Paper Machine Energy Case Histories

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May 1-4
PaperCon 2011
Northern Kentucky Convention Center

RETHINK PAPER:
Lean and Green

Reducing Energy Operating Costs

- Papermaking is a complex process and each machine is unique. Improving energy efficiency requires careful evaluation of total paper machine operation.
- Significant energy savings can be realized on most paper machines by monitoring and benchmarking energy consumption and implementing cost effective changes.

TAPPI TIP 0404-63 (2011)
Paper Machine Energy Conservation

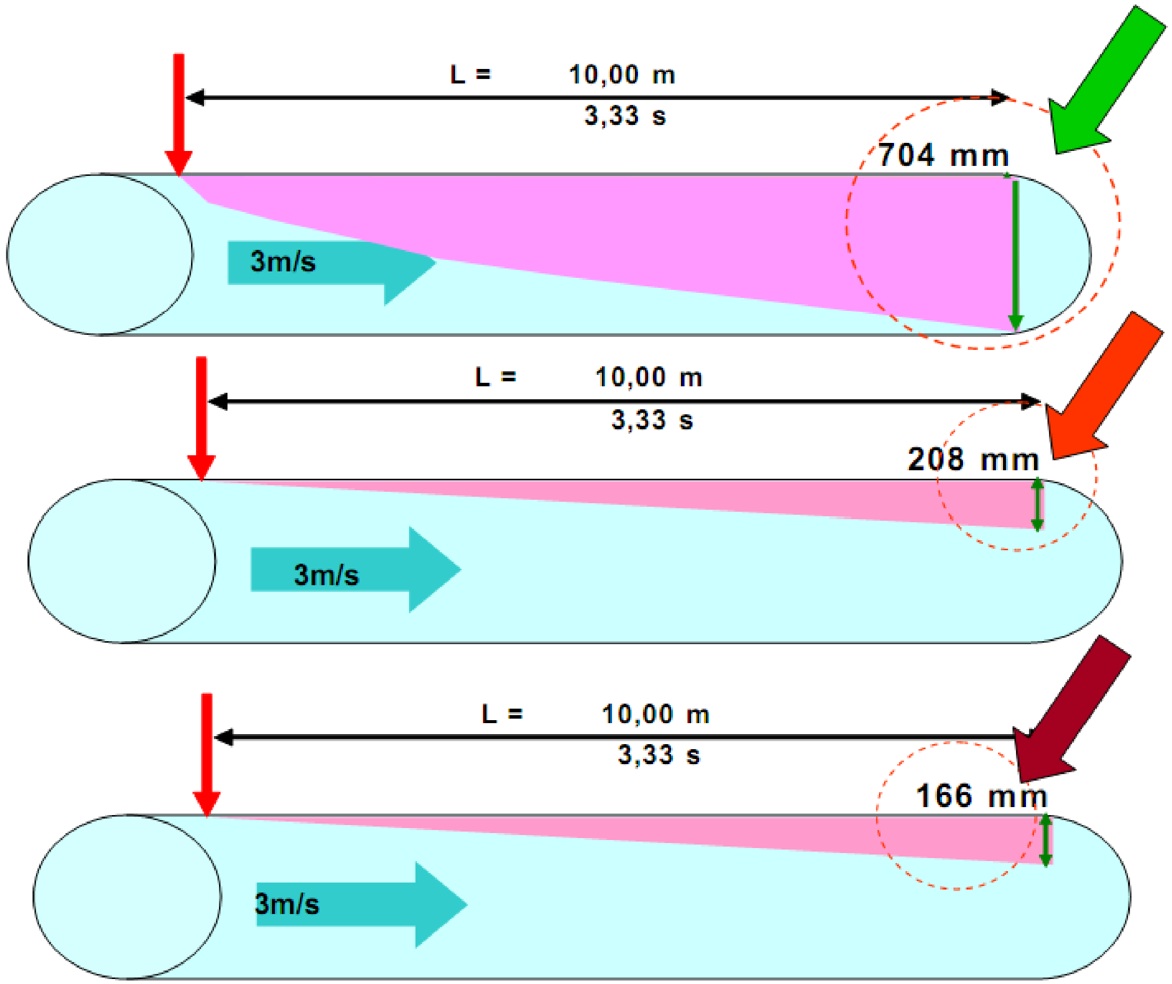
Five Basic Principles

1. Minimize amount of water evaporated in the dryers.
2. Minimize amount of steam condensed outside the dryers.
3. Maximize condensate return flow and pressure to the power house.
4. Minimize electrical consumption for key users.
5. Monitor and manage energy consumption and cost.

