Optimization of Wire Vacuum

Abstract:
Very often we find it a topic of debate what should be the adequate vacuum for wire part. Papermaker needs his demands of web dryness after the wire part are met without any problem, mill manager needs it should be done at optimum electricity consumption and the management wants to ensure that all sources of improving economy –be energy conservation or productivity improvement- are fully utilized. But, the problem remains how to optimize vacuum on wire part. Present work is a summary of guidelines in this area.

Key points to remember:

Before proceeding further, we should have a quick review of what we already know.

- Furnish plays an important role and target should never be to achieve the same dryness in one furnish on the basis of what we are getting with other furnish.
- When we increase the vacuum, the dryness increases, but the gains reduce with increasing vacuum levels and entering web dryness.
- When we increase the suction box width or open area (dwell time), the web dryness increases, but the increase in dryness (gains) reduce with increasing dwell time and entering web dryness.
- Web dryness is also a function of basis weight. It increases with increase in basis weight, (18-60gsm) and then reduces slowly with increases in basis weight. There also exists a limiting value for different basis weights and furnish only upto which we may try to get dryness.
- With increase in vacuum or open area, the air flow increases.
- Air flow also increases with increase in web dryness.
- In the suction boxes of wire part, the vacuum must be in increasing order.

How Can I Reduce Energy Required for Vacuum Without Affecting Dryness?
All points above indicate that after a particular point, the gains diminish to almost negligible. But, more and more energy is required after reaching that critical dryness level. If we are able to find out that point, we may trim that part of unnecessary power and save energy. A few more points to recall based on above fundamentals-

- Typically, last dry suction box is operated with very high vacuum levels. Furthermore, the web dryness is maximum in the same. Hence, maximum air flow or vacuum pump capacity (typically 75-85%) is utilized in this box.

- In the wire part, normally, vacuum levels of a maximum of 7” Hg (175mmHg) are more than enough.

On the basis of above two points, we may conclude-

- We should concentrate more on last suction box to achieve maximum dryness with reduced air flow.

- For such low levels, water ring vacuum pumps are really unnecessary. Use of centrifugal blowers, side channel blowers, twin/three lobe blowers must be considered for the same. However, a water ring vacuum pump may be considered for last suction box if really necessary.

In-Plant Experimentation:
Before we proceed further, some experimental work is necessary within your plant. Initially, ensure that the suction boxes are running in increasing order of vacuum. Obviously, the highest possible vacuum will be in the last suction box. Now, the previous box must have 60-70% of gauge vacuum compared to this. For example, if the maximum vacuum is 150mmHg, and there are 6 suction boxes, the vacuum in reverse order will be as under-

Reduction Factor	Box 6	Box 5	Box 4	Box 3	Box 2	Box 1
60%	150	90	54	32	19	11mmHg
70%	150	105	73	51	35	24mmHg

These figures are not in exact binding. Minor higher or lower values may also be used. But, these give an initial starting point. Quite often, you will observe an increase in last box vacuum level after doing this. If you check web dryness after the last suction box, that too could be slightly higher.

Note down the dryness achieved after each suction box. You may observe that the dryness increase across last box is very low. This means we have already achieved desired moisture in earlier box itself, and the last suction box is not very much required. Consider using a lower open area suction box in place of existing one particularly in last suction box.

The second phase of experimentation requires some basic instrumentation also. The vacuum pump supplying vacuum to wire part should be equipped with a VFD, tuned to give same gauge vacuum after sensing gauge vacuum level through a vacuum gauge installed in the suction of vacuum. Now, note down dryness readings after each suction box. During the next shut, reduce open area of last suction box by plugging half of the slots using wooden strips. Note down the observations while the machine is restarted. Most likely you are going to get the same dryness, but at reduced vacuum pump rpm and vacuum pump power consumption.

Optimization of Dwell Time:
As indicated above, the main emphasis is on reduction in dwell time (open area). One may rightfully ask- “What are the limitations of dwell time?” Ideally, 10-15ms is sufficient for most furnishes in the basis weight range of 50-100gsm. In case of lower basis weights, even a reduction may be considered. Those using a bagalley box, must recall that typically a dwell time of 2-3ms is enough to get good results.

