PAPER MACHINE HEAT RECOVERY REVISITED – A NEW ERA

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Introduction:

The cost of thermal energy, in the form of No. 6 Fuel Oil, is a significant component of the cost per tonne of Minas Basin's liner board products as it typically is for many pulp & paper mills.

The unit cost of No. 6 Fuel Oil and other fossil fuels such as natural gas has been increasing. Indications are that it will remain at its current levels or higher in the long term.

The purpose of this document is to summarize the technical and commercial arrangement details of a heat recovery initiative between Johnson Controls Inc. and Minas Basin Pulp & Power Company Limited whose objectives were to:

1. Reduce the Mill's dependency on fossil fuel and its cost.
2. Reduce the paper machine's thermal requirements while operating under the existing conditions.
3. Enable the paper machine to run at a higher speed by increasing stock temperature without increasing steam costs.

The initiative recovers 100,638 mmBTU of currently wasted heat per year and uses it to replace that which is currently being generated in the Mill's steam boiler systems.

Descriptive Information:

The Minas Basin Pulp & Power Company Ltd. (MBPP) was founded in 1927 in Hantsport, Nova Scotia. Today, using the latest in computer technology, this family-owned and operated company produces 100 percent recycled products including linerboard and coreboard. The company operates 24/7 and has the capacity to produce 80,000 metric tons per year. Each day, Minas Basin Pulp & Power brings in about 250 tons of recycled raw material and ships out approximately 240 tons of linerboard and coreboard to other companies for further manufacturing. The company's recycling reduces the need for approximately 10.8 million cubic feet of landfill space each year.

The Mill burns #6 (Bunker C) oil in three boiler systems. All boilers are steam boilers. Steam is used for process heating, plant heating, and office space heating. Some steam produced on site is sold. Significant process steam is directly injected into the process resulting in relatively high boiler make up water requirements.

Steam consumption is roughly 39,200 lbs/hr (39 mmBTU/hr) and an average seasonal consumption (i.e., winter season heating) of up to 8,300 lbs/hr of steam (roughly 8 mmBTU/hr). The seasonal variation is low relative to the baseline (season independent) load of at least 38,000 lbs/hr steam. The process consumes an estimated 85% of the total steam produced, with the plant and office air and space heating requirements making up the remaining roughly 15%. Dryer steam alone accounts for roughly 65% of this total.

The paper machine's speed is limited by its ability to dry the product from two perspectives:

1. Physically the machine has a fixed drying capacity which is met when producing heavier grades.
2. Economically in terms of the price of No. 6 fuel oil. In Dec 2002 MBPP shut down one of their two operating paper machines at the time after modifying the currently operating machine to achieve greater production capacity. One of the modifications was adding live steam injection to the stock silos to increase its temperature and achieve greater drainage at the wet end of the machine. Shortly after these heaters were commissioned the price of No. 6 fuel oil began its assent in unit cost. As a consequence the production benefits where negated by the increased fuel cost and these new heaters were taken out of service for a period of time.

The fixed costs (production labor, depreciation, administration and overhead) represent a greater percentage of the cost per tonne as a result of these limitations.

Control of No. 6 fuel oil cost is limited; in reality it is ***uncontrollable***, after supplier negotiations have been completed.

Pressure to reduce combustion emissions produced is increasing – the Nova Scotia government has pending provincial SO_2 regulations. Mill neighbors, as well as society in general look at industry as a major polluter.

Methods and Materials:

The following heat sources were discussed and considered for heat recovery:

- No. 6 Oil Fired Boiler Exhausts;
- Vent steam Exhausts.
- Paper Machine Dryer Ventilation Exhaust

Although a large amount of energy is available in the oil boiler exhausts, the #6 Oil fuel oil fired boiler exhausts were not considered optimal sources of heat due to:

- The presence of larger, richer heat sources;
- The seasonal variability in the heat available from this source;
- The significant amount of particulate matter (fouling, performance); and,
- The significant amount of sulfur (in the form of 1.5% sulfur in the fuel oil).

These would negatively impact heat recovery system cost, lifespan, performance, and maintenance and in turn negatively impact the return on investment for a direct or indirect heat recovery system.

The paper machine dryer ventilation exhaust is a large humid flow, ideal for recovery of low grade heat in a direct contact heat recovery system. The exhaust are relatively clean, though a small amount of paper fiber is carried within the waste stream. Further

- The exhaust is regular;
- The exhaust is close to major process heat sinks; and,
- The exhaust contains significant heat.