Top Areas for Energy Reduction

- Water Systems
- Steam and Condensate Systems
- Pressing
- Pumps
- Heat Recovery
- Slowed Back Production Rates
- Pulpers and Agitators
- Refining
- Steam Boxes
- Vacuum Systems
- Size Press and Coaters

Penetration of Injection Jet into Stock Flow High Velocity vs. Low Velocity



Mill A Savings by Upgrading Additive Injection System

- Coated fine paper
- Fresh water savings=900,000 gallons per day
  - 580,000 gallons saved directly
  - 320,000 gallons of clear filtrate used for pigment dilution
- $1 million energy savings to heat to process temperature
- Chemical savings =22%

Mill B Savings by Upgrading Additive Injection System

- Four machine North-Eastern mill
- Fresh water savings=340,000 gallons per day
- $365,000 energy savings to heat to process temperature

Steam and Condensate System Opportunities

- Install stationary syphons with low operating differential pressures, modern steam joint design, and dryer bars.
- Minimize number of dryers draining to condensers.
- Use blow through control or managed differential pressure control to minimize steam venting on sheet breaks.
- Minimize steam venting and system leaks.
- Optimize thermocompressor sizing and operation. More efficient designs now available.
- Properly balance cascade systems.
- Shut off steam to bottom unorun or felt dryers.
- Use pilot-operated safety relief valves.
- Make sure there is tight shut off of dryer vent valves.
- Improve steam and condensate piping insulation.
- Consider dryer management systems.

What Are the Ultimate Low Hanging "Fruits"?

Lower Pocket Ventilation Supply Air Temperature

- Reduce pocket ventilation supply air temperature
- Each 10 F^{o} reduction in average PV temperature will reduce steam consumption by one percent of dryer steam consumption.
- Some mills run PV supply air temperature as low as 120^{o}F
- Potential PM 1 annual savings=((220-170)/10 X 0.01 X 200,000 lb/hr X 24 hr/d X 350 d/y X $2.50/1,000 lb steam=$210,000
- Hood balance issues could get worse could reduce potential to lower temperature set points.

