Measuring Paper Machine Energy Performance

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Relevant Quotation

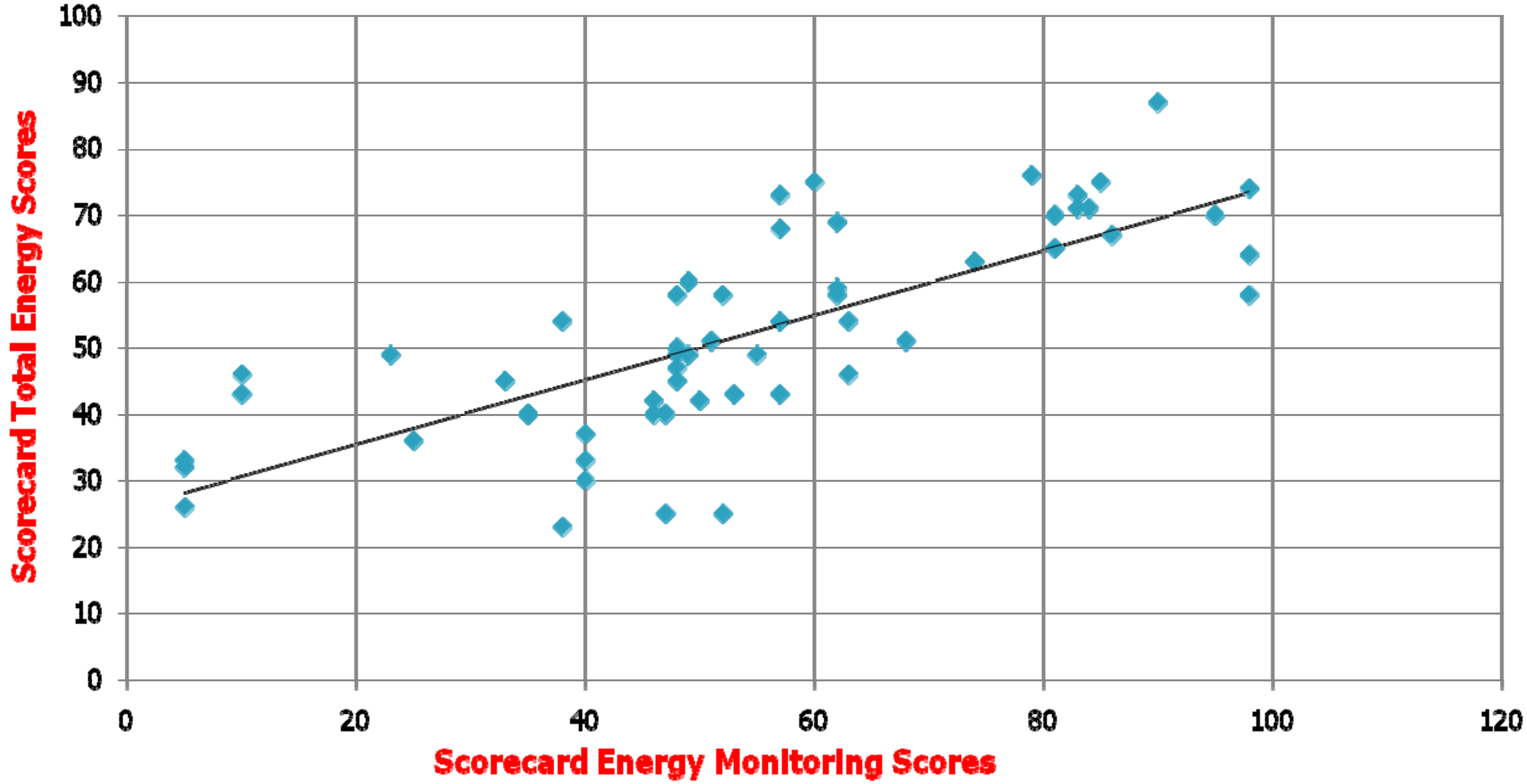
"If you can not measure it, you can not improve it."

