White-water strategies for integrated TMP newsprint mills - Implementation of a comprehensive system for energy and water conservation at Alberta Newsprint

By J. Wearing and K. Pierson

Abstract: A system was commissioned at Alberta Newsprint Company to optimize energy recovery and minimize steam usage for water and white water heating duties. A network of heat exchangers was designed to recover waste heat from effluent and atmospheric vapour sources and distribute the recovered energy to water and white water heating duties. Provisions were made to vent excess waste heat from the network to atmosphere, allowing independent moderation of effluent temperature. Allowance was made for variable TMP production rates, the mill’s response to extreme electrical price variations in Alberta. Design work showed that more energy savings could be achieved at lower installed cost if water consumption were simultaneously reduced. Recovery of press section filtrates was implemented to achieve the required reduction. The new energy optimization and water recovery systems were commissioned in December of 2004; steam usage for water and white water heating was reduced by 0.9 GJ/t.

The Alberta Newsprint Company (ANC) produces newsprint from TMP and deinked fibre. The mill was started up in 1990 and is a North American leader in quality and efficiency. Many successful projects have been implemented to reduce electrical and thermal energy consumption [1]; the projects have been identified and carried out by an Energy Management Team. The present project focused on the process heating requirements throughout the stock, white water and water systems.

Stock, water and white water heating and heat recovery prior to the present project is shown in Fig. 1. The mill was originally equipped with the four shell and tube heat exchangers shown in the diagram. PSF filtrate and TMP effluent were cooled by heating mill water in two parallel exchangers, and then directed to sewer. TMP reboiler condensate was cooled by warming the combined warm water streams from the effluent heat exchangers, and then it was returned to the TMP system. Hot water for paper machine showers was prepared using steam in a fourth shell and tube exchanger. The collected cooling waters were not used, despite their warmer temperature, because the prime purpose of the two effluent exchangers was effluent cooling. A spiral heat exchanger was later added to heat water recirculated from the paper machine silo, thus improving machine drainage and speed. Two years prior to the present project, atmospheric steam (0.6 GJ/t) was recovered from the reject refiner and several other sources by adapting the TMP start-up scrubber, transferring the recovered heat to the collected TMP cooling water in a spiral heat exchanger pair [1].

Several problems existed with the system. Steam consumption for hot water preparation remained high, approximately 0.9 GJ/t. Because mill water flow to the effluent heat exchangers was controlled to provide constant effluent temperature, warm water demand was periodically exceeded, resulting in warm water overflow to mill water storage. Conversely, when warm water demand was high, warm water was diluted by makeup of paper mill cooling water, increasing steam demand. In the stock system, maintenance of paper machine headbox temperature required a steam flow equivalent to approximately 1.1 GJ/t. Combined steam usage of 2.0 GJ/t was considerably above the best practices target of 0.7 GJ/t suggested by Paprican [2]. Effluent temperature was excessive and required summertime cooling, which was achieved by spraying effluent above the spill basin.

DESIGN ALTERNATIVES

Design alternatives were created using process judgment and guidelines from heat exchanger network analysis. The mill layout was considered for each case, because piping costs would inevitably be a major factor. Base case operating data was collected from the mill during summer and winter conditions. CADSIM was used to prepare a simulation in sufficient detail to capture all the relevant heat, water, dissolved solids and stock flows. The mill’s data collection system allowed detailed review of actual performance.

The heating and cooling duties depicted in Fig. 1 are represented in the thermal analysis shown in Fig. 2. The curve at the top represents the cooling demand, while the curve at the bottom represents streams to be heated. The portion of the lower curve that extends to the left of the upper curve represents the steam demand. If the bottom curve is transposed to the left, it can be seen that the higher temperature heating duties can be met by waste heat sources. A large potential source of low-grade heat, combined mill effluent, was added to the list of waste heat sources, Fig. 3 shows the resulting analysis. Despite an
acceptable temperature difference of 18°C, steam could not be fully displaced.

The case of reduced water demand (20%) was then examined. The upper and lower curves for this case, Fig. 4, correspond exactly to each other, with a favourable temperature difference of 19°C. It was not necessary to add combined mill effluent as a heat source to eliminate steam usage.

Opportunities for water reduction were then reviewed. Mill data and reports provided a good inventory of process water uses and flows to sewer. Two overall approaches were considered, employing co-current and counter-current white water strategies. A co-current strategy would result in the transfer of more heat, but also more dissolved solids, from TMP operations to the paper mill with the stock. Maintaining the mill’s existing counter-current white water management system affords lower dissolved solids in paper making but results in more heating load in the paper mill [3].