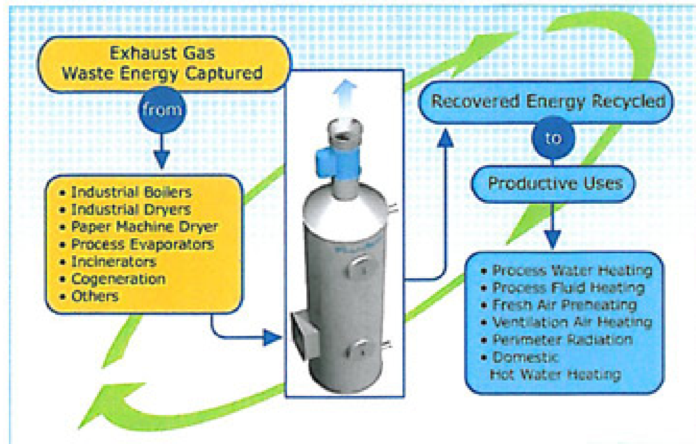
Vented steam from the dryer system is an exceptional but irregular source of waste heat.

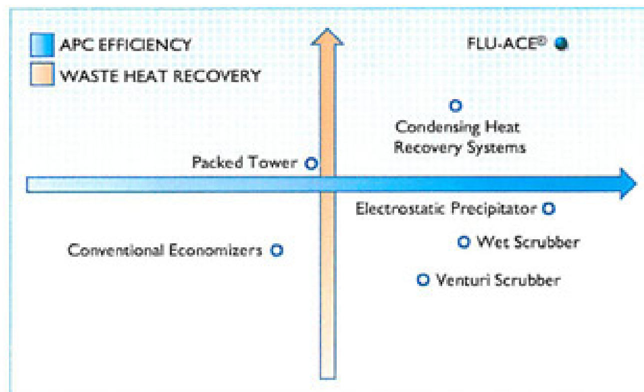
The dryer exhaust flows were determined to currently be the most appropriate heat sources for the proposed energy recovery system which was chosen to be a direct contact technology, as little "effective" heat from the dryer exhausts is available by standard, non-condensing heat recovery systems. Traditionally even these heat recovery systems have provided limited "effective" heat since they do not approach the dew point of the exhaust gas.

The exhaust is drawn from the Pocket Ventilation system, through an economizer (the first stage of heating of the pocket ventilation inlet air), and exhausted through a 6 foot by 4 foot exhaust on the roof of the plant. In a previous assessment it was estimated that only 10% of the available heat was recovered in the existing economizer, and that 8.5 mmBTU/hr was still available in the PV exhaust using technology available at that time. Improved condensing heat recovery technology now allows for recovery of 22 to 32 mmBTU/hr, depending upon grade, while in operation.

The technology applied to capture this larger volume of heat is a PMD FLU-ACE®, manufactured by Thermal Energy International Inc., Ottawa Ontario. This company has a working partnership with Johnson Controls LP.

This technology is extremely effective at capturing heat that is being exhausted by any warm moist waste gas stream such as paper machine dryer exhaust or a boiler. At the same time it is also extremely effective at scrubbing clean these same streams which for some applications is the primary motivator for its use, especially on combustion exhaust flows.





The unique element of the technology is its ability to create hot water that can be beneficially utilized. Conventional technology applied to this type of waste gas stream created temperatures in the 90 – 100 F range. The PMD FLU-ACE® technology is capable of creating hot water temperatures within a few degrees F of the waste gas stream's wet bulb temperature.

The amount of heat available for recovery from the exhaust depends on the temperature of the exhaust (sensible heat) and the humidity of the exhaust (latent heat). The latter is not recovered in non condensing heat recovery appliances.

A condensing heat recovery tower (PMD FLU-ACE®) will be installed on the Pocket Ventilation (PV) Exhaust. A portion of the PV exhaust will be diverted to the heat recovery system through new ductwork as the design was optimized to match the recovered heat with the available heat sinks. Depending on the heating demand of the heat sinks, a variable portion of the PV exhaust will be drawn through the PMD FLU-ACE® using a variable frequency drive (VFD) driven exhaust fan.

Although not used as a primary heat source, the paper machine dryer steam vents are routed through the heat recovery tower to increase recovery potential, and to increase heat recovery system supply water temperature.

The additional heat and temperature available by routing the dryer steam vents to the PMD FLU-ACE® will enhance the heat source during extended paper breaks.

This source was chosen due to the coincident reduced dryer ventilation exhaust flow heat content and the dryer venting that currently goes to atmosphere under an extended paper break condition. The original intent was to counteract each other, but practical expectations are that the result will be even greater heat recovery under this condition.

The water recovered (condensed) by the direct contact system is suitable for return to the process, recovering product and reducing energy and water consumption.

Results:

Recovered heat is transferred to mill systems through heat exchangers. The major uses of the heat are:

1. **Plant heating**: Replacing 97% of the heat required on the air makeup units for the paper machine building; this benefit will be seasonal with an annual average of 5.5mmBTU/hr.

2. **Process water heating**: By heating the discharge of the vacuum pumps to the seal pit, with an average temperature of 111 deg. F., which can be raised to 140 deg. F. This recovery will vary with a peak of 1.7 mmBTU/hr.

3. **Preheating Boiler Makeup**: The boiler makeup has an average temperature of 50 deg. F. By raising this temperature to 140 deg. F., the average heat demand would be 1.7 mmBTU/hr.