Different data and graphs are given at the end of the article. As clear from the data given, a dwell time of 20ms is sufficient for 48gsm newsprint. For a newsprint machine running at 600mpm, this means an equivalent of 4 suction boxes each with 5 slots of say 10mm width. Now suppose, you are having say 50ms dwell time, you may be having a potential of saving almost 50% or so power given to your vacuum pump.

Sequentially reducing swell time is also useful. If you study the different graphs, you would observe that the increase in web solids is steeper in case of higher vacuum levels. Furthermore, as more and more air passes through the dryer web, we should try to operate initial suction boxes operating at lower vacuum levels with relatively higher dwell time, and the last stage boxes with higher vacuum levels the least dwell time.

In case you are making paper of higher gsm, you need higher dwell time as well as higher vacuum levels. But, as the porosity of higher basis weight sheet will be lower, you may not necessarily need increased size of vacuum pump.

Installation of Twin-Tri Lobe Blower:
Installation of twin lobe or tri-lobe blower can be used effectively for wire part vacuum requirements. Yet, there are several misconceptions about using these. Some of these are being discussed here.

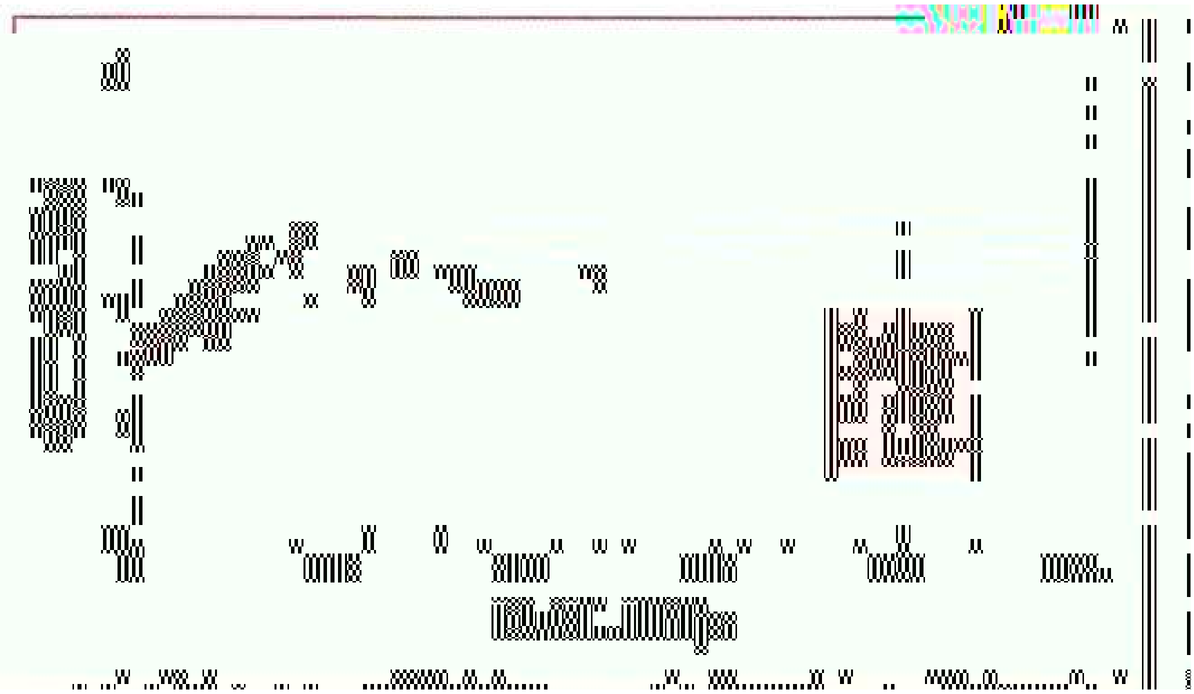
Pulsation is the biggest problem with such blowers. In fact, as the rotational speed is low coupled with lesser number of vanes (technically, lobes), pulsation will be there. However, this problem can be solved by having a longer pipeline with inline pulsation dampener. Tri lobe blower gives lesser pulsations and should be given a preference over twin lobe one.

