refiner gap is insufficient.

To solve this problem FSCN and CIT have started research project, "Filling the Gap", together with the companies; Dametric, Holmen, Metso, Norske Skog, Pöyry, SCA and Stora-Enso co-financed by the Swedish authorities; Vinnova and Swedish Energy Agency. The objective of this research project is to show how to improve the electric energy efficiency of chip refining by means of utilizing the fundamental knowledge of wood material properties relevant for chip refining i.e. refining hypotheses in combination with output variable knowledge from new and improved refining zone measurement methods as; exact gap distance, temperature-, force- and fibre material radial distributions combined with the traditional out/in-put variables used. These data will be utilized in two ways:

1) Optimize refining conditions in a static way, i.e. of conditions to maximize energy efficiency to reach the functional fibre properties aimed for.

2) Maximize process stability and minimize quality variations to these functional fibre properties.

This paper reports a general overview from the preliminary results of these evaluations.

INTRODUCTION

It has been seen that one within a production system for TMP or CTMP can find large differences in energy efficiency to very similar fibre (pulp) properties. In many cases these differences can be attributed to variations in incoming wood material or due to wear of refiner plates and wear of equipments related to feeding systems. Many production engineers and operators have however noted that it is possible to optimize the refining systems in different ways also with a given raw material, process equipment set and equipment wear situation. Also in this "known" situation it is possible to run the production system in a more or less energy efficient way still reaching "similar" fibre properties. Furthermore it has been shown in mill trials *(1)* that also very fast load variations in refining systems seem to be reflected as large variations in fibre properties. Researchers have made very large efforts to describe fibre distribution inside the refining zone by means of interpretation of signals from sensor measuring; pressure, temperature, force and even residence time (2-4) and in most cases the conclusion is that the distribution varies a lot. The present refiner control systems are far to slow to cope with these fast variations. Most process suggestions to improve energy efficiency are based on ways of reducing and/or optimizing the gap distance *(5-9)*. Reduced gap distance increases the demand to thoroughly control and keep gap conditions stable minimizing process variations and thus fibre property variations. In order to solve this problem it is necessary to minimize process variable variations that today actually may seem relatively small. For this purpose it is necessary to develop better control strategies and process models. In order to succeed with this the level of detailed understanding has to be improved regarding the refining action in the gap of the refiner.

We have since many years had access to successively improved suggestions to models describing what happens in the gap *(10-16)*. The problems with these have been that they are difficult to utilize as a basis for full-scale process control as long as we are not able to validate them.

The objective with the project described in this article is to improve the understanding of the action in a typical chip refiner gap by means of testing existing refining models in pilot and mill scale. In testing these models the best available measurement technology in terms of gap distance, temperature profiles etc. is utilized. In parallel new techniques to measure force distribution and fibre distribution are developed. The data measured are combined with conventionally measured data in order to validate the refining models mentioned as well as to improve models developed within the project. The general goal is to show how to improve energy efficiency by 25% in existing machinery at similar functional pulp properties.

METHODOLOGY

The methodology utilized consists of three parts; deep review of earlier published refining theories combined with interviews of key TMP experts on what is used today, development of measurement technologies describing fibre and force distribution along the gap and full-scale testing of successively improved refining theory knowledge and measurement techniques. In order to measure the improvements in energy efficiency reached within the project an initial evaluation of the TMP line utilized in this study was performed during test year one. This TMP-line is successively equipped with state of the art measurement techniques as, gap distance technique AGS® (Dametric) and temperature profile measurement equipments (13-14) and after development of force and fibre distribution techniques, these will also be tested making validation of existing and modernized refining theories possible.

RESULTS AND DISCUSSION

This project is run as four parallel sub-projects:

1. Laser technology for fibre distribution measurement. (17)
2. Strain gauge technology in hollow bars for force distribution measurement. (18)
3. Refining theory evaluations and investigation of in practice utilized hypothesis at mills participating in the project. (19)
4. Full scale evaluations at one of the participating mills. (20)

Fibre distribution

Combining different measurement techniques improves the opportunities to capture important information and thus the ability to identify interesting correlations. Sensors measuring light extinction and dynamic pressure are used.

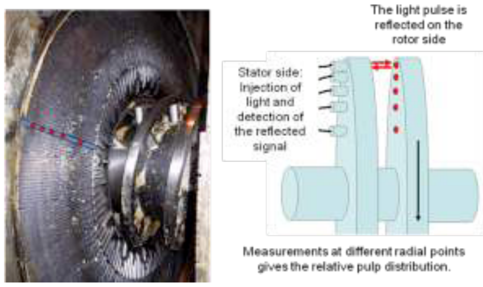

Figure 1. General overview of the laser based fibre distribution measurement technique.

