PaperCon '09

TEN MYTHS REVEALED ABOUT PAPER MACHINE VACUUM SYSTEMS

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TAPPI
people resources solutions™

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SO, WHAT IS VACUUM?

According to Webster's:

vacuum \ vak-uym \ n: 1) a space absolutely devoid of matter, or partially exhausted by artificial means; 2) a state of isolation from outside influences; from the Latin word vaccus, meaning empty.

SO, WHAT IS VACUUM?

As applied to papermaking, vacuum is the combination of two criteria.

1. **Airflow** – provided by the mechanical device (vacuum pump)
2. **Resistance to airflow** – caused by the sheet, fabrics, suction roll shell, piping and valves

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

- BY PAPERMAKERS?
- BY ENGINEERS?

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

It is human nature to know a lot about what seems to kick your butt all the time.

Right?

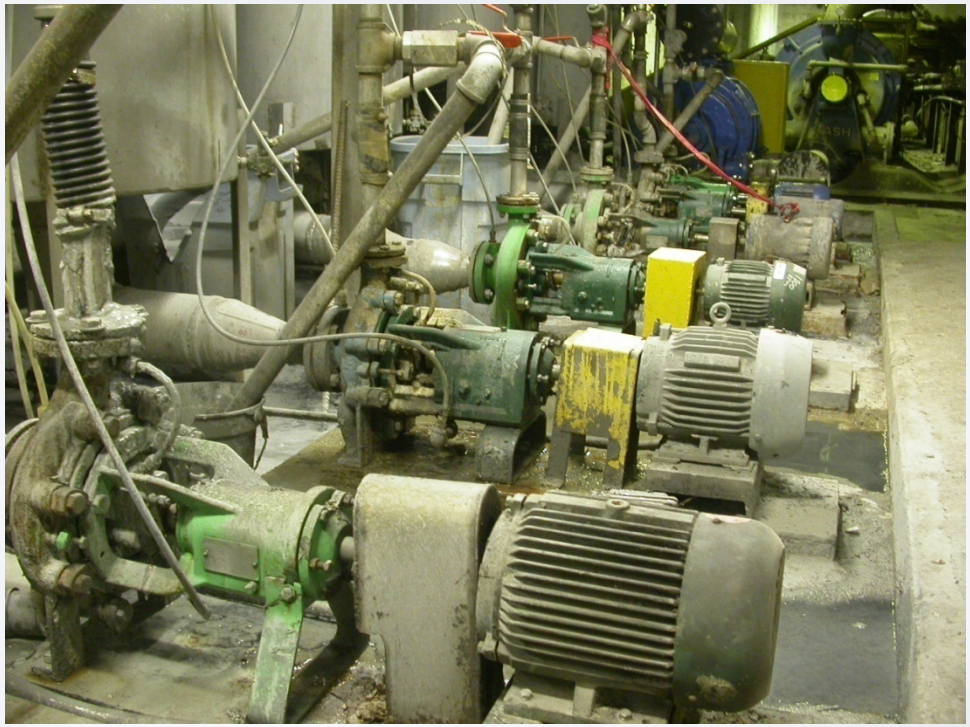
WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

We know a lot about processes operating under **PRESSURE**.

- Water
- Stock
- Steam
- Hydraulics
- Instrument Air

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

We know a lot about fluid machinery (pumps) and most of these are **CENTRIFUGAL PUMPS**.

