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Testing of Heat Load Model for Pulp and Paper in two TMP cases

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Heat load model for pulp and paper (HLMPP) is a generic tool developed for screening potential for improving energy efficiency with reasonable effort and with sufficient data accuracy. Current consumptions of hot and cold utilities of the mill can be compared against the provided theoretical minimum values. This shows whether there is a potential for improvement or not, before going into detailed evaluations. The tool has been proven to work well with a pressurized ground wood (PGW) mill in previous studies. HLMPP has been developed further to cover thermo mechanical pulping (TMP) and de-inked pulp (DIP) lines. In this paper the developed version of HLMPP is tested in using two different cases. One is a simulated case containing one TMP line and one paper machine and the other one is a real European mill containing one TMP line, one DIP line and two paper machines. The results show that the model works with a suitable accuracy level and provides valuable information of the energy system of the mill

1. Introduction

Pulp and paper mills contain typically a large number of heating and cooling duties. Due to the complexity, a large number of man hours are needed in evaluating the process and its heat exchanger network to establish energy saving targets. A detailed process simulation model is often needed to provide data for the related analyses, requiring significant resources for data collection and model building. One possible outcome of the analysis is that the process is energy efficient, and the hard effort has been a waste of time and money. With the HLMPP tool it is possible to estimate with reasonable effort and with sufficient data accuracy how well the mill in question operates from the energy targeting point of view. This estimation shows whether there is a potential for improvement before going into detailed evaluations. Energy targeting is carried out by Pinch analysis (Linnhoff et al., 1982).

The tool has been proven to work well with a PGW mill in previous studies (Hakala et al., 2008). HLMPP has been developed further to cover thermo mechanical pulping (TMP) and de-inked pulp (DIP). In this study the new developed version of HLMPP is

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tested in using two different cases. One is a simulated case containing one TMP line and one paper machine and the other one is a real European mill containing one TMP line, one DIP line and two paper machines.

2. Heat load model for pulp and paper (HLMPP)

The HLMPP tool is a simplified representation of the mechanical pulp and paper process from the energy point of view. The goal of the HLMPP is to convert the mill data into heating and cooling requirements of the process, and thus lot of process details have been left out. In the model, several sources for wood fibre and several paper machines for different paper products and drying section setups can be applied. The tool shows the theoretical improvement potential by providing the minimum hot and cold utility consumptions for the given mill parameters. If the utility consumptions (steam, cooling needs, etc.) at the operating mill are considerably higher than what the energy targeting in HLMPP gives as a minimum, it is an indication that there is potential to improve the heat exchange network. HLMPP does not provide information what is the economically achievable level for hot and cold utility consumptions, still it provides a signal of possibility to improve the energy economy. A broader description of the model has been presented by Hakala et al., (2008) The HLMPP tool is visualized in Figure 1.

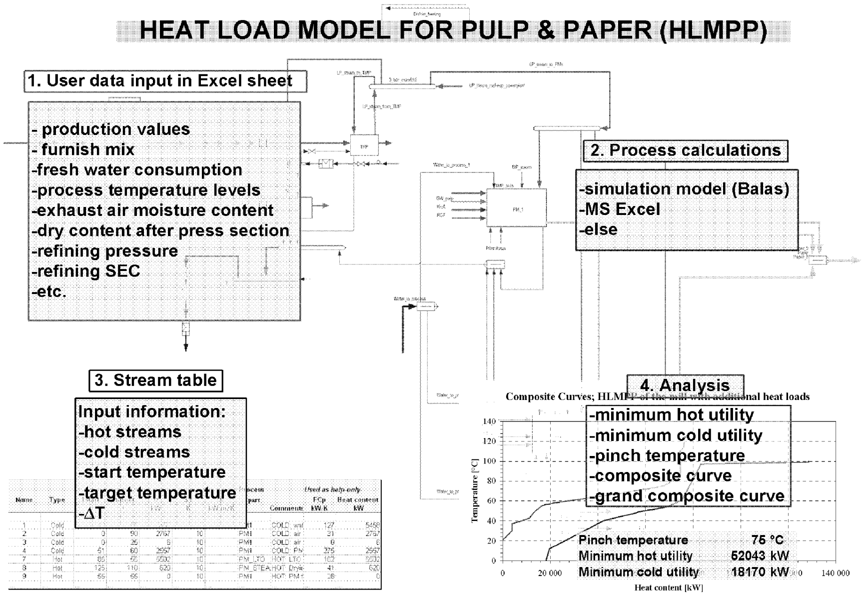

Figure 1. Visualization of the HLMPP tool (Hakala et al., 2008).

3. A simulated case

The HLMPP has been tested using a simulated case. The case contains one TMP line, one paper machine, debarking and waste water treatment. Pinch analysis has been carried out using a detailed simulation model and HLMPP. There are 11 hot streams and 11 cold streams in the analysis, including incoming air and water, other heat requirements of the paper machine, filtrates at the mechanical pulping and cooling needs of the whole mill. A minimum ΔT of 10 °C is used. The resulting grand composite curves are shown in Figure 2.

