TRACKING AND OPTIMIZING REEL TO WINDER PRODUCTIVITY IN A SUPERCALENDERED PAPER MILL

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ABSTRACT

Results of automated tracking and optimizing of dry end productivity for a papermill producing supercalendered grades and having multiple papermachines, supercalenders, winders and mixed process lines is reported. The use of modular operator and data collection stations, together with RFID or Bar-Code automated reel tracking and a central database, allowed all paper slab and machine time losses to be automatically followed through the process path. The resulting accurate, automated and quick display of trends of left-on-spool and other slab losses provides the information operators need to use the reel sizing calculator tools most effectively. Floor inventory data and production run tracking aid in order fulfillment accuracy and reduce the costs of over and under runs. Reliable loss data provides focused information needed to minimize dry end slab and time losses. Some unique challenges related to the widely differing wound-in-caliper changes for supercalendered versus non-supercalendered grades were encountered, and overcome. The combination of reliable and precise visibility of losses together with unique operator tools for optimal sizing and consumption of reels resulted in 1.5 to 2% reductions in dry paper losses. Unaccounted slab losses, from before and after implementation, are shown along with current detailed monitoring results.

ST. MARYS PAPER LTD.

St. Marys Paper Ltd. operates a 260,000 ton per year paper mill producing SCA premium, SCA and SCB paper grades under the trade names Sequence, Sequel and Synpress. Paper produced at the mill is primarily purchased by magazine publishers and large retail companies for high quality advertising inserts, flyers and catalogues.

Located at the hub of the Great Lakes in Sault Ste. Marie, Ontario, St. Marys Paper and its 400 employees are dedicated to maintaining a safe, productive and environmentally sound operation.

LSZ PAPERTECH

LSZ PaperTech Inc. of Toronto and Vancouver, Canada, has focused on supplying process automation systems and consulting for reeling and winding quality and productivity optimization since it was formed in 1992 by three papermaking physicists.

LSZ combines advanced computer technology with the best available product and process physics expertise to provide state of the art computer systems and process expertise for its customers. This provides improved roll and reel quality, improved production from existing equipment and reduced waste on its customers' paper machines.

ST MARYS UNACCOUNTED LOSSES

In early 2000, in their ongoing efforts to maximize productivity, St Marys Paper identified "Unaccounted Losses", which at the time were between 6 and 7 % of gross production, as a target for improvement. These are paper losses that occur between the paper machines and the wrap line. It does not include full rolls culled after winding since these are already accounted for by their Proconex roll tracking system, although these culls can be fed back to the run list accumulation portion of the LSZ system to minimize grade over and under runs.

St Marys already had LSZ roll quality systems on their 3 winders to monitor and optimize roll structure and had confidence in LSZ's technology and capabilities. In late 2000 St Marys contracted LSZ to implement a paper loss tracking and optimization system throughout their process line. According to the mill, a key to the project's success was that the technology use an open database and off the shelf hardware so they would not be buying into a closed, proprietary system. This allowed the mill to use the data generated by the LSZ system in other mill developed or third party systems.

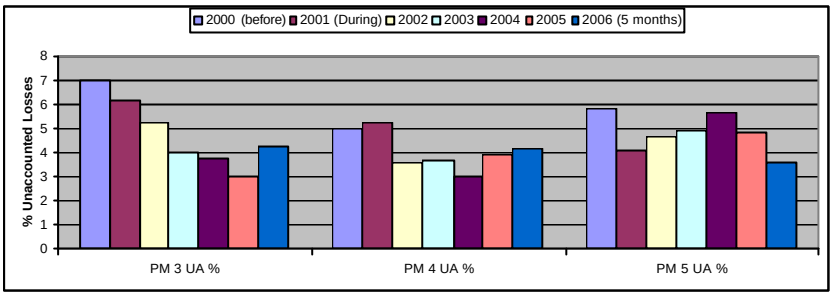

Figure 1 % Unaccounted Before and After LSZ Implementation

Figure 1 shows St Marys Unaccounted loss data for 2000 (before the project began), 2001(the period of development and implementation) and the years 2002 through 2006. Unaccounted Losses were calculated as the difference between papermachine gross production (speed * basis weight * trim * up time) and wrap line weight as a % of gross production. PM 3 & 4 achieved sustained 1.5 to 2 % reductions in unaccounted losses. Initially PM 5 had a similar reduction but the reduction was not sustained. This is partially explained by an increase in PM 5 break frequency related to other process developments. PM 5 unaccounted losses decreased again as this situation improved.