The laser light interacts with pulp through scattering, absorption and transmittation. The sum of losses in intensity due to absorption and scattering is called the extinction of light. Analyzing the light after interaction with pulp gives information about pulp distribution along the gap, (17).

Force distribution

The basic idea behind this measurement technique is to design a hollow bar integrated into the plate pattern. Strain gauges are used as sensor elements mounted inside the bar

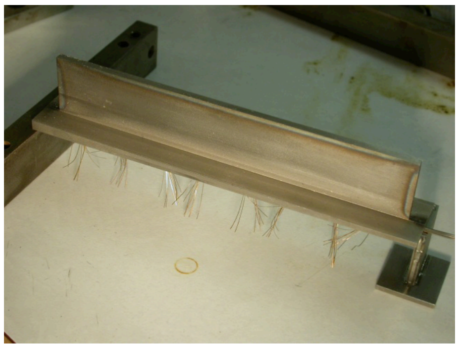

Figure 2. Force distribution bar protected from the environment in the gap (18).

Refining theory evaluation

Until now the project have tested three models relevant for the purpose on the same set of data for comparison purposes. (19). The models tested were; ”Miles and May Model” (11), ”Fluid Dynamic Model” (15) and

”The Entropy Model” (16). Predictions from the Miles and May model deviated most from the estimates based on measured values. The fluid dynamic model and especially the entropy model showed good agreement both when it came to describing the specific energy distribution and the local refining intensity distribution over the refining radius. The later is shown in *figure 3*, below.

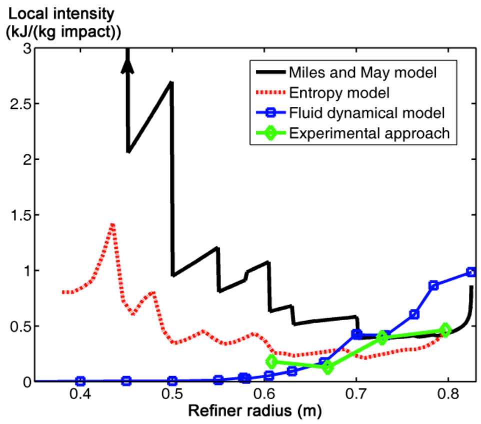

Figure 3. Intensity (kJ/kg*impact) as a function of radius in the refiner.

The data used to test the models comes from Härkönen *(4, 12, personal communication).*

Mill scale tests

The initial evaluation of the TMP line utilized in this study was performed during test year one. Some of the results are shown in *figure 4*, the sampling was performed at 10 occasions during 1,5 months.

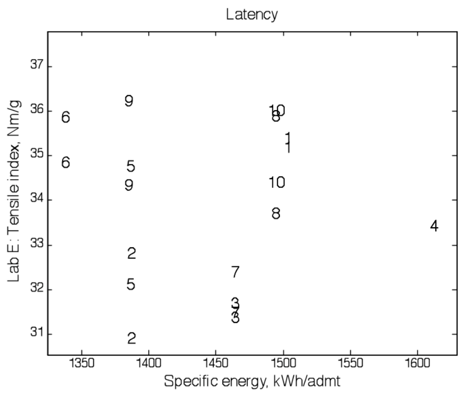

Figure 4. Tensile index versus specific energy consumption shown for duplicate samples (except occasion 4) taken after latency chest tested at 4 different laboratories.

No actions were taken to adjust the refiner settings, i.e. the variation in quality and process parameters from the ten sampling occasions reflects the variations were present during the 1.5 months. There is thus no indication that higher energy consumption within the interval shown in *figure 4* results in better tensile index. Although there was some scattering between duplicate samples there was a rather good correlation between different laboratories.

CONCLUSIONS

Less than two years from project start it has been confirmed that even very modern refining system can show large variations in electric energy consumption without measurable differences in strength properties. In this case the energy interval 1350–1600 kWh/t showed no significant difference in strength properties.

By means an improvement of the level of detailed understanding regarding what happens in the gap of chip refiners we believe that there is a great chance to reach the goal of this project regarding the reduction of energy consumption. A prerequisite is of coarse that we understand how test and implement this knowledge in full scale.