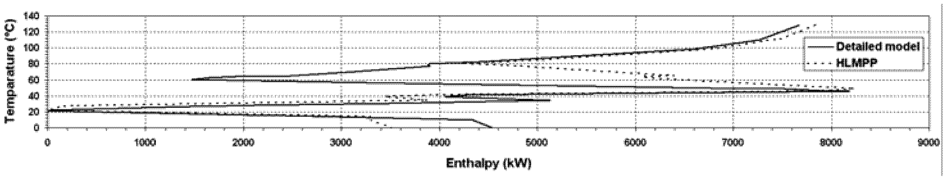

Figure 2. Grand Composite curves of the process in detailed model and HLMPP.

The both curves show almost identical pinch temperatures; 21.38 in detailed model versus 21.4 in HLMPP. The amount of hot utility needed is 7676 kW in detailed model and 7841 in HLMPP. In cold utility there is a slightly bigger difference; cold utility demand is 4537 kW in detailed model and 3507 kW in HLMPP. The resulting pinch temperatures, hot utility demands and cold utility demands are shown in Table 1.

Table 1. Comparison between the detailed model and HLMPP.

	Detailed model	HLMPP	Difference (%)
Pinch temperature (°C)	21,38	21,40	0 %
Hot utility (kW)	7676	7841	2 %
Cold utility (kW)	4537	3507	-29 %

The main difference in the results, in addition to the different amounts of cold utility demand, is the temperature level on which hot utility is needed. The detailed model shows that about 1.5 MW can be supplied below temperature 60 °C. According to HLMPP this amount would be 4.2 MW. This difference is caused by linearization in the heat content of the exhaust air heat recovery of the paper machine. Therefore one must be careful when interpreting results that include paper machine heat recovery.

4. A real mill

The mill used as an example in this study is a European mill that produces paper on two paper machines. The mill has two pulp lines; one TMP line and one DIP line. The study covers also debarking and waste water treatment. Pinch analysis has been carried out with a minimum ΔT of 10 °C. Six different cases have been studied using the HLMPP:

a. Base case with current amount of heat integration.
b. Case a + one hot stream going to the waste water treatment (WWT)
c. Case a + the steam consumption of the drying sections of the paper machines is presented at the temperature level where the heat transfer actually takes place.
d. Case c + outlet moisture content of exhaust air of PM2 is set to 150 g/kg.
e. Case c + outlet moisture content of exhaust air of both the paper machines is set to 160 g/kg.
f. Case e + one hot stream (warmer than in case b) going to the WWT.

To make it easier to interpret the results they have been presented using four levels:

1. Only the heat exchanger network of the mill.
2. Level 1 + heat needed at the drying section of the paper machines.
3. Level 2 + TMP steam use in the TMP plant
4. Level 3 + as much TMP steam use as the analysis shows possible.

In the model it is possible to switch between the levels by simply choosing from a list which parts of the mill the user wants to include to the study. These four levels have been illustrated in Figure 3 using case a as an example.

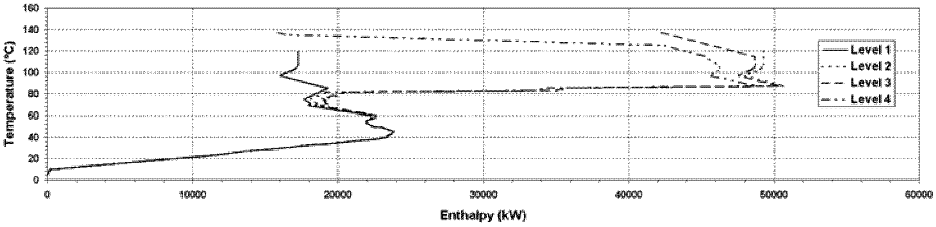

Figure 3. Description of the four levels in case a.

The analysis shows that pinch temperature of the process is very low, only 5 °C, and no external cooling is required. The heating demand, 17300 kW, is all located on a low temperature level. The amount of TMP steam can cover all steam needs. Currently in the mill there is no external heating below pinch. The only cross pinch heat transfer is heating of incoming air in paper machine heat recovery. However, this heating requirement can not be seen as technically feasible to cover by any other way. The main pinch violations are all cooling demands, currently covered by external cooling and all of the warm flows that leave the mill site. Because the pinch temperature is so low, it would be possible to make good use of flows at very low temperature levels. These can be found mainly from flows going to the waste water treatment. Another possibility is to improve the paper machine heat recovery.

The possibility to improve heat recovery from waste water has been discussed in Figure 4. Using a warm waste water flow, 100 kg/s, to heat the incoming water reduces external heating needs for about 2.5 MW. It also removes the need to cool down this water in the waste water treatment plant (Not shown in Figure 4). The resulting grand composite curves have been shown on level 1 to improve clarity.