ST MARYS PROCESS DESCRIPTION:

St Marys Paper mill site has three papermachines, five supercalenders and three winders. Production from each papermachine is streamed to the same supercalenders and winder but paper machine widths are similar giving the operators the flexibility to optimize use of equipment and efficiency by occasionally crossing production paths. Thus, the system had to be flexible and sophisticated enough to track the spool, reel and waste through all possible pathways. Also, the mill produces a range of grades having quite different properties, clay content and degree of calendering.

LSZ TECHNOLOGY:

LSZ's slab loss tracking is built on the ability to accurately determine the precise diameter of rolls and reels. At every process unwind/windup station and for every stop, start, eject, turn-up and break event, LSZ records the precise diameter of the reel or roll being built or unwound. Most diameters are determined through a calculation using the rotation of the building or unwinding roll/reel and pulses counted from a tachometer on a reference roller having a known diameter. The reference rollers used are typically the paper machine reel drum, the supercalender drive roll and winder back drum. A high resolution pulse count provides an extremely precise measurement of the length of paper wound into an integer number of reel or roll rotations. Dividing this length by p and the number of rotations, yields the diameter. Diameter resolution of 1 part in 24,000 is typical. This corresponds to precision of a couple of the sheet wraps in thickness. The basic method of determining diameter and wound in caliper from these signals has been well known since the 1980s[1]. Since then, LSZ has progressively developed this algorithm to achieve the accuracy and robustness required for loss tracking in instances where some slippage on the reference roll can occur.

In some situations LSZ uses an ultrasonic, or inductive based sensor to infer the diameter of the roll or reel but in most cases this is not sufficiently accurate. LSZ builds a database of diameters for every roll and reel and links the rolls/reels to each other by tracking them through the process line using RFID or bar code tracking technology. Diameter differences within

and between process stations are automatically measured and logged and the loss mass is calculated. In fact, the diameter measurement obtained from tach counts can be so precise it allows for the determination of wound-in caliper at the reel or winder, allowing the mill to diagnose and tune the primary/secondary arm turn-up pressures as described elsewhere[2] or to know immediately when they've achieved a target wound-in-caliper and thus bulk at the reel

In addition to tracking losses, LSZ provided operator tools to actively reduce losses. These tools include:
- reel size target determination at the papermachine based on the planned set grades and diameters or lengths
- run list management and tracking sets produced to prevent over and under runs.
- quickly and precisely determine makeup required to complete a partial reel or roll
- Count-down display clock and alarms to Turn-Up time
- reel usage optimization tools at the winder to optimize consumption of partial and orphaned reels
- auto stopping to target size or length to minimize consumption variability "Auto stopping at SC 3 & 4 is a god send " says one of the operators. It may seem a minor point but auto stopping allows the supercalender to run at full operating speed, ensuring constant quality, to the last moment, reduces waste by stopping precisely at the target size and reducing maintenance by eliminating cases of the tail running through the stack due to operator inattention.
- visibility on downstream performance to provide feedback to backtender

Because LSZ closely monitors process states in order to build the paper loss database, it also records process stop/down time. Although not initially of interest to St Marys, the Loss Time data has become one of the more heavily used part of the system.

CHALLENGES OF THE ST. MARYS IMPLEMENTATIO N

LSZ had applied this technology numerous times on simpler process lines having a single paper machine and winder[2] with no intervening or interleaving process steps. The St Marys process line and grade range, as well as some specific equipment details, required significant developments and modifications.

