Paper Machine Vacuum System: Problems and Solutions

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ABSTRACT

Most Paper Machines employ Liquid Ring Vacuum Pumps, which are low speed maintenance friendly machines. While the liquid ring vacuum itself does not require a great deal of attention, the Paper Machine Vacuum System being the heart of the machine need to be kept in good health to keep the machine running smoothly and efficiently. The present paper deals with the common problems encountered in the Paper Machine Vacuum System and gives the practical tips to identify the problems in timely manner and provides simple practical solutions. The vacuum system problems addressed in this paper include:

- Low Vacuum Levels
- High Motor Load & Motor Tripping
- Hot Pump Operation
- Noisy Pump Operation

INTRODUCTION

Low vacuum levels are one of the most common problems experienced on a paper machine.

Sources of vacuum problems can be the piping or separation problems, excessive air in-leakage, undersized vacuum pumps, or problems with the vacuum pump itself. Some times low vacuum levels may not be problems at but just an indication in the change in process condition such as change of basis weight or change of felt (Low basis weight or new felt will result in low vacuum) Very often, the problem is with the system but vacuum pump often gets changed out, only to discover later that the problem still exists. In order to solve low vacuum problem it is important to gather the correct data and observe the system carefully before deciding to change the pump. Probable causes of low vacuum and solutions are given below:

1. **Restrictions in the Inlet Piping**: in the inlet piping including closed or partially closed valves, objects in the line, plugged inlet screens, etc. cause a pressure drop that gives low vacuum at your system and a higher vacuum at the pump. This can be easily determined by putting a vacuum gauge at the inlet of vacuum pump and at vacuum service point. In a well designed piping the vacuum loss between vacuum pump inlet and service point shall not exceed 25 mm Hg.

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2. **System Leakages**: Leakages from the system that can include opened drain valves, blown gaskets, loose flanges, poorly packed valves, inadequate barometric drop legs on separators, broken pipes, etc will result in lower vacuum levels. Most of these leakages can be identified by hearing the noise caused by sucking of air or careful observation but the leakages from interconnecting piping are most difficult to identify and hence piping shall be kept as simple as possible.

3. **Seal Water Flow**: Inadequate or Excessive seal water flow will adversely affect vacuum.

4. **Seal Water Temperature:** High sealing water temperature adversely affects the capacity of the pump and this in turn may case the drop in vacuum level. It is better to use as cool water as possible. Higher the vacuum level, the more important it is to have cool water in sufficient quantities.

5. **Vacuum Surges**: Intermittent vacuum surges are often caused by carryover from separators, or from low points in the line that accumulate water that burp over periodically into the pump. It is important to have good pre-separation and vacuum pipe containing liquid must run down ward.

6. **Low Pump Speed**: Low pump speed will result in reduced capacity and consequently the low vacuum. Check the speed with tachometer and make correction in motor or belt drive.

7. **Plugged Inlet Screens:** The screens tend to blind over a period of time with felt hairs, fibers and old lunch sacks etc. Plugged screens then act as a throttling valve at the vacuum pump inlet and causes a high vacuum reading at the pump and a low vacuum reading at the process. Inlet screens should be removed after initial start up or should be kept clean. It is important to locate the pump vacuum gauge directly into the vacuum pump inlet, below the screen, since there is usually a tapped connection at that point. This allows you to observe any increase in the vacuum at the pump compared to the level at the vacuum service on the paper machine.

8. **Capacity Erosion:** Pump looses the capacity due to normal wear and tear. 1% drop in capacity per year is quite normal. Low capacity will result in lower vacuum levels and in case capacity drop beyond 10%, it is perhaps right time to go for major overhaul or change the pump in worst-case scenario. However it advised to check for all possible reasons before changing the pump.