Lord Kelvin-Engineer/Natural Philosopher, 1824-1907

How Well are Mills in USA Doing with Energy Monitoring?

- Great?
- Good?
- Fair?
- Poor?

Paper Machine Energy Scorecard Results



Key Performance Indices

A & B Paper Machine Energy Tracking

A PM Current Values / 24 Hour Trends

Machine Information		
Machine Break	N	
Paper Grade #	978	
Basis Weight	61	lb/3300sq ft
Reel Moisture	5.1	%
Size Press Moisture	2.9	%
Reel Speed	3057	fpm
Production Rate	34.5	tph
Steam		
Total Steam Consumption	3597	lb/ton
Electricity		
Total Electricity Consumption	306	kWh/ton
Water		
Water Consumption	2500	gal/ton
Warm Water Consumption	1256	gal/ton
Energy Cost		
Total Energy Cost *	30.16	$/ton
Energy Consumption		
Total Energy Consumption	5.7	MMBtu/ton

B PM Current Values / 24 Hour Trends

Machine Information		
Machine Break	N	
Paper Grade #	891	
Basis Weight	50	lb/3300sq ft
Reel Moisture	5.4	%
Size Press Moisture	3.4	%
Reel Speed	3268	fpm
Production Rate	44.1	tph
Steam		
Total Steam Consumption	5119	lb/ton
Electricity		
Total Electricity Consumption	600	kWh/ton
Water		
Water Consumption	1413	gal/ton
Warm Water Consumption	986	gal/ton
Energy Cost		
Total Energy Cost *	50.28	$/ton
Energy Consumption		
Total Energy Consumption	8.2	MMBtu/ton

Real-time Energy Monitoring

(P) TM7 COSTS : TM7 Drying And Energy Costs

Exit Update TimeSpan Print Mail Functions Help 06:46:38 02-Sep-2003

TM7 REAL-TIME DRYING AND ENERGY COSTS

Production: 243.68 TPD | Grade: 641401 | Basis Weight: 0.0 lbs

Condensate

% Return:
Total Return: 0 GPM
Condensate Temperature: 204°F

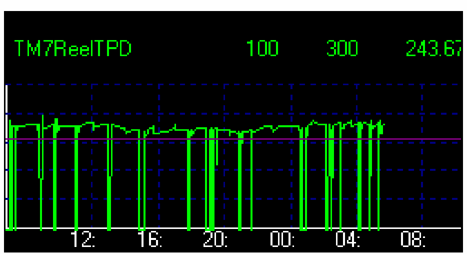
TM7 Drying And Energy Costs

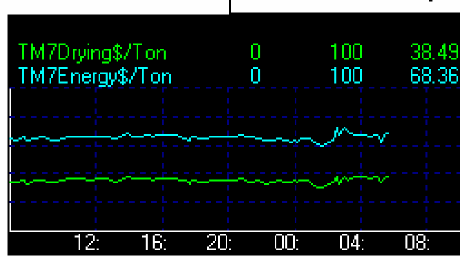
	Flow	Unit	MMBTU's Per Ton	% Dry Load	Actual Price / Unit	Actual $/Ton	Standard Price / Unit	Standard $/Ton
850# Steam	4.08 MLbs/Hr	MMBTU	0.48	6.9%	5.04	2.20		
150# Steam	12.72 MLbs/Hr	MMBTU	1.31	18.9%	1.99	5.77		
50# Steam Box	6173 Lbs/Hr	MMBTU	0.64	9.2%	2.41	3.06		
Total Drying Steam	22.69 MLbs/Hr	MMBTU	2.42	34.9%		11.04		
Gas	44.75 MSCFH	MMBTU	4.51	65.1%	5.80	27.46		
Total Drying		MMBTU	6.94			38.50		
Water	482.48 GPM	MMGals				0.53		
Electric	7.85 mWH	mWh				28.59		
Compressed Air	1034 SCFM	MCF			0.123	1.08		
50# Miscellaneous	1.23 MLbs/Hr	MMBTU				3.06		
Total Energy						68.36		