Shut Off Bottom Unorun Dryers

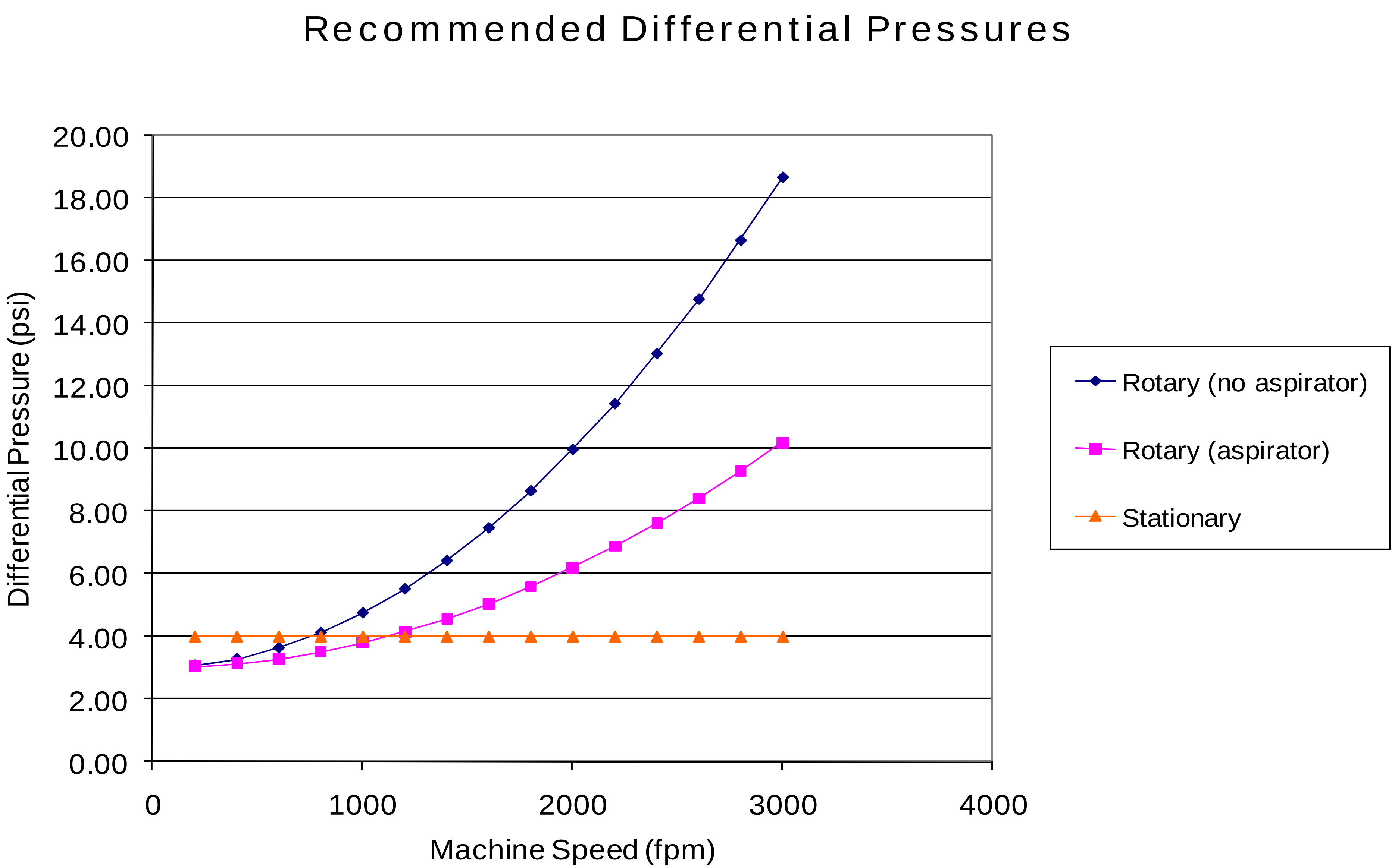
- Conduct trials removing steam from bottom unorun dryers 2, 4, 6, 8 and 10
- The dryer fabric is between the sheet and bottom dryer cylinders so little heat transfer occurs and blow through steam flow is very high. High steam blow through erodes condensate side piping and increases maintenance requirements.
- Most paper machines with unorun fabrics have shut off steam to bottom dryers.
- Relative diameter of top and bottom dryer changes due to differences in temperature so it may be necessary to remove some dryer gears to eliminate gear wear issues.
- Conduct trials for a few hours one dryer at a time by valving off steam and condensate lines and monitoring steam system operation and machine performance.
- If successful, remove steam and condensate piping on next outage.

Shut Off Bottom Unorun Dryers

- Estimated steam flow per bottom dryer is 2,000 lb per hour
- Potential annual savings= 5 X 2,000 lb/hr X 24 hr/d X 350 d/y X $2.50/1,000 lb steam= $210,000 per year.

Lower Differential Pressures

- Differential pressures were 7 to 12 psig on a paper machine vs. 4.2 to 5.1 on a sister machine running at similar speeds. Both machines had rotary syphons.
- Motive steam flow was ~20,000 lb/hr
- Total steam consumption did not change but use of more low pressure steam permitted more power generation in the steam turbine.
- Potential annual savings when motive steam flow was cut in half=10,000 lb/hr X 24 hr/d X 350 d/y X ($2.80/1,000 lb)=$235,000
- $2.80 is the difference in cost of high pressure motive steam and low pressure steam
- Installation of stationary syphons would permit running even lower differential pressures.