The two strategies were simulated in CADSIM to determine the impact on white water chemistry. In the co-current option, the TMP effluent purge would be discontinued. In the counter-current option, paper machine press section filtrates would be recovered to the paper machine white water system. The simulation predicted that the average requirement for warm water dilution of the clear white water would decrease by a corresponding volume through either option. Non-fibrous cationic demand (anionic trash) distribution was predicted based on the behaviour of dissolved solids, an assumption verified recently in mill tests [4]. The above co-current and counter-current options were predicted to increase anionic trash by 52% and 16% respectively. To minimize impact on the mill’s cationic retention aid, the counter-current strategy was selected for further evaluation.

Before proceeding further with the design, the impact of water use reduction on the dynamics of the white water system was evaluated. This was accomplished both by evaluating trends from the mill’s data storage system and by dynamic simulation with the CADSIM package. The magnitude of the variations was similar for existing or reduced water usage cases.

As a final step in sorting through the options, heat recovery systems were designed for the two cases, existing and reduced water consumption. Water reduction was achieved by press filtrate recovery. For both cases, several networks were assessed at a low level of detail before selecting and developing two for budget level costing. The performance of the networks was then evaluated using the CADSIM simulation, accounting for typical TMP production schedule, seasonal temperatures, etc. Designing for lower water consumption would reduce capital cost by 25% and increase savings by 25%.

PRESS FILTRATE RECOVERY

Dr. F. Zippel reports that recovery of press filtrates has become very common in newsprint and magazine paper mills in continental Europe [5]. The filtrates are screened through hydroseives to remove press-felt fragments and returned to the white water system. Dr. Zippel observes
that fresh water input to the circuit through felt fabric cleaning is often the principle fresh water supply to the mill. An informal survey of a number of North American producers showed that the practice is not common here. Along with concern over felt hairs, paper makers were wary of the pitch in press filtrates. Continental European mills all run a large percentage of recycled fibre and thus would not have the same issue with pitch derived from wood resin. To complicate matters, ANC has a high percentage of pine in its wood supply. However, the advantages of press filtrate recovery, established in the initial design phase, warranted further examination.

We compared the pitch content of gravity and suction press filtrates with other white water samples in the mill. Press filtrates are rich in fines and fines contain a disproportionate percentage of wood resin, so we also analyzed free dispersed pitch, which is a known indicator of deposition tendency [6]. Free pitch was determined by pitch particle counting and also by solvent extraction following removal of resin, so we also analyzed free dispersed pitch, which is a known indicator of deposition tendency [6]. Free pitch was determined by pitch particle counting and also by solvent extraction following removal of resin. Acetone extractives and 90-95% of dispersed pitch were flocculated.

A variety of polymers were tested in bench-scale flotation tests, carried out at Poseidon Inc. The polymer-assisted flotation treatment removed 90 % of total extractives and 90-95% of dispersed pitch particles. The retention aid system in use at the mill produced satisfactory results as a flotation aid and it was selected to avoid the potential for negative interactions among polymers in the white water.

**SYSTEM DESIGN**

The key elements were in place to allow final design to proceed. What follows below is the system as implemented.

A press filtrate recovery system was designed. Weir boxes, required for felt diagnosis, were relocated to discharge into a new press water collection tank. The press water was pumped to a new strainer, and from there, gravity fed to a DAF. Provisions were made to optionally by-pass the DAF because it was not certain that pitch removal was necessary and the press water contained a considerable quantity (2-5 g/L) of valuable fines. The by-pass would facilitate future trials to recover these fines.

The heat recovery network is shown in Fig. 5. The heating load with the highest temperature is silo circulation. It is heated with reboiler condensate in a new spiral heat exchanger, providing about half the thermal load. This exchanger required the longest piping runs. The exchanger was located midway between the source and the load. The balance of the machine white-water heating load is provided by the atmospheric steam heat recovery system. For this purpose, we chose to heat the combined gravity and suction press waters, since their temperature is the lowest in this area, affording the highest temperature differential and lowest heat exchanger area.

The PSF and TMP effluent heat exchangers were replaced with new spiral heat exchangers with larger thermal capacity. The source of water for warm water preparation in the wintertime is the TMP cooling water. In summertime, TMP cooling water approaches the desired effluent outlet temperature. Therefore, supply to the effluent exchangers is switched to mill water to facilitate effluent cooling.

Additional heat was supplied to the warm water by a second loop from atmospheric steam recovery. The overall heat recovery network is shown in Fig. 6. The heating load with the highest temperature is silo circulation. It is heated with reboiler condensate in a new spiral heat exchanger, providing about half the thermal load. This exchanger required the longest piping runs. The exchanger was located midway between the source and the load. The balance of the machine white-water heating load is provided by the atmospheric steam heat recovery system. For this purpose, we chose to heat the combined gravity and suction press waters, since their temperature is the lowest in this area, affording the highest temperature differential and lowest heat exchanger area.