Utilities Daily Control Charts
TM7 Energy Overview
TM7 Real-time Costs Trend
TM7 Hourly Costs Control Chart
TM7 Daily Costs Control Chart

Yankee BlowThru

- Actual MLbs/Hr: 12.6
- Recommended MLbs/Hr
  BlowThru (@175 Ft/sec): 14.1
  BlowThru (@150Ft/Sec): 12.1
- Recommended Straw Tip Velocity: 150 - 200 ft/sec
- Actual Straw Tip Velocity: 171 fps Excess BlowThru $: 0.28





Effective Energy Monitoring Programs-TIP 0404-63

- Monitor energy flows to each paper machine.
- Establish key energy parameters
- Highlight variables that affect energy consumption.
- Include energy parameters in operator rounds and centerlining efforts.
- Provide information to operators, engineers, and managers to encourage continuous improvement.
- **Appoint an energy champion to monitor and improve paper machine energy consumption.**
- Discuss energy cost and conservation efforts in production meetings.
- Conduct periodic checks of key systems.
- Benchmark machine operation with best achievable for equipment installed.

Identify and Monitor Key Energy Use Factors

- Venting from thermocompressor or cascade sections.
- Any additional steam venting.
- Condenser water valve output/condensate flow.
- Differential pressure (especially for early dryers).
- Steam valve positions for water heating.
- Basis weight versus standard.
- Press solids-usually requires grab samples.
- Press section weir flows.
- Size press starch solids.
- Pocket ventilation temperature.
- Temperatures through hood exhaust heat recovery systems.
- Warm water flow from pulp mill.
- Mill water make-up into whitewater or warm water system.

Monitor Key Energy Use Factors-Ventilation Systems

- Operate air systems in automatic temperature control with recommended set points.
  - Pocket ventilation-180^{o}F-High enough to prevent hood sweating.
  - Dryer section blow boxes- 160^{o}F
  - Building ventilation units- 75^{o}F
  - Roof supply units- 120^{o}F
- Industry best practice includes high-performance dryer hoods and heat recovery from hood exhaust to preheat PV, glycol systems for machine room ventilation, and water heating.
- Heat recovery from condensate flash.

Monitor Key Energy Use Factors-Condensate Return

- Return all condensate from indirect steam users to the power house at as high pressure as possible.
- Ensure proper level control.
- Ensure no condensate pump, piping, or drain line leaks.
- If condensate must be flashed at low pressure, reuse flash steam where it will replace fresh steam.
  - Wet end dryers.
  - Preheat pocket ventilation air.
  - Steam showers (with proper trapping and piping design).
  - Flash steam should generally not be used to heat water.