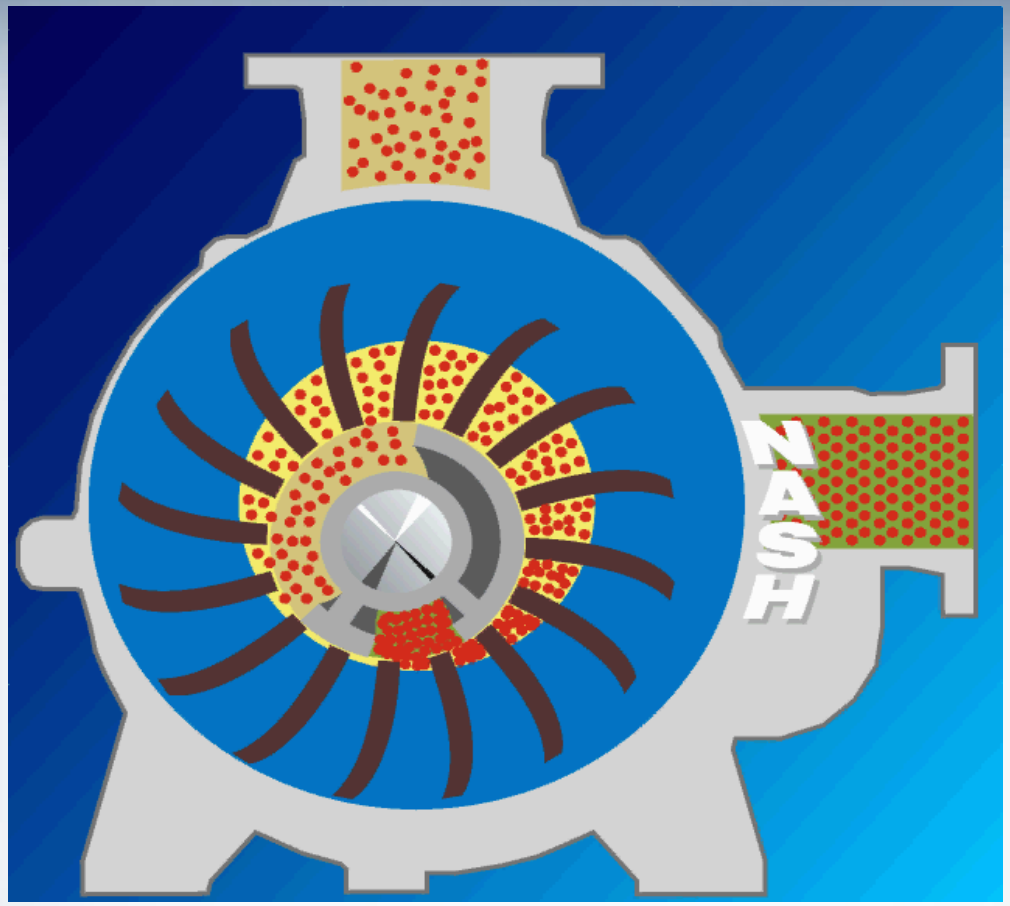


WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

BUT, WE ARE DEALING WITH NEGATIVE PRESSURE AND, MOST OFTEN, LIQUID RING VACUUM PUMPS.

THESE ARE **POSITIVE DISPLACEMENT**, NOT **CENTRIFUGAL** PUMPS.

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?



WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

Liquid ring pumps are thought to have similar operating characteristics to centrifugal pumps because they are rotating machinery. NOT TRUE

For example, their lowest power is at maximum mass flow, and at low pressure (vacuum). This is opposite from centrifugal pumps.

Misunderstandings like this lead to poorly or improperly designed systems and controls. Even if correctly designed and installed, they often are still operated improperly.

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

Vacuum Measurement: Units

- Inches of mercury (“ Hg)
- Millimeters of mercury (mm Hg)
- KiloPascals (kPa)
- Pounds per square in. absolute (psia)
- Inches or feet of water (“ H_2O, ft. H_2O)

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

- Normal atmospheric pressure at sea level = 29.92” HgA = 14.7 psia
- Full vacuum at sea level = 29.92” HgV = 0.0 psia = 0.0 “ HgA
- Common couch vacuum = 20” HgV ≈ 5 psia ≈ 23 ft H_2O ≈ 6.9 m H_2O ≈ - 68 kPa

UNDERSTANDING VACUUM

	"HgV	"HgA	mm Hg	PSIA	PSIG	Ft H_2O
FULL VACUUM	30	0	0	0	-15	34
VACUUM	20	10	252	5	-10	22.6
	10	20	506	10	-5	11.3
ATMOSPHERIC PRESSURE	0	30	760	15	0	0
PRESSURE		40	1012	20	5	

WHY IS THE VACUUM SYSTEM OFTEN MISUNDERSTOOD?