Recommended Differential Pressures
Differential Pressure (psi)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
1000
2000
3000
4000
Machine Speed (fpm)
Rotary (no aspirator)
Rotary (aspirator)
Stationary

Dryer Management System Case History

- Problems before included:
  - High steam venting during breaks (steam turbine drive)
  - Average break length of 47.8 minutes
  - Variable dryer temperature response to changes contributed to sheet threading issues
  - Significant failures of dryer bearing inner races due to improper warm-up after outages
  - Dryer control issues
  - Curl control issues

Dryer Management System Case History

- Installed Windows XP based work station with supervisory logic linked to DCS to control steam and condensate system.
- Benefits included:
  - 8.1 minutes per break reduction and faster quality recovery =$272,000 annual increased revenue
  - Steam reduction-130 psig (7.8%), 160 psig (1.6%), and 600 psig (4.8%)=$240,000 per year
  - Dryer bearing problems greatly reduced
  - Consistent operation from one shift to next
- Simple payback < 6 months

Press Optimization

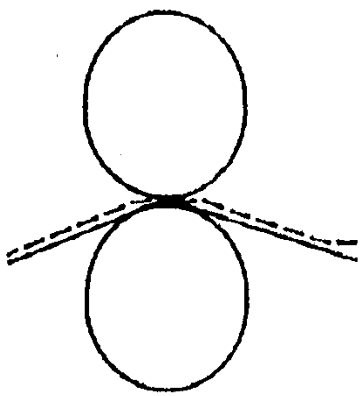
- Run advanced technology fabrics
- Move towards nip dewatering
- Optimize nip conditions
- Optimum roll, shoe, and sleeve designs
- Effective doctoring of suction rolls and shoe press sleeves
- Minimize sheet rewet
- Optimize fabric conditioning-monitor water flows, vacuum application, showering, shower water temperature, etc.
- Conduct press optimization per TIP 0404-52

Corrugating Medium Paper Machine

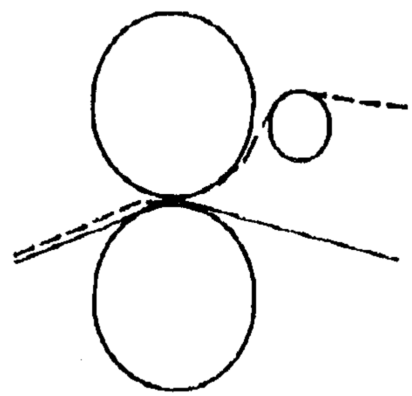
- Sheet followed second/last press fabric ~10 feet after press nip
- Comment:
  - Estimated sheet rewet was 2 to 3 percentage points that equated to 4,000 to 6,000 lb/hr increase in dryer steam consumption.
  - Mill changed press fabric designs and changed sheet run to get sheet off fabric without compromising runnability.
  - Steam savings was 5,000 lb/hr.