HIGH MOTOR LOAD AND MOTOR TRIPPING

Causes of high horsepower can be varied such as change in operating conditions/vacuum levels, water loading, high pump speed, high back pressure and internal scale build up etc. Sometimes, there is not real problem at all, but merely a perceived problem. Comparing actual data with performance curves is the best starting point. If the measured pump power exceeds the pump power given in the curve then it becomes necessary to search for real cause and make desired correction. Simple measurements like pump speed, motor load, vacuum levels, and pressure in discharge line help to determine the real cause. The following section discusses the most common causes of high motor loading and suggests the remedies:

1. **Operating Conditions:** It is important to check if the pump is running at the selected vacuum levels. Change in operating conditions such as change in basis weight or clogging of suction points may cause increase in the vacuum levels. Restrictions in the inlet piping also cause higher vacuum level at vacuum pump inlet. Higher vacuum levels usually but not always require higher pump power and may result in higher load on the motor. Make sure that the selected drive motor allows the pump to operate the pump covering full range of anticipated vacuum levels or it would be desired to have vacuum relief valve to save the motor from tripping in the event of high vacuum surges.

2. **Pump Speed:** Check if the actual pump speed is the same as what was originally intended for the installation. Ratios of drive pulleys and gear reducers should be compared to the actual output speed or driven speed. An increase in pump speed will result into corresponding increase in pump power.

3. **Water Overloading**: Severe water loading is another common reason for high horsepower. This can come from excess seal water or carry over from the paper machine vacuum service (couch, uhle box, etc.) A liquid ring vacuum pump has a specific rating for seal water flow. Increasing the flow by 25% or 50% does not typically cause a power problem. However excessive water in the order of two to three times the rated flow caused motors to overload, or belt drives to fail. Also, sudden slugs of water are problematic. These can be intermittent, causing difficult troubleshooting.

   High seal water flows are caused by several reasons, including high seal water pressure, lack of orifice and worn spray nozzles (if the pump has them) or all of the above. Typical seal water pressure is 10psig to 15psig.

   Excessive carryovers from the paper machine are usually detectable and can be resolved. The easiest way to detect carryover is to look at the water discharging from the suspected vacuum pump, if the flow is visible. Cloudy water discharging from the vacuum pump using clear seal water is a good sign of carryover. This problem can be solved by installing effective pre-separators between the vacuum services (Flat Boxes, Felt Uhle Boxes and Couch Roll) where carryovers are expected and the vacuum pumps.

   Sometimes, the carryover problem comes as slugs due to pockets in the vacuum piping. This causes intermittent slipping of the belts that drive the vacuum pumps and fluctuating load that can be at the drive motor. Solution to this problem lies in removing the pockets from the piping and/or adding separation equipment.

4. **Back Pressure:** Backpressure occurs when the vacuum pump is operating with a discharge pressure of greater than 1psig and this causes additional load on the drive motor. Well-designed vacuum systems operate with a discharge pressure of less than 0.5psig. This is the most common problem in older vacuum system that may have added additional vacuum pumps without modifying the discharge system and piping. The additional vacuum pump will push more air through undersized piping, causing additional friction and resulting backpressure on the vacuum pumps.

   A second cause of backpressure occurs when the seal water leaving the pump is not removed from the discharge separator or vacuum pump sump at the same rate it entered. The discharge separator should be checked for free flow to an open drain. Systems with a discharge sump must have the water level in the sump regulated to hold it at proper levels. The first indication of high water levels in a sump or plugged water outlets in a discharge separator is water blowing out the exhaust stack.

5. **Internal Scale Buildup**: Internal buildup within the pump is another cause of pump overloading. This can be from lack of pre-separation or from calcium carbonate scale deposits. These deposits usually occur on the pump rotor and within the discharge ports. This buildup causes internal backpressure and does not allow seal water and air to exit freely. Many times, the scale and buildup can be removed with a de-scaler while the pump is shut down. Also, in the event of hard water, a chemical dispersant can be added to the seal water to keep the calcium carbonate in solution.

HOT PUMP OPERATION

A liquid ring vacuum pump operating at 55 deg C and above may be an indication of a problem, although the operating temperature does not necessarily damage the pump. The vacuum pump usually operates at a temperature of about 10 to 15 deg C higher than the temperature of the seal water flowing to the pump. The following lines give the cause and cure of hot pump operation problem.

1. Insufficient or hot seal water supply is the problem in most causes of high temperature of the pump. Low flows can be caused by plugged orifices or spray nozzles and/or low seal water feed pressure. Make sure that the seal water flow is not interrupted due to closed valves, plugged lines or plugged orifices.