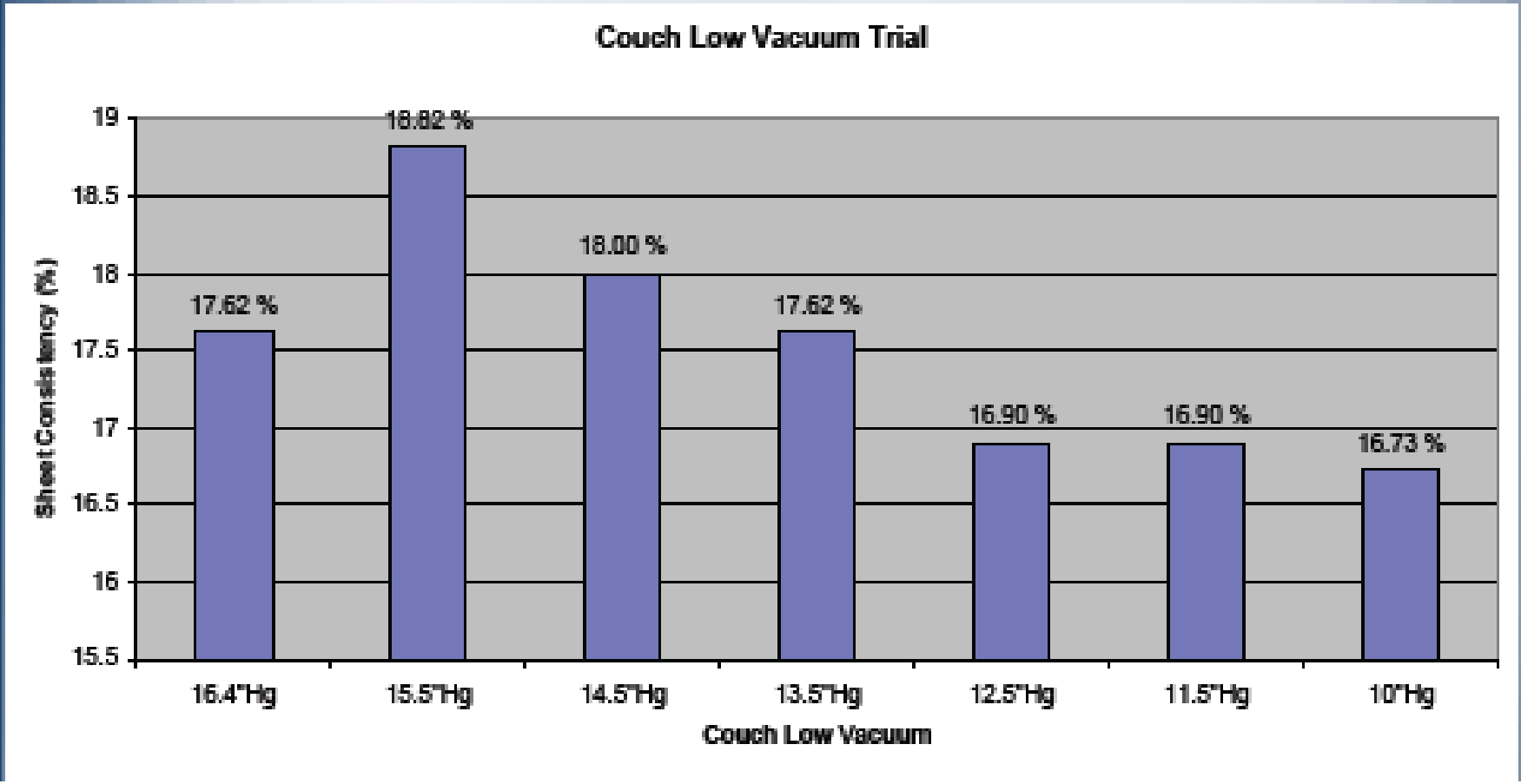
- The typical working range for a paper machine vacuum system is about 2/3 of the total range for negative pressure.
- No one would be concerned with a pressure drop of 5 psi in almost any other fluid flow, but 10” Hg vacuum loss (about equal to 5 psi) can be a troublesome and expensive problem.
- **LET’S TALK ABOUT THE MYTHS…..**

MYTH #1: More vacuum capacity and/or higher vacuum levels are always better

- Of course, this is a paper mill….more of everything is better. Right?
- Not necessarily!
- Just because you have calculated the vacuum factors, and feel you are low on connected vacuum capacity (cfm), don't just jump and add another pump.
- This may have been already done.