Press Rewet

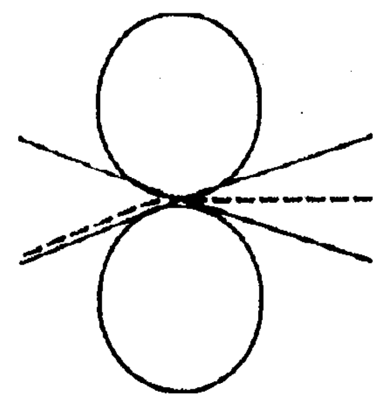
Single Felt Rewet



Single Felt Rewet Minimized

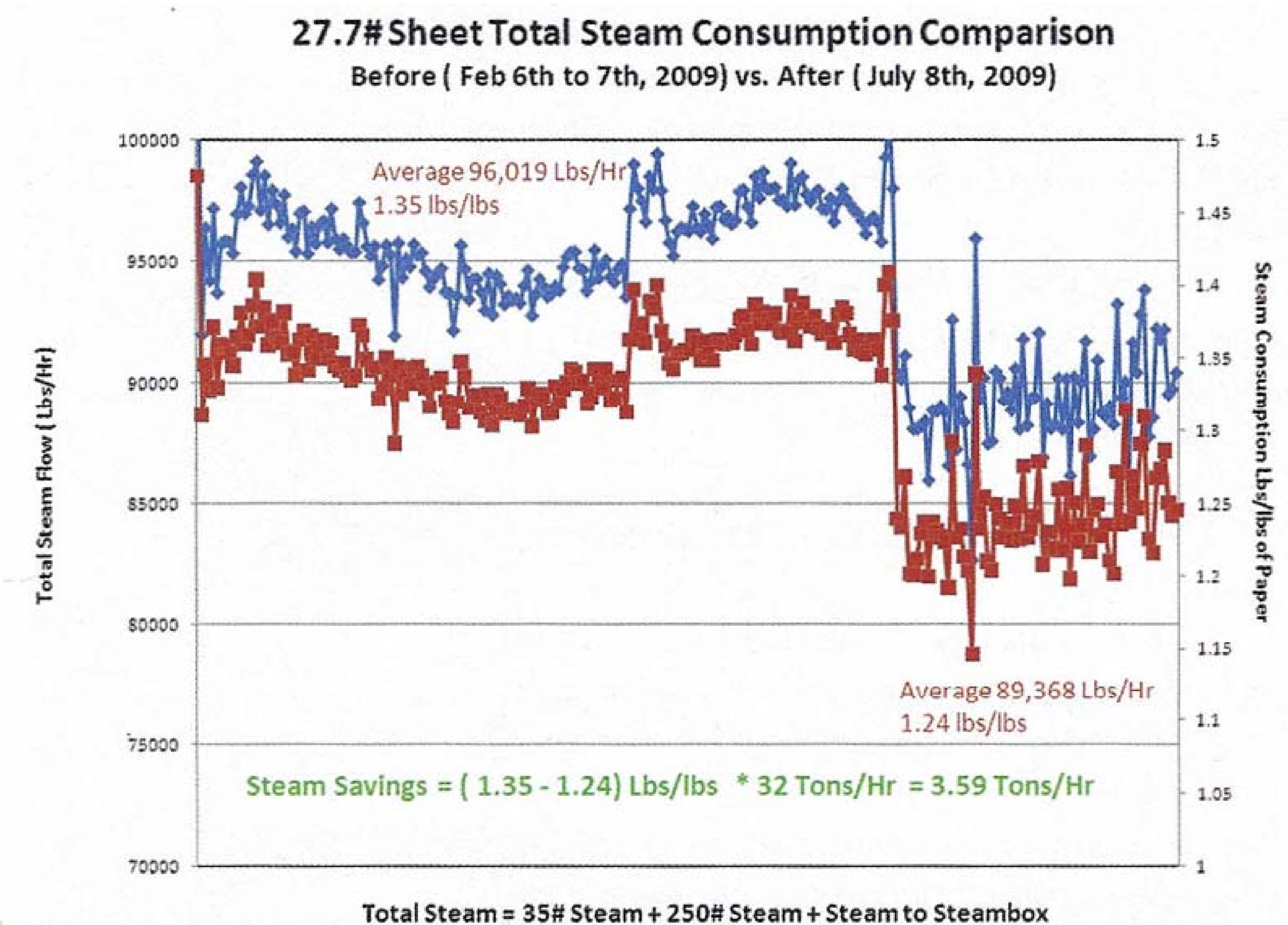


Double Felt Rewet Minimized



Steam Box Replacement-Fine Paper

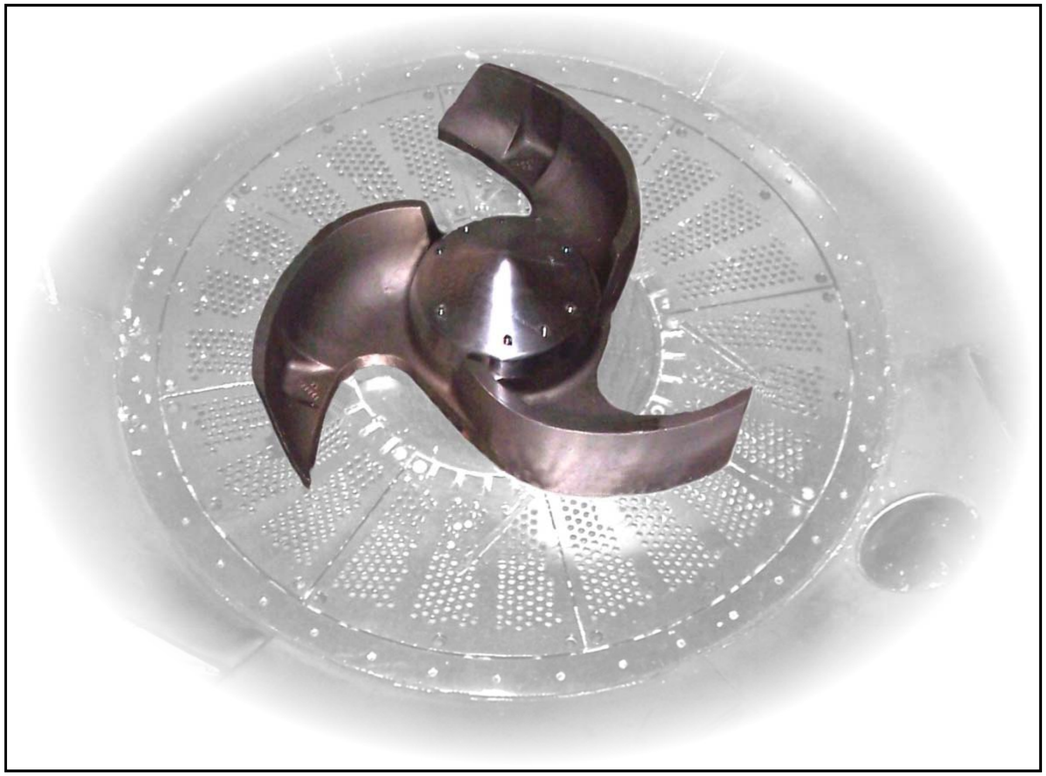
- Old steam box was located over the suction holding box in a trinip plus 4th press.
- Replacement with a modern steam box in the same location provided the following benefits:
  - Permitted raising pre-size press moisture from 2.8 to 3%.
  - Improved reel moisture profile.
  - Reduced total steam consumption cost by $50,000 per month.
  - Simple payback less than one year.