Some of the major complications were due to:

- **Tracking complexity:** mixing of paths, jumping from PM directly to Winder …

- **Spool end geometry:** spools have square ends with no bell housing, are chucked from either end, moved extensively by cranes and have lots of opportunity for spool ends to be bumped. This created difficulty for determining safe location for RFID tracking tags and rotation sensor targets.

The 3 photographs above show, from left to right, the spool end with reflective tape for rotation counting and RFID tag on the very end of the spool (not clearly visible), spool end with RFID reader picking up RFID tag on spool end, customized label with bar code ID printed by LSZ system. The system supports RFID or bar codes and scanners for spool tracking.

- **Accounting for SC compression of paper.** LSZ studied the SC compression for all SCs and all grades and incorporated this into the system so that each papermachine reel size target is based on the known compression of the planned grade at the SC and Winder to be used.

PAPER AND TIME LOSS DATA

Most of the data is automatically collected without involving the operator. However, operator input can be used to add detail to the loss data to allow more powerful analysis to be done. All the data is stored in an SQL2000 or Oracle database.

Short term loss trend data is provided to the operators where it helps them make better operating decisions. Higher level and longer term loss data is summarized in a variety of reports for management to monitor performance and make resource allocation decisions.

A selection of charts and tables are presented below showing some of the capability.

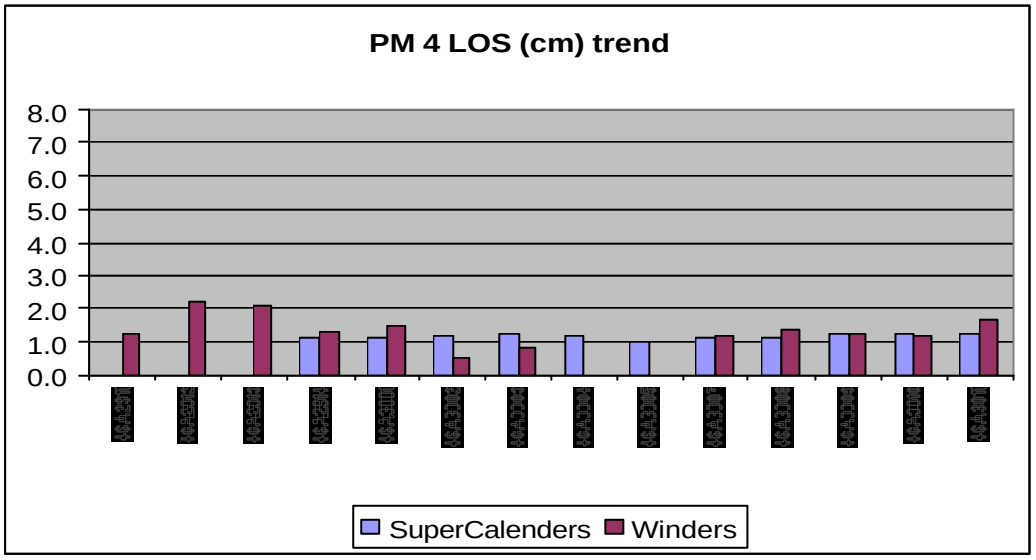

Figure 2 Left-on-Spool Trend as Backtender Feedback for Optimal Reel Sizing

Heels (otherwise know as Left-On-Spool, jacket, butt, …) are typically the largest controllable type of loss. Figure 2 shows the Left-on-Spool trend for PM 4 for a selected day. This trend gives the operator feedback for adjustment of reel target size at the PM.