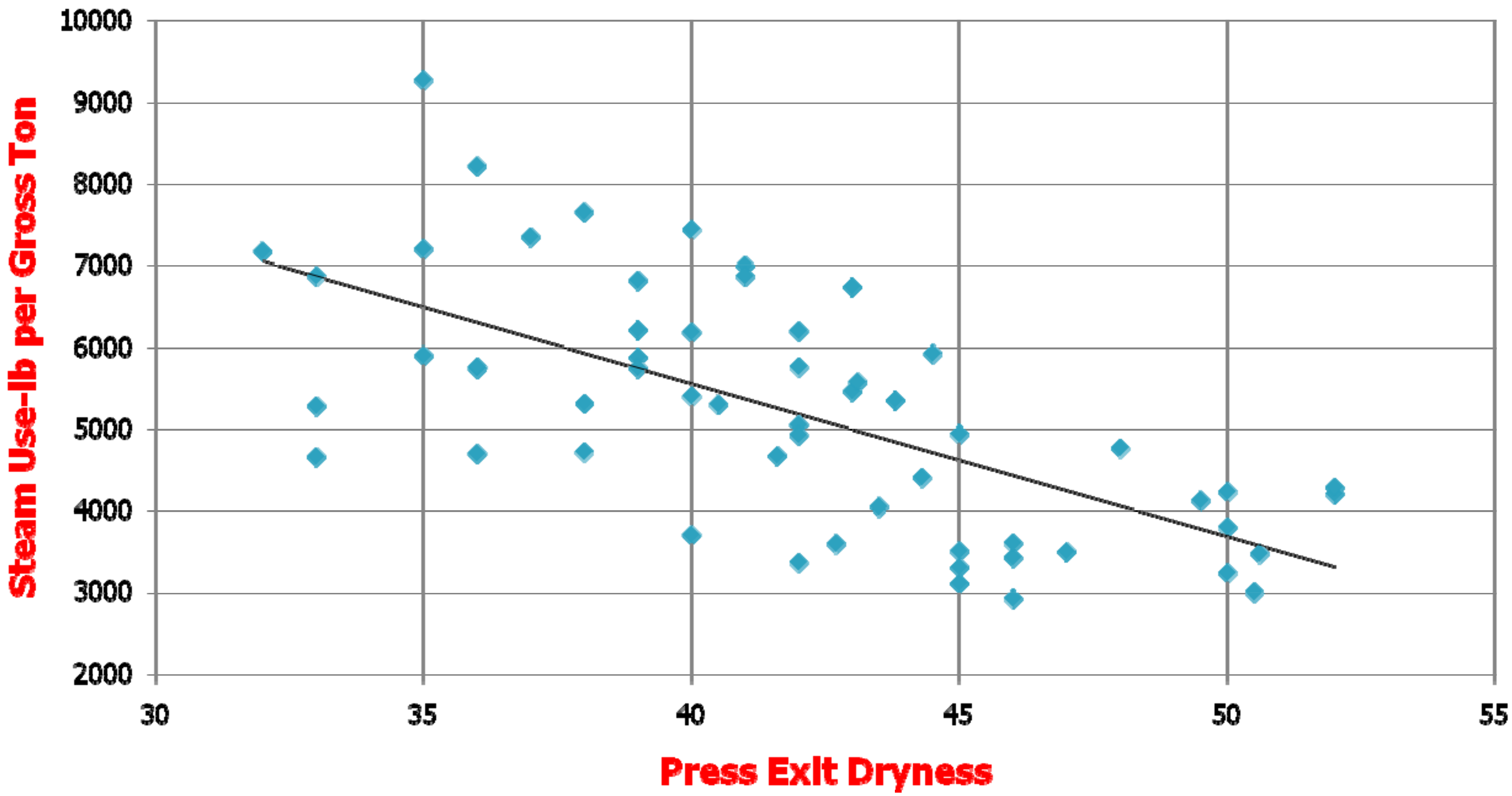
Track Specific Energy Indices- TIP 0404-63

- Steam consumption (kg or lb steam/ton of paper).
- Electricity consumption (kWh/ton).
- Natural gas consumption (m^3 or kscf/ton).
- Total energy consumption (kJ or MMBtu/ton).
- Water consumption (m^3 or gal/ton).
- Compressed air consumption (m3 or kscf/ton).
- Condensate return to power house (%).
- Total energy cost ($/ton).

Sheet Dryness Measurement After Last Press

- On-line sheet moisture measurement.
- Continuous calculation with dryer management system.
- Newsprint mill gets grab samples on first break on each shift.
- Occasional grab tests.
- SWAGS by clothing suppliers.
- No clue.
- Range of reported drynesses-26 to 54%.

Press Exit Dryness vs. Steam Use



Some Great Press Sections

- Fine Paper=54%
- Recycled Liner=52%
- Fluff Pulp=48%
- Market Pulp=51%

Process Information Systems- PI, MOLE, PARCView, etc.

