Rethinking Barometric Legs

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Barometric Legs

- Barometric legs are long neglected specially for paper machine wet end vacuum systems.
- There are many mills using these since long, still, improper designs have led to poor functioning, and hence, operational problems.
What Papermakers Want?

- Essentially, a papermaker wishes to get maximum web dryness with minimum vacuum, least drag load and good control over the entire operation.
- Yet, paper machine operators adjusting vacuum levels, valves to reach the desired level; are common for many machines.
Wire Vacuum Control

- Wire vacuum control is a complex, difficult and annoying process.
- When you alter gauge vacuum level in a suction box, this results in changes in outlet web dryness and hence airflow in all subsequent suction boxes.
Airflow

- The sum of airflow through the individual suction boxes is what the vacuum pump is supposed to handle.
- But, with change in airflow, the gauge vacuum reading changes again.
- Thus, we need to make different alterations.
Vacuum Pump

- Vacuum level depends upon the total amount of air flow through the vacuum pump.
- Any alteration in a particular suction box alters the total airflow and hence vacuum level in other suction boxes.
Machines in Developing World

- Most of the paper machines in developing world are assigned for many different grades, raw materials, and basis weight range.
- Vacuum level settings for one grade may or may not work for other grades.
Designing Barometric Legs

- The trouble with barometric leg design is its simplicity.
- Barometric legs allow a significant flexibility from the design parameters.
- Often, it is considered a too simple job, and the barometric leg dimensions are just copied from other installations rather than proper designing.
Thinking Outside the Box

- This shows the need to think beyond the conventional barometric legs, and explore possibilities to have a better vacuum control with these.
- Let’s have a quick look with the problems encountered.
Non-Linear Vacuum

- Quite often we face a problem that the dewatering rate is too high from a particular box even if the vacuum valve opening is slightly increased.
- If you close the valve slightly again, the drainage (almost) ceases.
- This finally results in more vacuum in a particular suction box than actually desired.
Larger Seal Pits

- Seal pits are designed on the basis of barometric leg volume. The more is the volume of seal pit, the more will be the retention time in this and hence the possibility for slime generation.
Ideas to Improve Design

• The first major problem is related to control.

• If you evaluate on the basis of operational data you will find that the initial suction box handles much more water compared to the last one.

• For air, the situation is reversed.
Conventional Barometric Legs

- Conventionally, many mills have installed barometric legs of almost the same design and size.
- This generally results in too overdesigned barometric legs, particularly in the last section.
- The concept indicates we MUST use two or three different designs for better control.
There is nothing new. Only, we must design each leg separately.

The idea is to use three/four different barometric leg types; with larger, medium and smaller leg water line size.

Each leg must be adequate and fully capable of handling the desired flow.
Dewatering Control

- We can use flow control valves to restrict flow rate.
- But, the problem is that if drainage is more at a particular vacuum, and we restrict water flow, after some time, the water level will reach nearly at same level as the box, and hammering will start.
- That is why, good airflow control valve is a must to get desired vacuum.
Dewatering Control

- In the initial suction boxes, even a minor change in gauge vacuum level results in significant variations in dewatering rates.
- This means we need better vacuum control in these boxes.
Vacuum => Dewatering

- In the initial suction boxes, web is less dry, hence, airflow will be less. Furthermore, we need lesser vacuum level. Thus the airflow would be very low.
- As the dewatering is too sensitive to applied vacuum in the initial sections, oversized valves are the main reason of problems.
Smaller Valves!

- Yes! In the initial suction boxes, the size of valve should be very small. Furthermore, as these boxes are too sensitive, we need fine control valves like V-notch ball valves or even the needle valves.
- But, in the later sections, air valves are of higher sizes, while the water pipe (bottom side) is of much smaller diameter.
Valve Size

- A simple technique to check if the valve size is higher than the desired one is to check if the valve opening is too little.
- If this is the case, replace the valve with a lower size one.
- Typically, if the valve opening is between 25%-75%, the valve is suitable.
- Refer to sample calculations on the next slide for an insight of designing process in brief.
Typical figures

<table>
<thead>
<tr>
<th></th>
<th>box 1</th>
<th>box 2</th>
<th>box 3</th>
<th>box 4</th>
<th>box 5</th>
<th>box 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cy. At start of dry suction box</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Cy. At end of dry suction box</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Water removed from box</td>
<td>16667</td>
<td>5556</td>
<td>2778</td>
<td>1667</td>
<td>1111</td>
<td>556</td>
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<tr>
<td>Water Pipe size @2.4m/s flow</td>
<td>3.7</td>
<td>1.2</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Typical Airflow Rate</td>
<td>0.2</td>
<td>0.7</td>
<td>1.7</td>
<td>3.4</td>
<td>6.2</td>
<td>10.0</td>
</tr>
<tr>
<td>Vacuum Valve Size @50mps</td>
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<td>0.7</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>

- Water removed is nearly 30 times more in first box compared to sixth.
- Airflow is 50 times more in last box compared to first.
Initial Suction Boxes

• A minor change in initial suction box vacuum level can result in a significant change in dewatering rate in these boxes.
• For a better control on dewatering, one needs to give more attention to vacuum levels.
• Valves like needle valves, or even better V-notch valves can be considered for such applications.
Finishing Suction Boxes

- Here, an excess vacuum level does not yield in proportionate savings in dewatering.
- Thus after a limit, benefits of additional vacuum diminish. However, the drag load on wire keeps on increasing with applied vacuum.
- That means- more drive power, more wire wear (poor wire life), and more wear of suction box tops.
Finishing Suction Boxes

- That is why a good vacuum control of these is important.
- A good control should include a set point based methodology, where the valve opening is automatically adjusted to ensure desired vacuum level.
Future Scope

- After having an individual barometric leg vacuum control, a future modification of having a “TOTAL WET END VACUUM CONTROL” system.
- This system would be a PLC based system to control the followings-
  - Vacuum level in individual boxes
  - Header vacuum level
  - Vacuum pump speed through a VFD
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