2. High pump operating temperatures may also occur with proper seal water flows in case the pump is operating at hot vacuum service such as vacuum box beneath steam box. In these instances, the elevated pump

temperature is normal. However correct seal water flow is very important for hot vacuum services.

NOISY PUMP OPERATION

Noisy pump operation can be caused by a number of things. If there is a noisy pump, it is particularly important to identify the type of noise and whether it is continual or intermittent. While some noises are of minimal concern but others call for immediate action. If the pump has swallowed a hard object or has broken a rotor blade, it might damage the pump if the object becomes lodged between the rotor and the body. The type of noise can diagnose the problem. To solve a noise problem, first gather some information such as motor load, seal water temperature and flow, frequency of noise (continuous or intermittent) and also observe the pump if it is noisy at start up or at low or high vacuum. Also observe the carry over. These observations will help identify the possible causes that are described below:

1. **Foreign Objects:** If hard object gets into pump it will cause erratic noise and vibration. This is very serious problem and need immediate attention. Shut down the pump as soon as possible and remove object. Inspect pump internals for damage and repair if required. Install ¼" mesh stainless screens on pump inlet to prevent reoccurrence.

2. **Water Overloading:** Sever overloading of water may cause groaning or hydraulic noise. Verify correct total seal water flow and ensure that seal line pressure, orifices, spray nozzles, etc., are providing the correct flow. Excess carry over from the process is another cause of hydraulic noise that can be solved by installing proper separation equipment.

3. **Cavitation:** Noise due to cavitation sounds like marbles in the pump. If noise reduces or goes away by bleeding extra air into pump inlet, then sound is most likely from cavitation taking place inside the pump. Look for inlet restrictions, plugged inlet screens, closed or partially closed valves on inlet line that cause the pump to operate at higher than normal vacuum and if so make necessary correction. Ensure the adequate flow of seal water. Inadequate water flow can cause hot operation and invite cavitation.

4. **Misalignment:** Misalignment of belt drive/gear drive can cause noise. Also poorly mounted pump results in vibration that in turn cause noise.

PUMP VIBRATION

Vibration in liquid ring vacuum pumps is an occasional problem and it is important to understand the causes in order to avoid replacing a good pump. This section will not go into details vibration due to bearings but will focus on most common causes that are easy to recognize:

1. **Excess Seal Water:** High seal water flows of two to three times the standard rating can cause a vibration or internal "knocking" within the pump, which may sound like a hammer bouncing around within the pump. This high seal water flow may also show up as high horsepower, as already discussed.

2. **Misalignment/Poor Piping Support:** Misalignment of pump foundation and poorly supported vacuum piping will cause vibration. Proper alignment and piping alignment is necessary to avoid vibration. Flexible hoses/bellows at the pump inlet help isolate the pump from vibration due to the system piping.

3. **Internal Scale Buildup:** Pump vibration occurring at the rotation frequency may be due to scale buildup on the rotor. While normal pump wear may be uniform, and not heavily contributing to vibration, the buildup and removal of scale (calcium carbonate) is not so uniform. In mills with hard water, there are routine descaling procedures that can sometimes leave scale deposits attached to areas of the rotor. These deposits can cause the rotor to be unbalanced and will show up as vibration.

4. **Blind Suction/Lack of Airflow:** A liquid ring vacuum pump operates with the development of a liquid ring due to centrifugal force of the spinning rotor. During startup, this ring of water develops as long as the vacuum pump has a free flow of air from the process. If the pump does not get a good airflow due to restriction in line or closed valve, it may not develop the liquid ring fully. This will not allow the pump to operate at typical vacuum levels and may even show up pulses in the indicated vacuum level. The pump will vibrate slightly, or in some instances, it may shake enough to crack a concrete foundation. There may even be a random knocking sound coming from within the pumps. The problem shows up just after the pump has been started and not after it has been operational for hours or days. The solution to the stalling problem is to start the vacuum pumps with all vacuum system valves open.

CONCLUSION

Paper Machine Vacuum System with Liquid Ring Vacuum Pumps is a reliable system but do encounter problems that need attention. Most of the problems can be either prevented or taken care in house at mill site without outside expert help. Practical tips given in this article can be used as a quick reference guide for solving common problems of Paper Machine Vacuum System.