The heat recovery network is shown in Fig. 5. The heating load with the highest temperature is silo circulation. It is heated with reboiler condensate in a new spiral heat exchanger, providing about half the thermal load. This exchanger required the longest piping runs. The exchanger was located midway between the source and the load. The balance of the machine white-water heating load is provided by the atmospheric steam heat recovery system. For this purpose, we chose to heat the combined gravity and suction press waters, since their temperature is the lowest in this area, affording the highest temperature differential and lowest heat exchanger area.

The PSF and TMP effluent heat exchangers were replaced with new spiral heat exchangers with larger thermal capacity. The source of water for warm water preparation in the wintertime is the TMP cooling water. In summertime, TMP cooling water approaches the desired effluent outlet temperature. Therefore, supply to the effluent exchangers is switched to mill water to facilitate effluent cooling.
cease when sufficient waste heat was available. The waste heat system was controlled by venting excess heat from atmospheric steam recovery, rather than by rejecting heat with the effluent streams. In this manner, combined mill effluent temperature could be moderated without spray cooling. Referring to Fig. 5, opening valve A reduces the heat transferred to warm water. Closing valve B accomplishes the same for the paper mill white water heating duty.

COMMISSIONING

The new heat exchanger network was commissioned on December 3, 2004 and the DAF started up one week later. Concurrent with this start-up, the de-ink plant was taken out of operation, resulting in a small decrease in total pulp mill purge rate.

The DAF started smoothly and produced excellent water quality. The accept showed low turbidity and colour. The pitch particle concentration was below 5 MM particles/mL. The strainer functioned well, however, the reject volume was high. It was decided to rely on the DAF alone and bypass the strainer. No felt hair problems have occurred.

The PSF heat exchanger became plugged during commissioning. Although temperature sensors were provided to allow calculation of the degree of fouling of all heat exchangers, in retrospect, pressure gauges would have been desired to detect plugging, and several have since been installed.

Soon after start-up, the press filtrate heat exchanger exhibited rapid fouling. An initially thin layer of deposits accumulated steadily, causing pressure drop to increase. Cleaning was required once per week. Polymers from the DAF were suspected to be destabilizing pitch in the gravity filtrates. For 6 days following January 26, the DAF was temporarily taken off line and press filtrate recovery was suspended. The rate of heat exchanger plugging on gravity press filtrates alone dropped by about 50%, but remained unsatisfactory. The composition of the flow to the heat exchanger was altered by adding clear white water from a nearby line and, since that time, the rate of fouling has been in line with the other exchangers.

The appearance of the deposits in the heat exchangers and their progression over time led us to conclude that resin deposition occurs, and the resin subsequently entraps fines. Resin deposition is dependent on hydrodynamic shear and on the hydrophilicity of the heat exchange surface [7]. The on-line fouling factor data revealed that the thickness of the deposited layer is shear dependent, decreasing at higher flowrates. The deposit thickness grows over time and periodic cleaning, typically after several months running, is required to maintain system performance. The fouling factor data is used to schedule cleaning.

Steam consumption before and after project implementation is shown in Fig. 6. Average savings over 9 months was 12 tonnes of steam per hour. Simulation results show that steam savings are strongly dependent on both water usage and the availability of waste heat from TMP operations. Opportunities for further water savings are presently under investigation.

CONCLUSIONS

1. Improved savings at lower installed cost were achieved in an energy reduction project by simultaneously reducing waste usage.
2. Average steam savings of 0.9 GJ/t were obtained over nine months following implementation.
3. Recovery of all press filtrates was achieved in a newsprint mill utilizing a high percentage of pine in the furnish by employing a dissolved air flotation system to remove pitch.
4. Heat exchanger fouling was severe in this service, probably initiated by shear-induced pitch deposition. Simple on-line instrumentation was invaluable in maintaining heat exchanger surface performance.
5. An energy project can achieve excellent return on investment by focusing on a comprehensive solution consistent with the strategic goals of the mill.

RECOMMENDATIONS

1. Fundamental study of heat exchanger fouling in pulp and paper service is recommended.
2. Waste heat from pulping operations should be partially allocated directly to the paper mill white water in an integrated newsprint mill, rather than being transferred only to the warm water system, particularly if the mill employs counter-current white water management.

ACKNOWLEDGEMENTS

The project involved the efforts and expertise of many people at ANC and NORAM, whose contributions are gratefully acknowledged. We also thank the participating staff of Alfa Laval, Buckman Laboratories, Paprican, and Poseidon Inc.

LITERATURE


Résumé:


Keywords: THERMOMECHANICAL PULPS, NEWSPRINT, ENERGY CONSERVATION, WATER MANAGEMENT, STEAM HEATING, WHITE WATER, HEAT EXCHANGERS