Older Deculator stock deaeration systems are still in use at many mills, but proper diagnostic techniques are critical to their capability for providing good formation and quality benefits

Proper Diagnostic Methods Help Accurately Pinpoint Problems in Stock Deaeration Systems

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In today's business environment, it is essential to find opportunities for reducing operational costs and improving quality.The paper machine approach system provides such opportunities in its stock deaeration and stock cleaning systems. Often, changes are introduced to headbox flows and consistencies, but performance of deaeration and cleaning systems is ignored. However, air and entrained gasses can be very detrimental to paper formation.

This article discusses the components of stock deaeration and traces the history of the trademarked Deculator stock deaeration process. This discussion is important, since many of these 20- to 40+ -year-old systems are still in operation and are critical to paper machine efficiency.

However, older Deculator systems may no longer be providing all of their original benefits to the papermaking process. Therefore, this article offers methods for pinpointing and correcting poor deaeration performance, as well as ways to correct problems associated with stock cleaning systems.

A PHYSICO-MECHANICAL PROCESS. Stock deaeration has been described as a physico-mechanical process, meaning it relies upon both mechanical and physical means to accomplish its objective.Three components make up the stock deaeration process: boiling, spraying, and impinging.

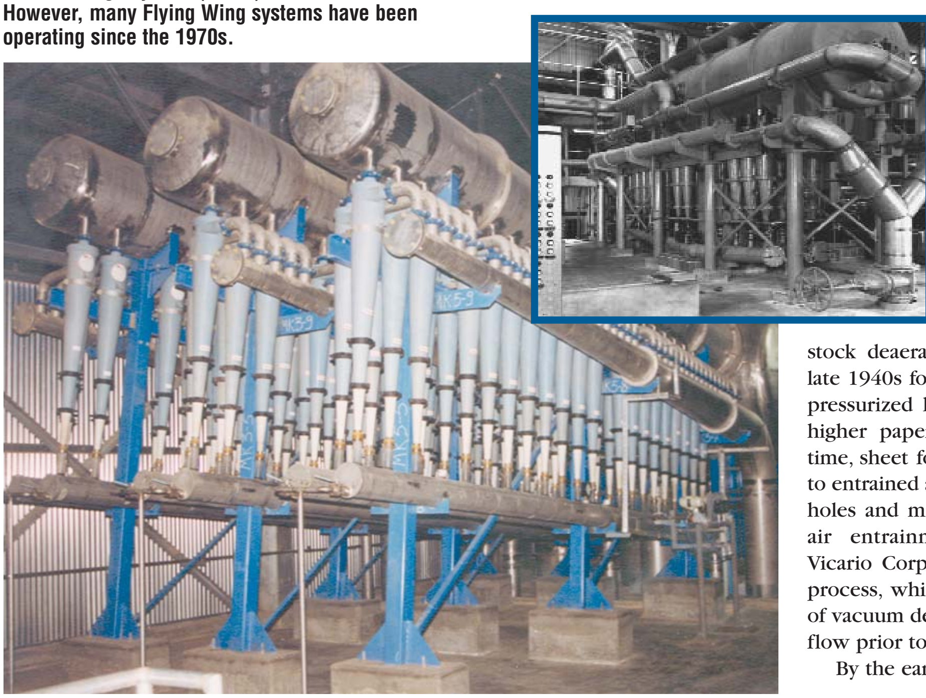
Boiling is achieved through the introduction of stock flow into a vessel under vacuum. The level of vacuum must be very close to the "boiling point" of the stock at its typical operating temperature. A this temperature, the vacuum level is within a few tenths of an inch of mercury (in. Hg) of the vapor pressure (or boiling point) of water. Such high vacuum levels are necessary for removal of dissolved gasses from the stock.

The component of *spraying* means the stock must be somewhat atomized to create significant surface area for the fiber and water mixture in order to provide adequate exposure to vacuum. This requires the stock to spray through several nozzles within the deaeration vessel. Improved spraying requires a tangential feed on each nozzle to produce a "spin" to the flow.The stock will quickly spread out within the vessel as it exits the nozzle, creating maximum surface area.

The third deaeration component is *impingement* of the stock against the interior surface of the deaeration vessel.This is a mechanical process that provides the energy to overcome surface tension between small air bubbles and fibers.

DECULATOR HISTORY. Development of the stock deaeration process began in the late 1940s following introduction of the pressurized headbox and the quest for higher paper machine speeds. At that time, sheet formation was impaired due to entrained air bubbles that created pinholes and microflocculation. To address air entrainment problems, Clark & Vicario Corp. introduced the Deculator process, which embraced the principle of vacuum deaeration of the entire stock flow prior to the headbox.

By the early 1950s, the Deculator was



Located on an upper mezzanine, this Flying Wing system is considered a modern Deculator design compared with the 1950s-vintage system (insert) found on the machine floor. However, many Flying Wing systems have been operating since the 1970s.

proven in its ability to remove air from stock. Stock cleaners had also been added to the Deculator system, combining two processes with mutual enhancements.

With the combination design, spraying within the vessel was accomplished with the centrifugal cleaner attached to the nozzle, or accepts pipe, exiting inside the vacuum vessel. Also, stock cleaners had improved characteristics when operated under vacuum. Primarily, they could utilize a much larger rejects orifice with equal rejects rates of cleaners under atmospheric or pressurized conditions. The results were much less plugging of the reject tips and more reliable cleaning efficiencies.

During the following decades, the Deculator underwent several enhancements, including adding the overflow weir, providing a stable pressure to feed the secondary fan pump, and elevating the Deculator to overcome the influence of vacuum on the fan pump. Various configurations of the process also evolved, including the Flying Wing and Space Saver Deculator-Cleaner systems.