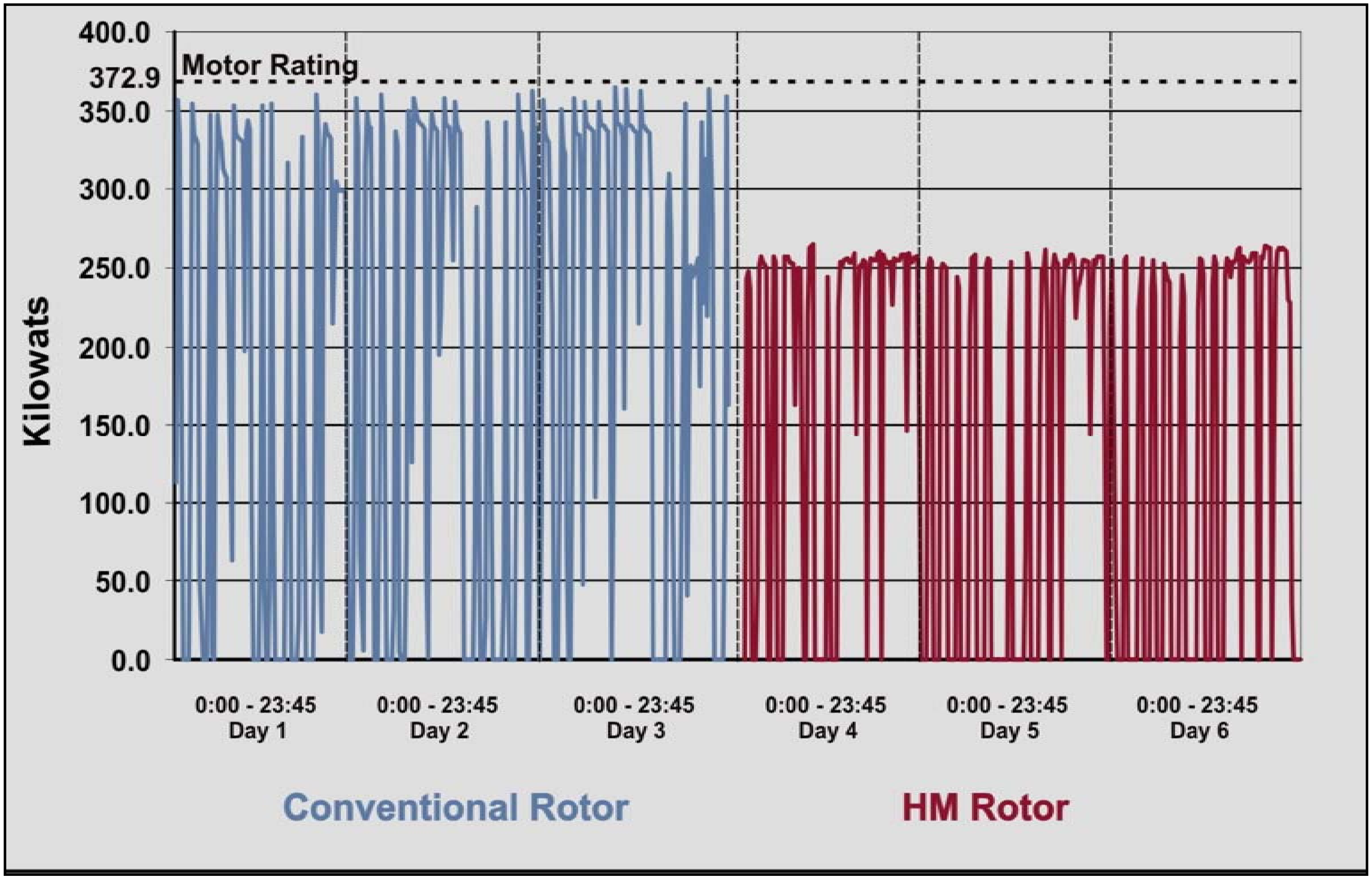
27.7# Sheet Total Steam Consumption Comparison
Before (Feb 6th to 7th, 2009) vs. After (July 8th, 2009)
Average 96,019 Lbs/Hr
1.35 lbs/lbs
Average 89,368 Lbs/Hr
1.24 lbs/lbs
Steam Savings = (1.35 - 1.24) Lbs/lbs * 32 Tons/Hr = 3.59 Tons/Hr
Total Steam Flow (Lbs/Hr)
Steam Consumption Lbs/lbs of Paper
100000
95000
90000
85000
80000
75000
70000
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
Total Steam = 35# Steam + 250# Steam + Steam to Steambox

Energy Efficient Repulper Rotor

Energy is a controllable operating expense



Batch Repulper Power Response Three Day Comparison



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Pulper Agitators Run Continuously

Application	Connected HP	$ Annual Cost @$487/hp/yr (0.6 factor)
Wet End Pulper	2@150 hp	88,000
Dry End Pulper	2@200 hp	117,000
Reel Pulper	2@200 hp	117,000
Winder Pulper	2@200 hp	117,000
Total	900	439,000
Also pump on No. 8 outside whitewater pump	125	33,000

Candidates for Variable Frequency Drives

- Pump applications where flow is often highly throttled
- Many broke system applications
  - Couch pit
  - Reel pulper
  - Other pulpers
  - Broke chests

Estimated Cost of VFD

- Estimated installed cost of low voltage VFD:
  - <100 hp=$30,000
  - 150 hp=$40,000
  - 200 hp=$50,000
  - 250 hp=$60,000
  - 300 hp=$70,000
  - 350 hp=$80,000
- In addition substation or infrastructure upgrades may be required.
- Replacement of medium voltage motors will be more expensive.

Challenge

If Chile can rescue 33 miners from ½ mile underground, paper mills can reduce their energy consumption by 10%.

Go for it!