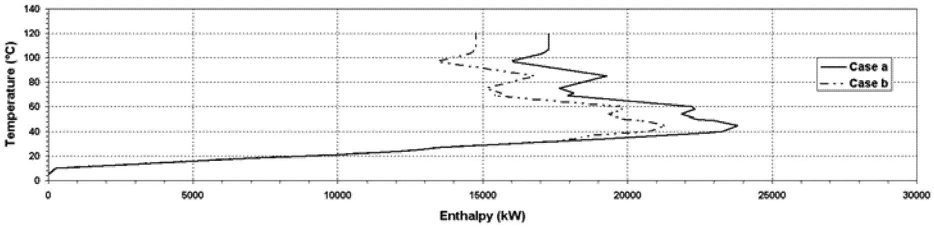

Figure 4. Grand composite curves of cases a and b.

As shown in Figure 3, the model treats the heat required at the paper machine drying sections as a cold stream. This shows the thermodynamic possibilities to provide the heat but does not take into account the needed drying speed and dimensioning issues. It can be discussed if the steam use in the drying section should be presented in the temperature level where it actually takes place. This approach is presented in Figure 5.

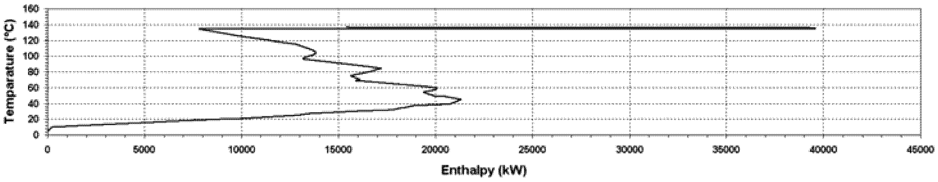

Figure 5. Grand composite curve of case c.

From Figures 3 and 5 it can be seen that the amount of hot utility needed does not change between cases b and c, but case c describes the actual situation more accurately; part of the hot utility demand is at high temperature levels and needs to be covered by steam from the power plant.

The model is used further to find possibilities to cover more low temperature heating demands by other means than steam. Case d describes the possibility to reduce the amount of air used in the drying section of paper machine two, which makes it possible to raise the moisture content of outlet air and thus improve possibilities to recover more heat. The moisture content of outlet air has been raised to the same level as currently at paper machine one, 150 g/kg. In case e the moisture content of exhaust air of both of the paper machines is raised further to 160 g/kg. In none of the cases c, d and e heat recovery from waste water exists. In case f, heat recovery from waste water has been added to case e. The amount of the waste water is the same as in case b, but the starting temperature of the stream is higher to describe the possibility to recover heat from separate warm streams instead of mixing them to the same channel.

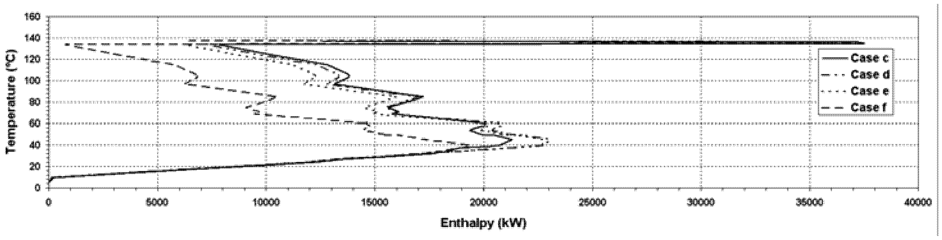

Figure 6. Grand composite curves of cases c, d, e and f.

The results (case d compared to case c) show that it is possible to reduce hot utility demand by 400 kW by improving the heat recovery of paper machine two to the same level as in paper machine one. Improving heat recovery further in both paper machines (comparing cases d and e) can save another 1.1 MW. Recovering heat from waste water (comparing cases e and f) can save additional 5.4 MW. The resulting hot utility demands in the six different cases are gathered in Table 2. Pinch temperature is 5 °C for all of the cases and there is no cold utility demand in any of them. If the same accuracy level is achieved as in the simulated case the results are expected to have about 2 % difference to values given by a detailed simulation model.

Table 2. Results from the real mill.

Case →	Level ↓	a	b	c	d	e	f
Hot utility demand (kW)	1	17294	14787	14787	14287	14287	7761
	2	49297	46790	48834	46398	45325	39892
	3	42243	39736	41780	39344	38271	32838
	4	15867	13360	13360	12969	11895	6462

The results show that all the suggested improvements together (comparing cases c and f) would mean steam savings of almost 7 MW. Most of these saving can be achieved by taking heat from warm water flows going to the waste water treatment. This also beneficial because it reduces the demand for cooling at the waste water treatment plant. After all the improvements there would still be about 800 kW heat required at a very low temperature level and it would be interesting to try to find more possible sources of low temperature heat.

5. Conclusions

The Heat load model for pulp and paper (HLMPP) was tested using one simulated case and one real mill. Results from the simulated case show that the HLMPP works with a suitable accuracy level. In the analysis of the real mill, six different cases with different heat integration possibilities were discussed.

With the Heat load model for pulp and paper (HLMPP) it is possible to examine the same kind of improvement potentials as is usually done by a detailed simulation model. However, with the HLMPP the work can be done using much less man hours. More work is still needed improving the model in terms of more user friendly data input and possibilities to have more predefined cases.

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