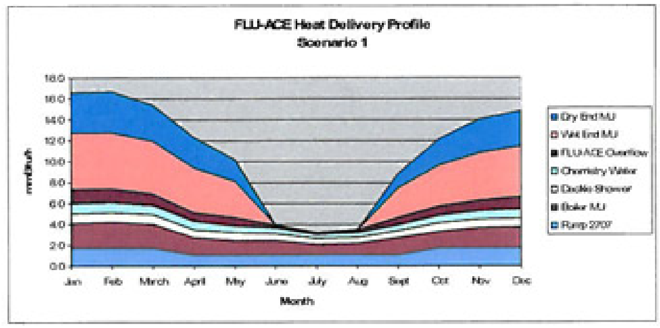
4. **Chemical Water preheating**: Water that is used as make down and push waters can be raised from an average of 50 to 95 deg. F. The benefit would average 0.8mmBTU/hr.

5. **Decal Water Preheating**: The paper machine decal water would be raised up to 140 deg. F to match stock temperature. 0.9mmBTU/hr of heat can be consumed.

6. **Flu-ace Overflow**: The PMD FLU-ACE® will recover the moisture in the pocket vent exhaust and generate a temperature of 143 deg. F. water, which would be added to the filler silo. This heat represents 0.8 mmBTU/hr on average.

Sinks 2, 4, 5 & 6 avoid make up water required by the boiler since they displace live steam previously injected into the filler silo. These components have additional value. Specifically, each pound of live steam injection reduced results in a pound of boiler MU water not being heated from river temperature to 350 °F, in addition to the latent heat of the steam.

The delivery profile of each sink is as follows:



The initiative recovers 100,638 mmBTU of heat per year. This volume is guaranteed through a performance contract with Johnson Controls. Johnson Controls are responsible to design, build, operate, monitor and maintain the system under contractual agreement. If the agreed volume of heat is not delivered, Johnson Controls is obligated by guarantee to pay Minas Basin a fixed amount for each mmBTU of the deficiency.

Conclusions:

Benefits Evaluation

The initiative conserves oil through a combination of more efficient utilization of current generation and reduced generation requirements by reclamation and employment of heat which was previously exhausted to the atmosphere. Three of the heat application points involve direct oil savings equal to 59% of the total. Two others involve oil and machine speed benefits relating to 25% of the total. The balance involves machine speed benefits only.

Although the initiative was approved by MBPP's board using fuel oil savings only the following other benefits will be achieved:

Increased production capability. The production impacts were simulated utilizing the existing stock heating system that was taken out of service due to the cost of No. 6 fuel oil. The contribution from an incremental tonne of production is actually several times greater than the anticipated oil value.

The capital cost is eligible for an investment Tax credit as it qualifies for accelerated capital cost allowance. (CCA Class 43.1 @ 30%).

Carbon and other emission credits. The emissions that will be reduced are:

CO_2	11,400 Tonnes
SOx	110 Tonnes
NOx	26 Tonnes

If MBPP were to monetize the emission credits available on the market today these alone would be worth $ 242,000 per year.

The initiative and its contractual form was originally structured as a heat purchasing agreement where by Johnson Controls would sell the output of the system to MBPP whom would treat it as an expense similar to purchasing of electricity. Although all necessary parties approved the structure as an operating expense, MBPP chose to capitalize the project.

Traditionally performance contracts require complex methods by which guarantees are provided. The commercial arrangement used greatly simplifies performance evaluation. The heat recovery system's primary loop's flow and leaving and returning temperatures are monitored providing the ability for real time heat delivery validation.

As a consequence of the in-depth analysis of the process and systems at MBPP, there were two ancillary benefits of the initiative.

1. The process water temperature was not always above the optimal temperature recommended by the chemical supplier. It will now always be above this temperature resulting in better mixing and suspension retention times.
2. A significant amount of fresh water was found to be required for vacuum pump seal cooling. This was causing a reduction in fluid stream temperature as it cascaded through the system to the filler silo. Although detrimental to the heat recovery project's economics (a reduction of 9,200 mmBTU/yr of heat that would have been sinked), a redesign of this situation took place the result of which are this water is now used in a non process contact manner through a heat exchanger reducing over flow in the process water systems and being now available for other uses.

Risk Review

All projects have elements of risk such as the possibility that the price of oil will change significantly during the project life or the possibility that the equipment will not perform as expected. Minas Basin is protected in terms of equipment performance with Johnson Controls' guarantee to deliver a predetermined volume of heat each year and hence this risk is eliminated. Given current world market influences the price of oil is unlikely to decline significantly or permanently any time soon, or ever.

Summary

Johnson Controls considers this solution, in terms of both technical and business arrangement details, to be highly repeatable in the Pulp and Paper marketplace. Provided as a single solution or integrated with a suite of other solutions that Johnson Controls can apply to pulp and paper mill operations, this solution can have a significant impact on reducing the cost of producing a tonne of product.