MYTH #1: More vacuum capacity and/or higher vacuum levels are always better

For example, here is data from a trial where vacuum is reduced on a low couch vacuum zone and the sheet got drier:



MYTH #2: We can save a lot of money if we don't install a vacuum separator between the uhle boxes and vacuum pumps

- True only in initial capital cost
- No separator often results in larger pipe sizes and complicates piping runs
- Added vacuum pump horsepower due to extra water
- Vacuum pump maintenance is high because of carryover containing felt cleaning chemicals (acid and caustic)

MYTH #2: We can save a lot of money if we don't install a vacuum separator between the uhle boxes and vacuum pumps

Separators can come in all sizes and shapes

MYTH #3: Let's use filtered whitewater for vacuum pump seal water. There is plenty of it and it's essentially free

- Ouch, this can be a bad choice
- Lost efficiency due to relatively hot seal water
- Eventually requires premature rebuild of the vacuum pumps with stainless steel internals
- Sometimes this is the only choice

MYTH #4: Vacuum pump cooling towers are foolproof.

Actually, this can be a true statement, but…

Errors have been made following the fairly common decision to use a cooling tower in a vacuum pump seal water system.

These problems can include:

MYTH #4: Vacuum pump cooling towers are foolproof.

- Poor choice of tower design – film fill (wrong) vs. splash fill (right).
- Poor system design – Whitewater allowed to pass through to the vacuum pumps and contaminate the closed loop seal water system.
- No one owns it – They are usually quite some distance from the paper machine, and some mills pass operating and maintenance responsibility over to the power house or other group. Eventually, someone gets a phone call saying “we don’t have any seal water”, or “it’s too hot”. By then, it’s too late.

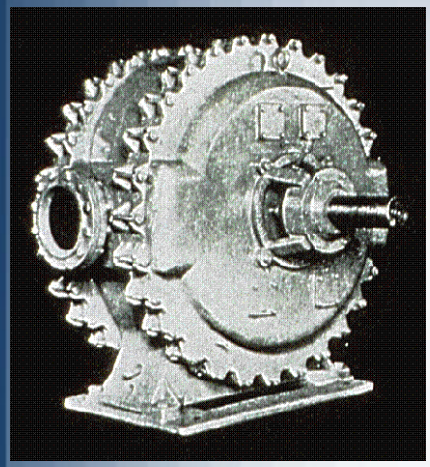
MYTH #5: We keep the valves partly open between the flatboxes, couch and suction press just in case one vacuum pump trips out. Then we don't break the sheet.

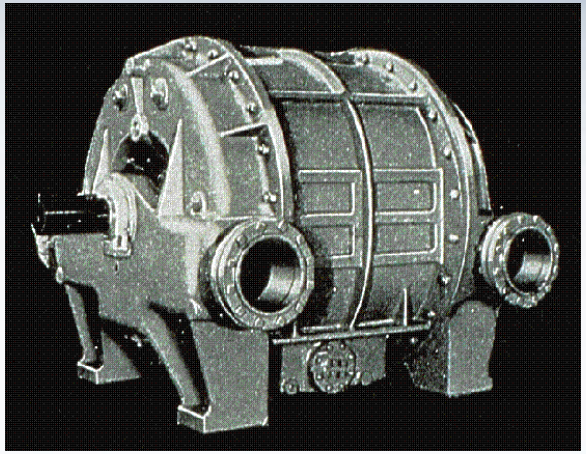
- No one wants to have downtime! Of course!
- But, don't compromise the process 99% of the time for a potential problem occurring occasionally.
- Fix the problem, not the symptom.