- Great tools for energy monitoring, **IF THEY ARE USED**
- Track:
  - Steam system vent valves
  - Steam valves for heating whitewater
  - Mill water make-up into stock, whitewater, or warm water systems.
  - Broke system monitoring
  - Batch pulper operation
  - Etc., etc., etc.
- Put key measurements in DCS for routine monitoring and/or alarms.

Paper Machine Energy Evaluation Grades

- Fine paper
- Liner
- Medium
- Newsprint
- LWC
- SCA
- Directory
- Fluff pulp
- Kraft paper
- Specialty kraft paper
- Specialty fine paper
- Coated paper

Paper Machine Energy Evaluation Observations

Indices	Units	Low Observed	High Observed	Good Performance
Steam Use	lb/ gross t	2,387	17,300	2,000-5,000
Electricity Use	kWh/gross t	133	1,132	150-500
Total Energy Use	MMBtu/t	3.4	12.4	4.0-7.0
Water Use	gal/gross t	129	25,520	1,000-2,000
Whitewater Temp.	ºF	90	165	120-130
Couch Solids	%	15	30	21-30
Press Solids	%	26	54	42-51
PV Temperature	ºF	160	270	180
Drying Steam	lb steam/lb H_2O evap	1.2	1.5	<1.3

Paper Machine Energy Evaluation Observations

Indices	Units	Low Observed	High Observed	Good Performance
Fiber Loss	% Production	0.04	2.0	<0.1/<0.5
Cleaner Diameter	in	3	12	<9
Vacuum Pumps	model	Nash #	Blower System	Modern Designs
Press Shower Temp	ºF	43	150	Same as W/W
Trim Loss	%	1.0	10.0	<2
Wet End Dryers	Control	None	Low DP	Low DP
Reel Moisture	%	3.6	10.5	Varies By Grade
Moisture to Size Pr	%	0.7	5.0	3.0
Starch Solids	%	4.5	19	8/13
Condensate Return	%	?	85	75-80

What Are the Ultimate Low Hanging “Fruits”?

Relevant Quotation

"Do what you can with what you have, where you are."

Teddy Roosevelt, 26th President of US

Energy Quote

"Energy bills can be reduced by 10% without any capital investment costs."