	Month			
REASON	Jan-06	Feb-06	Mar-06	Grand Total
Other	8.8%	13.6%	36.7%	12.6%
Turn Up on Break	18.0%	7.5%	10.1%	12.1%
Edge Defects	2.5%	20.3%	0.0%	11.7%
Weight Variations	11.8%	6.5%	2.0%	8.5%
MF Reel made too big	5.3%	10.3%	13.6%	8.3%
Offsize due to PM Break	11.0%	5.2%	3.7%	7.6%
Moisture Variations	4.0%	9.3%	1.5%	6.7%
Bad PM Turnup	4.5%	6.0%	4.3%	5.2%
Start-Up	8.0%	2.7%	6.0%	5.1%
Wrinkles	5.7%	4.8%	0.0%	5.0%
Too Many Breaks in Reel	3.6%	5.7%	0.0%	4.6%
Poor Profile	6.9%	0.7%	11.1%	3.8%
SC/Winder Snap Off	4.3%	3.0%	0.8%	3.4%
Reel too Small	2.5%	2.9%	5.0%	2.8%
Grade Change	0.0%	1.5%	0.0%	0.8%
Water Drops	0.7%	0.0%	5.1%	0.6%
Shut-Down	1.2%	0.0%	0.0%	0.5%
Holes	1.0%	0.2%	0.0%	0.5%
Formation	0.0%	0.1%	0.0%	0.0%
Grand Total	100.0%	100.0%	100.0%	100.0%

Whenever a loss is greater than a threshold defined by the mill, the operator is prompted for a REASON CODE from a St Marys specific and Loss Type sensitive list. The Loss Type (Slab, Heel, Splice, Small Set or TornOffTop) is automatically determined but the addition of a REASON CODE provides additional insight. Knowing that you have a certain tonnage lost as Heels (Left-on-Spool) is useful in itself but knowing how much of that Tonnage was due to PM break or Turn-Up issues, off spec paper or simply overbuilding the reel is even more valuable. This allows management to focus efforts and dollars to the problems of biggest payback.

In Table 1, the tonnage lost is reported according to REASON. Normally the actual tonnage would be reported but for the purpose of this paper % of total lost tonnage has been shown. It is important to note that in a multiple downstream process station like an SCA mill it will be significantly more difficult to precisely size reels which may not be wound to finished rolls for days.

Table 1 Losses by Reason Code as a percentage of total losses for the month

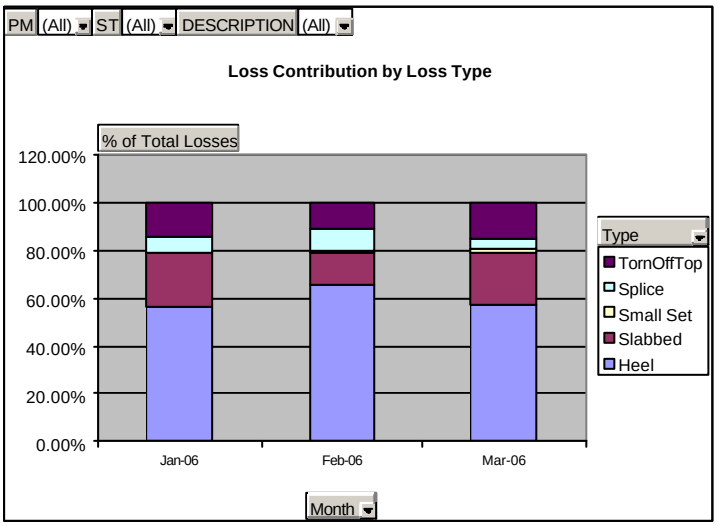

Figure 3 Daily Slab Loss Tonnes Inferred by Process State Sequence

The loss information can be presented in many ways with different degree of detail. Typically tonnages would be reported but for this paper Figure 3 shows the month by month contribution to total losses by loss type. Loss Type is automatically inferred by Process State Sequence. Other reports show day be day trends. If a day looks abnormal a more detailed view of losses can be examined to learn what was happening.

Loss Time Details

Station	AreaCode	STARTTIME	ENDTIME	Duration	REASON	STOPCOMMENT
PM #5	Sheet Break	1/1/06 20:55	1/1/06 20:59	4.3	Other	snapoff at turnup
PM #5	Sheet Break	1/1/06 16:53	1/1/06 17:08	15.7	Edge	back edge dropped off at p/u

Table 2 Loss Time Details for Papermachine 5

Table 2 shows the Loss Time Details for a selected time period for PM 5. All breaks events are automatically detected and recorded along with the start and end time. Each break has several "code" fields used by reports and diagnostic analysis to group similar break events. Each break is automatically given the Area Code defined for the sensor that first detected the break. At St Marys only one break sensor is currently integrated to the LSZ system so all breaks are initially coded simply as "Sheet Break" as a default. Depending on what transpires the operator or shift personnel recode some or all of the break time to other Area Codes using context sensitive drop down pick lists. The St Marys specific Area Codes are used to group papermachine down time in general categories for reporting and efficiency calculation. Most of LSZ's installations use a similar approach although there is variation in the number of Area groupings used from mill to mill.