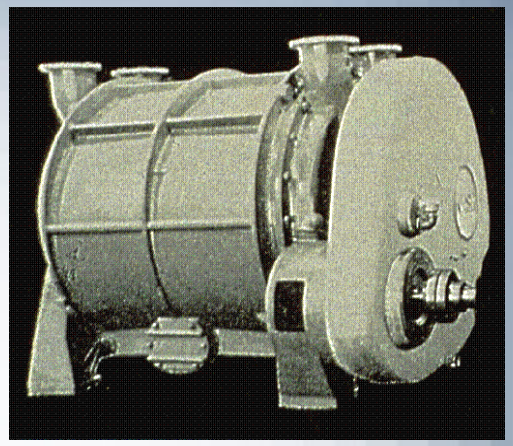
MYTH #6: We keep running those old vacuum pumps because they are just indestructible. They just don't make them like that any more.

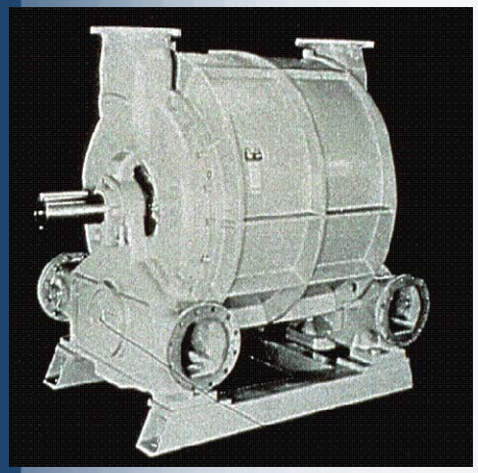
- Tremendous efficiency difference between pumps developed in the 1930s and modern models.
- The CL series seems like the "new" design, because there are so many of them in operation. Several "clones" of these models exist.
- Newest designs developed in the 1980s and 1990s have squeezed out a little more efficiency.
- Seal water reduction up to 60%

MYTH #6: We keep running those old vacuum pumps because they are just indestructible. They just don't make them like that any more.









MYTH #7: TRUE OR FALSE?

You can get the sheet to the reel with a poorly operating vacuum system.

Very true! Vacuum systems are extremely forgiving and can take a lot of abuse. Most of the examples discussed illustrate how screwed up the system can be and still not cause a noticeable problem.

MYTH #7: You can get the sheet to the reel with a poorly operating vacuum system.

The system can still run with:

- Vacuum leaks – big ones.
- Hot seal water – like 130° F.
- Pumps installed in parallel – but with one running backwards.
- Badly worn pumps in parallel – shut one down and vacuum increases.
- The paper machine will be adjusted to compensate for unidentified shortcomings caused by the vacuum system, and it keeps running…<u>although not as well at it potentially could run</u>.

MYTH #8:
There is nothing wrong with our vacuum system.

Please refer to Myth #7……

(You can get the sheet to the reel with a poorly operating vacuum system.)

MYTH #8:
There is nothing wrong with our vacuum system.

Since start-up, what has changed?

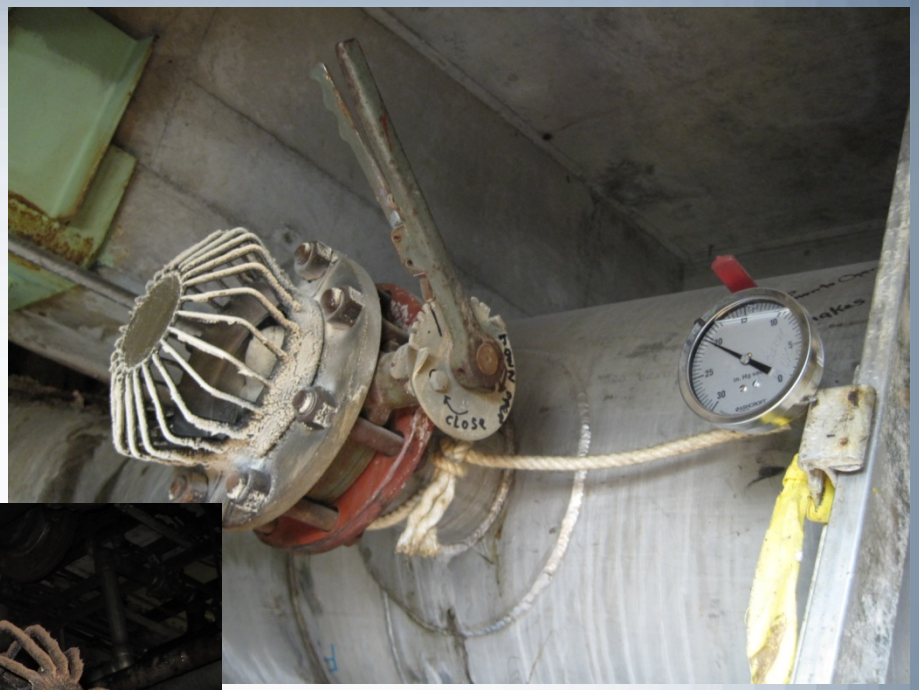
- Furnish
- Chemistry
- Headbox Consistency
- Retention
- Grade Structure
- Forming and Press Fabrics
- And Definitely, PRODUCTION RATES
- …but not the vacuum system!