ACKNOWLEDGEMENTS

This project is a part of the Swedish Forest Industry Research Program with the Swedish governmental funds Swedish Energy Agency and Swedish Innovation Agency and most important our company group; Dametric AB, Holmen AB, Metso AB, Norske Skog A/S, Poyry AB, SCA AB and Stora-Enso AB. We would like to greatly acknowledge all persons in this group of companies and supporting organizations for their great support and engagement in this project.

REFERENCES

1) Engstrand, P., Karlström, A., Nilsson, L., The impact of chemical addition on refining parameters, *1995, Int. Mech. Pulp. Conf., Ottawa, Canada pp.281*
2) Eriksen, O., High-frequency pressure measurements in the refining zone of a high-consistency refiner, *PhD Thesis NTNU Dr.ing.avhandling 2003:50*

3) Ouellet, D., Bennington, C.P.J., Senger, J.J., Borisoff,j.F., Martiskainen,J.M., Measurement of pulp residence time in a High-Consistency refiner, *J. Pulp Paper Sci., 1996, 22(8), pp. J301-J305*
4) Härkönen E. Huusari, E., Ravila P. Residence time of fiber in a single disc refiner. *1999, Int. Mech. Pulp. Conf. Huston, USA, pp. 77*
5) Höglund, H., Bäck, R.,Falk, B., Jackson, M., Thermopulp – a new energy efficient mechanical pulping process, *Pulp Pap. Can.,1995, 98(6), p.T215*
6) Sabourin, M., Aichinger, J., Wiseman, N., Industrial scale evaluation of low retention, high temperature, high speed (RTS) TMP pulping of southern pine, *2001, Int. Mech. Pulp. Conf., Helsinki Finland, p. 341*
7) Engstrand, P., Hammar, LÅ-., Htun, M., Pettersson, R., Svensson, B., PCT/SE 1989/000172 05.04.1989 06.05.1988, ”Method of making mechanical and chemi-mechananical papermaking pulp”
8) Hammar, L-Å., Htun, M., Svensson, B., A two stage refining process to save energy to save energy for mechanical pulps, *1997, Int. Mech. Pulp. Conf., Stockholm, Sweden, pp. 257*
9) Luukkonen, A., Olson, J.A., Martinez, D.M. Low consistency refining of mechanical pulp: A methodology to relate operating conditions to paper properties, *2010, 7th Int. Sem. on Fund. Mech. Pulp Res., Nanjing, China pp.144*
10) Brecht. W., A method for comparative evaluation of bar-equipped beating devices*, TAPPI J., 1967, 50(8), p. 40A-44A*
11) Miles, K.B., May, W.D. (1993) “Predicting the Performance of a Chip Refiner; a Constitutive Approach” *J. Pulp Pap. Sci., 1993,* vol. 19, no. 6, pp. J268-274
12) Härkönen, E.,Tienvieri, T. “Energy savings in TMP pulping”, *2001, Int. Mech. Pulp. Conf., Helsinki, Finland, pp. 547-556*
13) Karlström, J., Eriksson, K., Sikter, D. and Gustavsson, M. “Refining models for control purposes” *Nord. Pulp Pap. Res. J., 2008,* vol. 23, no. 1, pp. 129-138
14) Berg, D., Karlström, A. Dynamic pressure measurements in full-scale thermomechanical pulp refiners*, 2005, Int. Mech. Pulp. Conf., Oslo, p. 42-49*
15) Huhtanen, J-P., Karvinen, R., Vikman, K. Vuorio, P. “Determination of freeness reduction by refining intensity definition based on fluid dynamical model” *2009, Int. Mech. Pulp. Conf., Sundsvall, Sweden, pp. 209*
16) Eriksson, K., Karlström, A. Modelling approaches for critical process limitations in the operation of thermomechanical pulp refiners, *Nord. Pulp Pap. Res. J., 2009*, 24(2), 231-238.
17) Eriksson, K., Stina Hemdal, S.,Karlström, A. (2011) Fiber Distribution in Refining Zones*, 2011 Int. Mech. Pulp. Conf., Xian, China*
18) Gradin P A., Berg J-E.,, Gulliksson M.E., Nyström, S.K., ”Measuring Forces in a Refiner Plate Gap” *, 2011 Int. Mech. Pulp. Conf., Xian, China*
19) Engberg, B., Berg J-E., ”A Comparative Study of Models Describing High Consistency Refining”, *, 2011 Int. Mech. Pulp. Conf., Xian, China*
20) Ferritsius, O., Ferritsius, R., Eriksson, R., Engstrand, P., Uniform Non-Uniformity – What can we learn from Contiunuous Operation of TMP Refining Process? *, 2011 Int. Mech. Pulp. Conf., Xian, China*