Humbert Kofler-Andritz AG

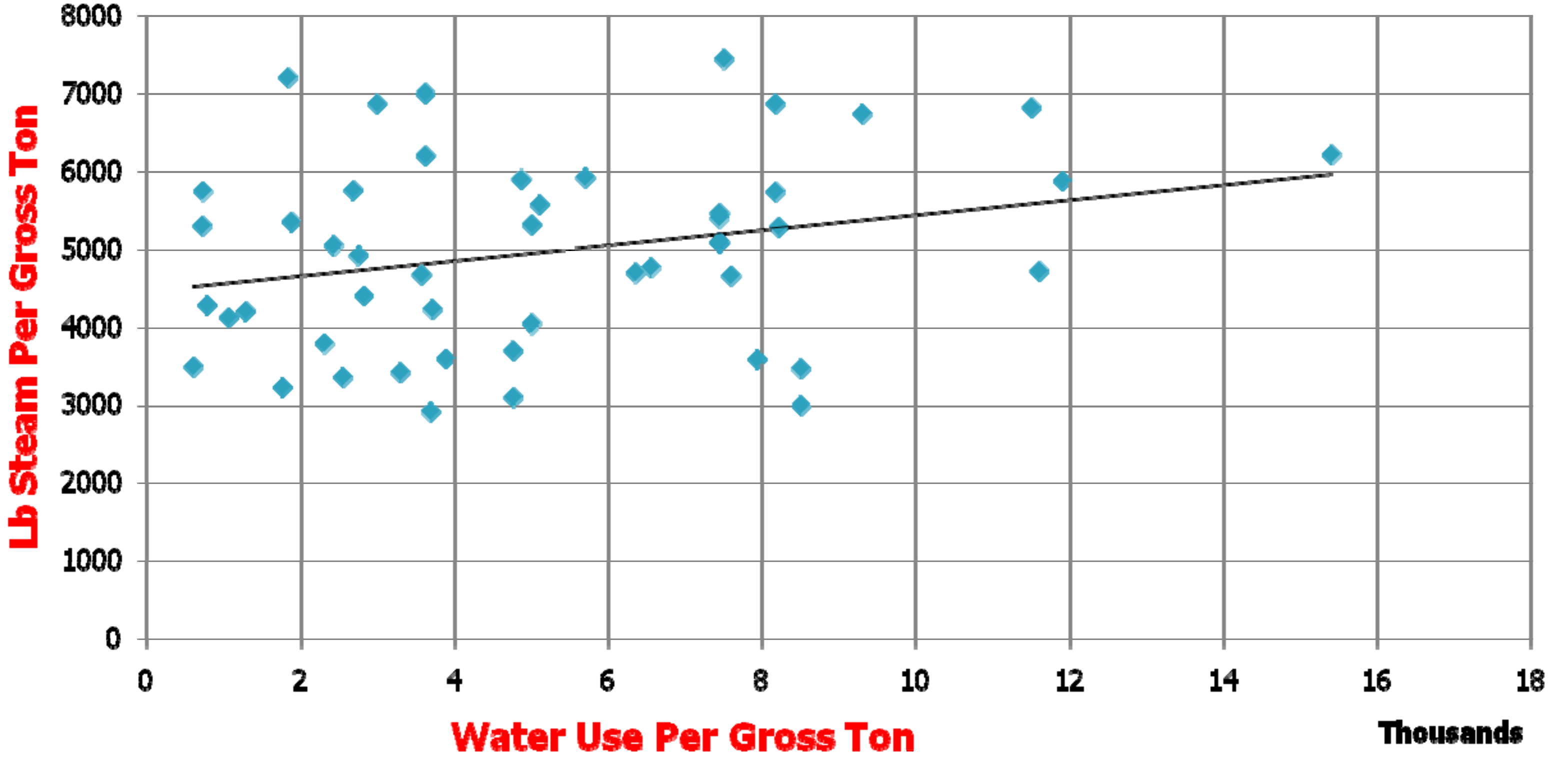
Top Areas for Energy Reduction

- 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

Water Use Reduction

- Water use reduction is a major opportunity on most paper machines.
- Approximately 10% of the paper machines surveyed meet the TAPPI good performance targets for water use per gross ton of production.
- Machine grades meeting the targets include recycled paperboard, liner, medium, LWC, and pulp.
- Lowest use observed was 129 gallons per ton in a recycled paperboard mill.
- Highest use observed was 25,520 gallons per ton on a specialty fine paper machine.

Water Use vs. Steam Use



Potential Water Energy Savings-Machine B

- Average PM water consumption per day (million gallons)= **4.1**
- Number of operating days per year =**352**
- Average annual temperature of incoming water to paper machine (^{o}F) =**55**
- Average annual temperature of effluent from paper machine (^{o}F) =**95**
- Incremental cost of low pressure steam ($ per million BTU) =**10.00**
- Potential annual energy savings ($) =**$4.9 million**

Water Energy Saving Opportunities

- Use warm water from pulp mill.
- Increase use of clarified whitewater.
- Reuse vacuum pump seal water.
- Minimize mill water make-up to stock and whitewater systems.
- Maximize entering stock temperatures.
- Keep cool water out of warm and hot water systems.
- Recover heat from paper mill effluent or hood exhaust.
- Modern saveall in good operating condition.

Steam and Condensate Systems Opportunities

- Stationary syphons with low operating differential pressures, modern steam joint design, and dryer bars.
- Minimal number of dryers draining to condensers.
- Blowthrough control or managed dp control to minimize steam venting on sheet breaks.
- Minimal steam venting and system leaks.
- Proper thermocompressor sizing and operation. More efficient designs now available.
- Properly balanced cascade systems.
- No steam in bottom unorun or felt dryers.
- Pilot-operated safety relief valves.
- Tight shut off of dryer vent valves.
- Good steam and condensate piping insulation.