MYTH #8:
There is nothing wrong with our vacuum system.

- Now consider the older paper machine which has been rebuilt 1, 2, or 3 times and ask what the vacuum system might have looked like with a clean sheet of paper.
- Following a survey of one newly rebuilt machine with a new press, many problems were identified with improper vacuum control and excess vacuum capacity.
- The potential existed to remove 700+ horsepower from the vacuum system through optimization and removing or slowing down some vacuum pumps.

MYTH #8:
There is nothing wrong with our vacuum system.

You are paying for all the air passing through a vacuum inbleed valve.



MYTH #9: We don't graduate our flatbox vacuum because we are at drive load limits for the table.

- Successive flatboxes at almost equal vacuum create more drag load.
- Incremental, additional water removal exists at increasing vacuum levels (beware of Myth #1).
- Whitewater lubricates fabric/flatbox interface.
- If you run with 7 flatboxes, you can run with 5 or 6.
- If you run with 4 flatboxes, you can run with 3.
- Etc…

MYTH #10: We need to add a vacuum pump to the couch, flatboxes, press, or uhle boxes because our vacuum factor is low compared to the TAPPI factors.

- Yes, this is another way of stating Myth #1, <u>but it is important</u>.
- But, THIS IS TAPPI!
- Why is Doug saying this?

TIP 0502-01

OLD NUMBER 014-9
ISSUED – 1963
REVISED – 1980
REVISED – 1992
REVISED – 1998
REVISED – 2002
REVISED – 2007

Paper machine vacuum selection factors

MYTH #10: We need to add a vacuum pump to the couch, flatboxes, press, or uhle boxes because our vacuum factor is low compared to the TAPPI factors.

TIP 0502-01 provides good information and guidelines to establish what a vacuum system might look like if there isn't one already, or to verify what may be operating.

However, if you have an operating paper machine there is an excellent opportunity to determine where dewatering deficiencies exist, <u>and why</u>.

Are you getting drainage studies from your forming fabric supplier? Are you getting grab samples off the couch and press? Has there been a press water balance?

MYTH #10: We need to add a vacuum pump to the couch, flatboxes, press, or uhle boxes because our vacuum factor is low compared to the TAPPI factors.

Example: A well built multi-ply linerboard machine is consistently getting only 20% couch solids. Many would agree this is pretty poor couch solids for linerboard. However, the press is exceptional and exit solids are 48 to 50%. Also, wet end breaks are extremely rare due to no open draws through the press. Unless there is a significant speed increase planned, no changes to the couch vacuum system should be considered.

MYTH #10: We need to add a vacuum pump to the couch, flatboxes, press, or uhle boxes because our vacuum factor is low compared to the TAPPI factors.

A good guide for evaluating sheet solids exiting the former and press is in TAPPI TIP 0404-47, Paper Machine Performance Guidelines. This has values for each grade, with typical ranges and exceptional performance levels.

TIP 0404-47

ISSUED – 1997
REVISED – 2001
REVISED – 2006

Paper machine performance guidelines

A FREEBIE FOR CONFERENCE ATTENDEES!

MYTH #11

ENERGY REDUCTION PROJECTS MAKE SO MUCH SENSE THAT THEY ARE APPROVED AND IMPLEMENTED IMMEDIATELY!

MYTH #11

ENERGY REDUCTION PROJECTS…

What keeps this from happening?