Operators and shift personnel add additional coding used for report groupings by picking REASON CODES from a pick-list. REASON CODES are context sensitive so that only those that St Marys specified as appropriate for the Area Code in use are presented for picking. In most cases a comment is also added by the operator in the free form comment field.

Station	PM #5			
Sum Minutes	Month			
REASON	Jan-06	Feb-06	Mar-06	Grand Total
Scheduled	16.4%	53.0%	26.0%	30.3%
Mechanical	25.8%	0.0%	0.0%	11.9%
E/I	1.1%	3.8%	39.2%	10.2%
Other	15.0%	1.8%	6.5%	8.9%
No Evidence	11.4%	7.3%	2.0%	8.0%
Pick Out	9.3%	7.0%	1.6%	6.9%
Lumps/Debris	6.3%	9.5%	3.0%	6.6%
Edge	7.8%	4.5%	1.8%	5.4%
Unassigned	0.0%	0.0%	13.9%	3.0%
Startup	1.9%	0.0%	4.2%	1.8%
Streak	1.3%	2.7%	0.5%	1.6%
Draw	0.6%	3.1%	0.3%	1.3%
Hole	0.4%	2.3%	1.0%	1.1%
Flicks	0.9%	0.7%	0.0%	0.6%
Ropes	0.0%	1.6%	0.0%	0.5%
Squirt	1.1%	0.0%	0.0%	0.5%
Doctor Blades	0.0%	1.5%	0.0%	0.5%
Retention Aid	0.6%	0.0%	0.0%	0.3%
Wash Up	0.0%	0.7%	0.0%	0.2%

Process Automation	0.0%	0.6%	0.0%	0.2%
Grand Total	100.0%	100.0%	100.0%	100.0%

Table 3 Time Losses for Papermachine 5 by Reason Code (displayed as % of total lost time)

Loss time data is presented in a variety of reports. Perhaps the most useful way to report the data is to break it down by REASON as shown for PM 5 in Table 3 above. For the purpose of this paper the data has been presented as % of total lost time instead of actual time duration.

Loss Time Contribution by Area Code

Station	PM #5

% of total	Stop Type				
Month	Maintenance	Sheet Break	Operational	Unassigned	Grand Total
Jan-06	43%	51%	6%	0%	100%
Feb-06	57%	39%	4%	0%	100%
Mar-06	72%	11%	4%	14%	100%
Grand Total	54%	38%	5%	3%	100%

Table 4 Time Losses for Papermachine 5 by Area Code

Table 4 shows the contribution to total Time Losses for Papermachine 5 by Area Code. Only the Area Codes having data for the time period selected are displayed in Table 4. The complete list of Area Codes for St Marys is:

Sheet Break
Operational
Maintenance
Capital
External

Time-loss data for supercalenders and winders is also recorded. It can be used for determining process cycle times but is not currently of high interest at St Marys as they are not often limited by supercalender or winder throughput. In other mills, having accurate, automated winder cycle time data can be key to making the most effective decisions to increase wound-roll production.

CONCLUSION

Precise, accurate and automated paper slab and time loss tracking and reporting is the foundation of useful loss accounting which informs actions for improvements in the papermill. Without this, your operations are running blind and losses will inevitably creep higher. Here we have described in a very complex multi-step and multi-pathway process line how this has been done. Previously "Unaccounted" losses have been significantly reduced simply by making them visible, and thus accountable and actionable. Operator software tools supporting optimal reel sizing at the papermachine, and optimal consumption of partial and orphaned reels at the winder, work to further actively minimize slab losses. Detailed current losses by category are also shown. The result is a sustained 2% improvement to the productivity for St Marys Paper Ltd.

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