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.

Pump Optimization

- Average pumping efficiency is below 40%. Over 10% of pumps run below 10% efficiency.
  - Major factors affecting pump efficiency are throttled valves and pump over-sizing.
  - Seal leakage causes highest downtime and cost.
  - Check for multiple parallel pumps when number of operating pumps is seldom changed.
  - Check batch or cyclical start/stop system with frequent pump cycling.
  - Look for significant cavitation noise.
- Consider variable-speed drives.
- Energy savings of 20% or more are possible with system optimization.
- More than 50% of pump lifecycle costs result from energy and maintenance expense. Less than 15% are initial purchase costs.

Heat Recovery Opportunities

- Recover heat from paper mill effluent to preheat fresh water.
- Check/maintain hood heat recovery equipment.
  - Preheat PV supply air.
  - Water heating.
  - Building make up air.
- Higher energy costs provide justification for heat recovery in climates that previously could not meet investment benchmark hurdles.

Stock Prep Opportunities

- Shut down pulper agitators automatically.
- Manage batch pulpers to minimize peak electricity and fresh water makeup.
- Install energy-efficient rotors (~25% savings) and extraction plates (~10% savings) in pulpers.
- Upgrade to energy-efficient agitators (~25% savings).
- Install vertical agitators in new chests (use less electricity than side-mounted agitators).