Water logging is another major problem. Since these blowers work under oil filled environment, water carryover to blowers may result a damage or even complete break down of blowers. Installation of water separator is a must. Still, these blowers must be installed at adequate elevation to avoid water carryover to them. Furthermore, an undersized pipeline may also result in water entrainment and hence carryover of water to blower. Proper designing of blower piping is a must to solve such problems.

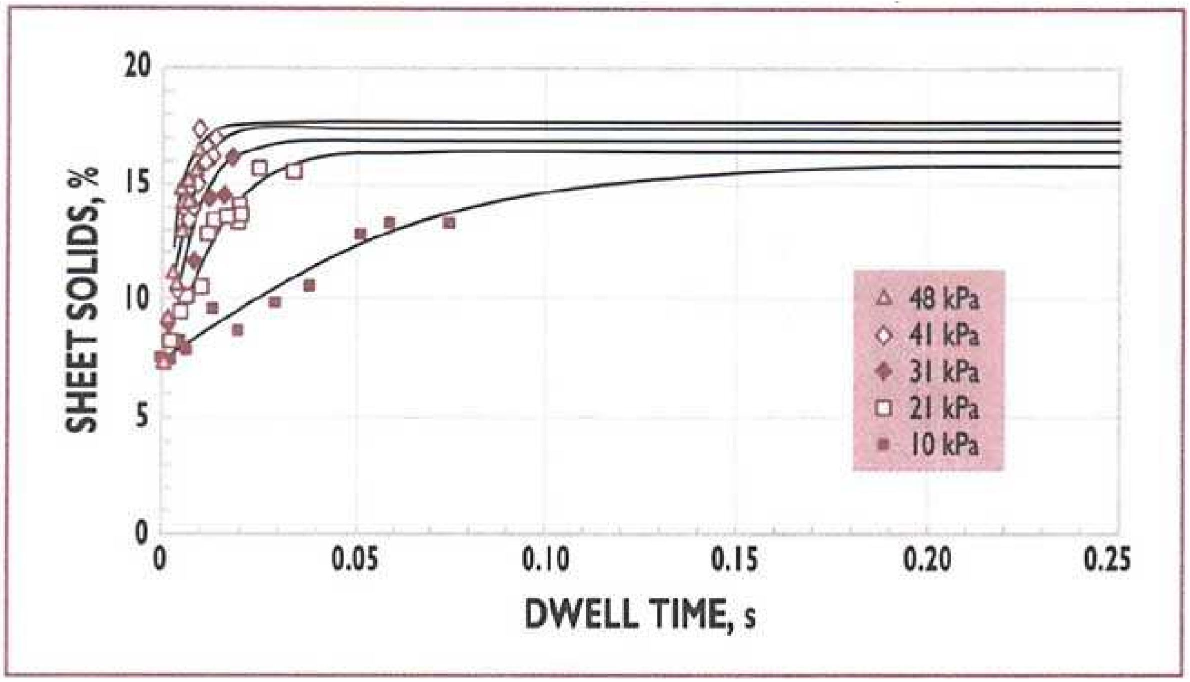
Useful Articles:

- John A Neun, “Performance of high vacuum dewatering elements in the forming section”, TAPPI, 77(9): 133 (Sept. 1994)
- Xiao Zhang, “The Dynamic Compressibility of Fibre Sheet during Suction Pulse with a Laboratory Suction Box”, TRITA-LWR Master Thesis, Royal Institute of Technology (KTH), Stockholm, 2006
- John A Neun, “High vacuum dewatering of newsprint”, TAPPI 79(9): 153 (Sept. 1996)

Some Findings by the Experts:

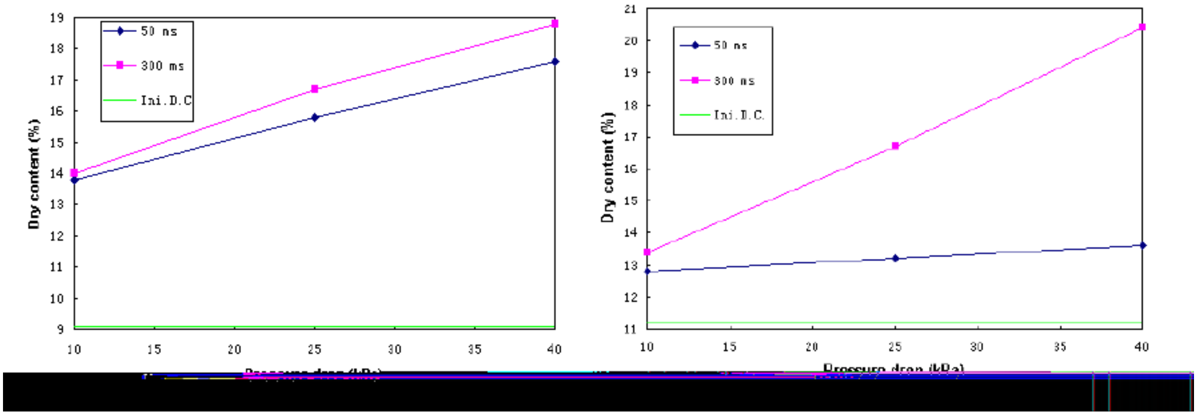


For 127gsm sheet

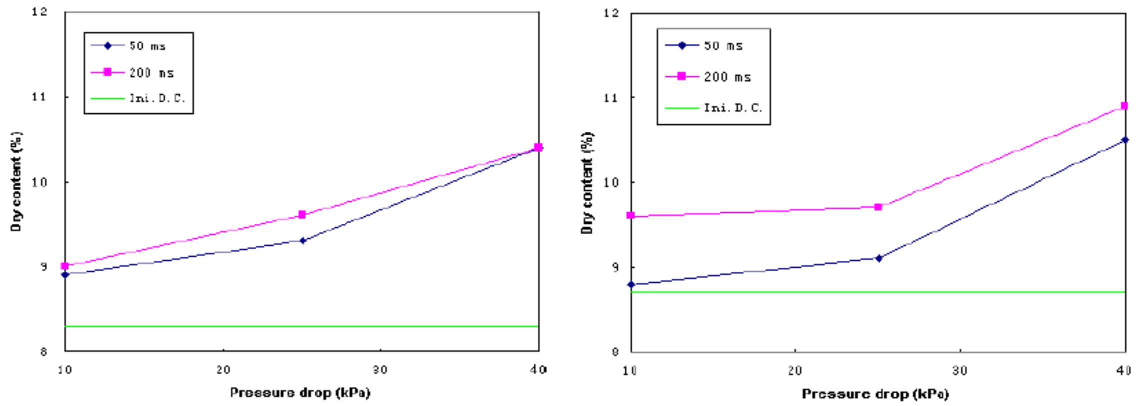


For 48gsm newsprint

Data from experimental work, 127gsm, chemical pulp



Chemical pulp; left graph: 132gsm, right graph: 281gsm
(Higher gsm sheet requires higher vacuum and dwell time)



Mechanical pulp; left graph: 52gsm, right graph: 122gsm
(Higher dwell time is not very much useful in lower basis weight)

Grammage (g/m^2)	Suction time (ms)	Pressure Level (kPa)	Average initial dry content (%)	Final dry content (%)
53	50	10	8.3	8.9
52	50	25	8.3	9.3
50	50	40	8.3	10.4
57	200	10	8.3	9.0
52	200	25	8.3	9.6
50	200	40	8.3	10.4
121	50	10	8.7	8.5
118	50	25	8.7	9.2
120	50	40	8.7	10.5
136	200	10	8.7	9.7
120	200	25	8.7	9.7
120	200	40	8.7	11.3

Data for Mechanical pulp
(Data shows that in case of lower basis weight, there is no or very little gains achieved by increasing dwell time. On the other hand, gains are significant.)

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