- Top down management needed.
- Who is responsible?
- Need to have a champion!
- Impact if nothing is done – closure?

MYTH #11

Data from studies of 14 paper, board and pulp machines: (don't try to read this)

Wire Width	270	270	330	182	182	262	200	190	360	276	330	265	332	334	--
Gross Metric Tons/Day	384	445	605	650	450	418	700	400	671	317	461	335	432	524	**6792**
Tons/Inch	1.42	1.65	1.83	3.57	2.47	1.60	3.50	2.11	1.86	1.15	1.40	1.26	1.30	1.57	
Installed Vacuum Capacity (CFM)	83,550	95,000	102,930	39,180	33,450	82,620	37,620	30,500	91,980	86,470	72,350	**70,300**	103,400	**113,100**	**1,042,450**
CFM/TPD	218	213	170	60	74	198	54	76	**137**	**273**	157	210	239	216	**153**
Installed Horsepower	**3550**	4250	5400	1950	1900	4235	1950	1600	4500	5150	5100	incomplete	5000	**6000**	**50585**
Installed Power/TPD	9.24	9.55	8.93	3.00	4.22	10.13	2.79	4.00	**6.71**	**16.25**	11.06	#VALUE!	11.57	11.45	**7.45**
Operating Horsepower	3336	3726	4572	1442	1702	3560	1837	1170	3599	3866	3597	**2800**	4567	**5780**	**45554**
Operating Power HP/TPD	8.69	8.37	7.56	2.22	3.78	8.52	2.62	2.93	**5.36**	12.20	7.80	8.36	10.57	**11.03**	**6.71**
Performance Curve Power	3033	3450	4476	1483	1617	3114	1560	1250	3600	**2956**	3269	unknown	4330	**6300**	**40438**
Seal Water Requirement (gpm)	920	920	1140	440	400	561	500	370	0	945	**835**	360	1295	**1840**	**10526**
Seal Water gpm/TPD	2.40	2.07	1.88	0.68	0.89	1.34	0.71	0.93	0.00	2.98	**1.81**	1.07	3.00	**3.51**	**1.55**
CFM/Operating Horsepower	25.0	25.5	22.5	27.2	19.7	23.2	20.5	26.1	**25.6**	22.4	20.1	25.1	22.6	**19.6**	**22.9**
POTENTIAL HORSEPOWER SAVINGS:	497	**50**	**840**	175	250	215	106	188	320	125	395	210	779	600	**4750**
EQUIVALENT KW SAVINGS:	373	**38**	**630**	131	188	161	80	141	240	94	296	158	584	450	**3563**
PERCENTAGE OF OPER. POWER:	15%	**1%**	**18%**	12%	15%	6%	6%	16%	9%	3%	11%	8%	17%	10%	**10%**
OPTIMIZED POWER:	2963	3689	3942	1311	1515	3399	1758	1029	3359	3772	3301	**2643**	3983	**5330**	**41992**
OPTIMIZED POWER/TPD:	7.72	8.29	6.52	2.02	3.37	8.13	2.51	2.57	**5.01**	11.90	7.16	7.89	9.22	**10.17**	

MYTH #11

Installed Vacuum Capacity (CFM)	**1,042,450**
CFM/TPD	**153**
Installed Horsepower	**50585**
Installed Power/TPD	**7.45**
Operating Horsepower	**45554**
Operating Power HP/TPD	**6.71**
Performance Curve Power	**40438**
Seal Water Requirement (gpm)	**10526**
Seal Water gpm/TPD	**1.55**
CFM/Operating Horsepower	**22.9**
POTENTIAL HORSEPOWER SAVINGS:	**4750**
EQUIVALENT KW SAVINGS:	**3563**
PERCENTAGE OF OPER. POWER:	**10%**
OPTIMIZED POWER:	**41992**

1,042,000 cfm

50,585 hp installed

45,554 operating hp

4750 hp potential savings

…or 3.56 MW!

CONCLUSION AND CHALLENGE

- Any process can be improved
- All vacuum systems can be optimized
- The “fix(es)” is/are usually inexpensive

- Add “VACUUM SYSTEM STUDY” to your office white board