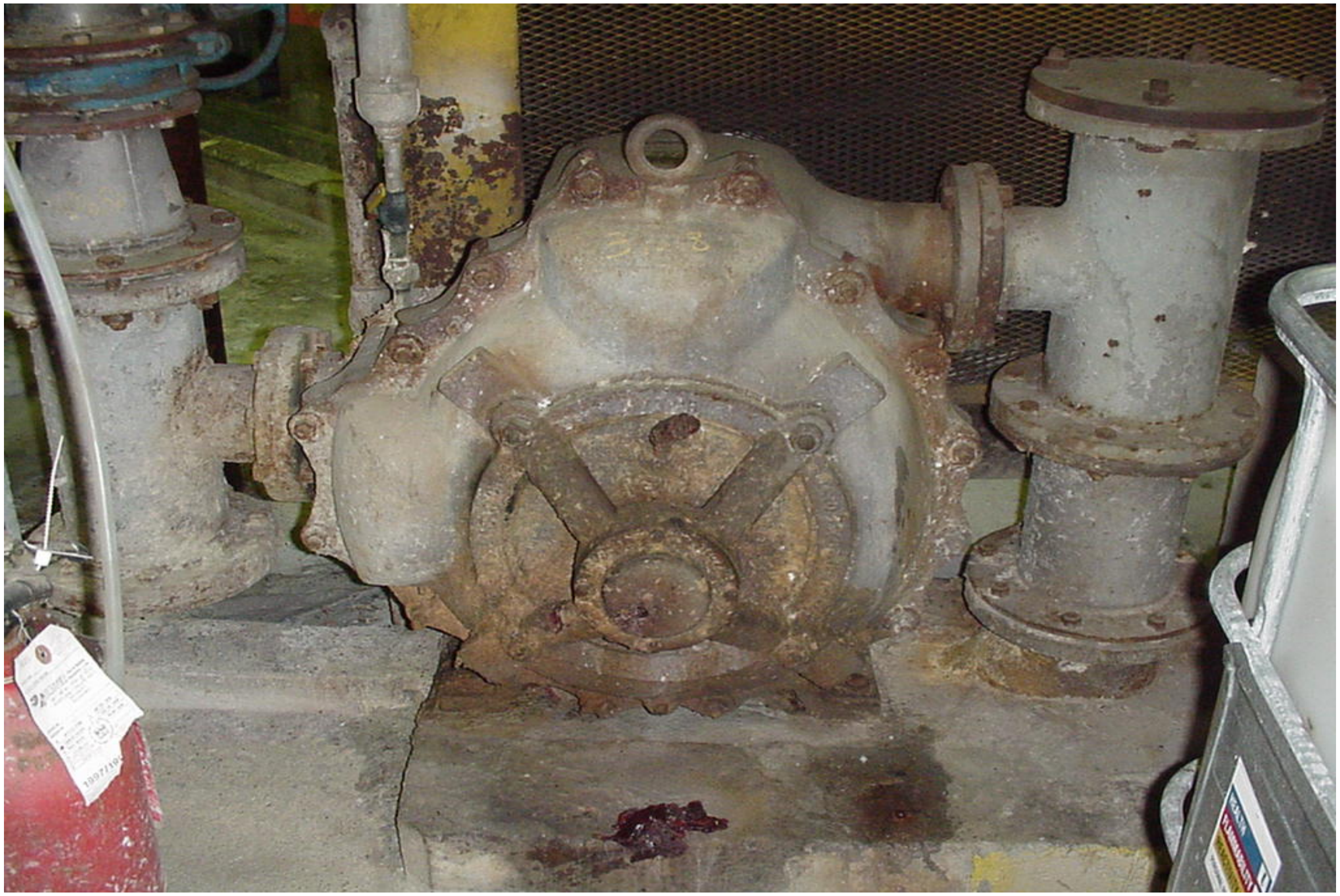
Refining Opportunities

- Run low intensity plate designs, especially on hardwood.
- Check refiner mechanical condition regularly.
- Refine each pulp type separately.
- Shut down tickler refiners when possible.
- Operate in design hydraulic flow ranges.
- Upgrade disk refiners with splined rotors.
- Consider modern energy-efficient designs when replacing refiners.

Vacuum System Opportunities

- Conduct regular performance tests-rebuild/replace inefficient pumps. Do not rebuild obsolete inefficient designs.
- Manage seal water temperature to maintain 40^{o}F below whitewater temperature. Consider cool seal water injection.
- Check vacuum pipe sizing.
- Monitor pump motor loads.
- Graduate flatbox vacuums.
- Shut off/lower unnecessary flatboxes and uhle boxes.

What is This?



Nash #7 Vacuum Pump Mfg. Before 1930

Size Press and Coater Opportunities

- Increase entering sheet moisture content.
- Increase starch and coating solids and reduce pick-up.
- Maximize cylinder drying.
- Measure gas/electricity flows to IR dryers and floatation dryers.
- Replace puddle size presses with metering size presses.

Motor Efficiency

- Evaluate motors on life-cycle cost rather than initial price.
- Specify NEMA Premium efficient motors for continuous duty applications.
- Consider upgrading to permanent-magnet (PM) rotor motors for even greater efficiency.
- System-efficiency upgrades (such as adjustable-speed drives) are possible to maximize potential gains.
- Consider grooved high-efficiency V-belts.
- Use fan-system analysis tools from DOE.
- Specify three-phase motors if possible.

Low Production Rate Energy Saving Opportunities

- Lower whitewater temperature.
- Maintain press loads to maximize sheet dryness.
- Reduce steam flow/shut off steam boxes.
- Ensure there is no venting from dryer steam systems.
- Utilize low pressure steam sources where possible.
- Reduce PV supply air temperatures or shut off if profiles and hood conditions allow.
- Shut down unnecessary equipment-refiners, pumps, agitators, vacuum pumps, exhaust fans, and in some cases cleaners.

A New Day Dawning

- Higher energy costs are changing 200 years of assumptions.
- The “party” built on centuries of cheap energy is running out of steam.
- The new party built on creativity and energy efficiency is just beginning.

Peter Garforth- Garforth Int’l LLC,
Plant Services-July 2008

Relevant Quotation

"Learning is not compulsory, neither is survival."

W. Edwards Deming

Do not let good performance keep you from achieving great performance.