In 1990, the Deculator process was acquired by Ahlstrom and was marketed with other stock approach equipment provided by Ahlstrom. Some changes were made to the process and equipment, but the basic deaeration components remained intact.

FOREMOST PRINCIPLE: 100% AIR REMOVAL. Throughout the history of the Deculator process, one principle has remained—100% air removal. Furthermore, this feature is defined as the removal of all entrained air and dissolved gases.

It has been proven that removal of entrained air and dissolved gases is essential to the best papermaking practices. Entrained air is defined as air bubbles that are attached or bound via surface tension to fibers, forming small flocs. Dissolved gases are suspended within the stock flow while it is under the pressures experienced in the stock cleaning and screening processes. Dissolved gases are released immediately from the dissolved state as soon as stock exits the headbox slice. Failure to remove the entrained air and dissolved gases can impact formation and, ultimately, sheet quality.

As recently as two years ago, research was presented on the topics of air entrainment and dissolved gases in stock, highlighting their detrimental effects on drainage, pinholes, and web breaks. This research reinforces the need for the proper operation of the many Deculator systems installed worldwide.

However, these stock deaeration and cleaning processes are some of the few papermaking processes that can operate improperly without noticeably negative effects. Additionally, inefficiently operating systems do not occur in an obvious way during an eight-hour shift, but inconspicuously deteriorate over several years.

Cleaners in the top photo are rejecting properly, but the cleaner in the lower photo is plugged at the accepts. There is no swirling of the stock, just a downward stream from the rejects orifice.

To complicate things, most of these systems are located at an upper mezzanine level that is not frequently visited by operators and maintenance personnel. Also, due to the remote locations, instrumentation is less frequently serviced and calibrated. Such factors contribute to the recording of erroneous data by operators and false comfort levels based on incorrect operating data.

THE MYSTERY OF DIMINISHED DEAERATION. Lack of deaeration is occasionally covered up by the addition of defoamers. This is kind of like buying premium fuel for a car rather than paying for a tune-up. Many paper machines with correctly operating deaeration systems require absolutely no defoamer.

Reduced deaeration performance can be due to several factors. These include operating the system at much higher flow rates than originally designed for, changing process conditions and operating temperatures, vacuum pump wear, worn out condenser spray nozzles, vacuum leaks, and reductions in availability of condenser and vacuum pump seal water. Even changes to the furnish and stock preparation process can increase air in stock content.

All of the preceding factors lead to reduced operating vacuum, which is the primary cause of diminished deaeration. The following sections discuss methods for maintaining efficient vacuum system operation in Deculator systems.

Establishing the correct vacuum. What is the correct vacuum for the Deculator? This is a commonly asked question with a simple answer. The operating vacuum is solely based on stock temperature.

Remember that this is a vacuum deaeration process, and the vacuum level must be near the boiling point to completely remove entrained air and dissolved gases. Therefore, the ideal operating vacuum is based on the vapor pressure of the stock at its normal temperature. It is not practical to try to operate at the boiling point, so a margin of 0.315 in. Hg, as partial air pressure, is added to the vapor pressure as Figure 1 shows. Yet, complete deaeration is still achieved.

Table 1 lists ideal operating vacuum levels at various stock temperatures. Since process conditions for any paper machine change over time, the operating vacuum level should be compared to the ideal level shown in Table 1 in order to determine if the system is close to boiling point vacuum. If it is not, the Deculator and its vacuum system must be examined.

Finding vacuum leaks. Checking for leaks is not a simple procedure because vacuum does not leak out onto the floor. Vacuum leaks can be found in valves that are not closed or fully seated, flanges, manholes, or even cracked vacuum piping that has work-hardened over time and failed.

Additionally, reject cones of stock

cleaners fitted on the Deculator have been found to have improper seating in the neoprene grommets. Some-times, maintenance improvements can eliminate leakage around the stock cleaners. Even very small leaks at high vacuum levels can result in significant vacuum loss.

Recently, during a Deculator- Cleaner system audit, two cleaner reject cones were discovered to have slipped away from the grommets holding the sight glasses. After aligning and securing the grommets back onto the reject cones, the operating vacuum increased by 0.5 in. Hg.

Solving tricky problems. After inspecting for leaks and finding the system is still not at the correct vacuum level, the vacuum system should be studied. Typical problems in this area include lack of proper water flow to the condenser, low vacuum pump seal water flow, and worn vacuum pumps. These are usually easily corrected.

Also, a vacuum system may function correctly and without leaks, but the vacuum level may still be incorrect. In this case, process conditions must be studied and compared to the original design.

Upon study, it is not uncommon to find a system operating at 125 to 150% of the original stock flow. Another common problem is changing stock or water temperatures, as several systems have been found with much higher condenser or seal water temperatures than for what they were initially designed. However, the most common cause has been the closing up of water systems, which resulted in increased mill water temperatures.

Maintaining vacuum systems. Mills should examine vacuum pumps yearly to insure they are at reasonable performance levels. Also, seal water orifices and spray nozzles should be inspected for plugging.

Most vacuum systems have two stages of vacuum pumps, and both must stay in good condition. With systems having steam jets as the initial vacuum stage, steam flow must remain at the design pressure, and jet nozzles cannot be worn. Many mills have tried to reduce steam consumption, often resulting in shutdown of steam flow to the steam jet. This is the same as shutting down the primary vacuum pump, leaving the vacuum system capacity inadequate. Vacuum systems with steam jets typically provide a good opportunity for energy-saving projects. Several such systems have undergone upgrades to improve deaeration capacity while also saving energy.

Modern and more efficient, two-stage vacuum pump systems are the best choice in terms of energy savings, longer pump life, and reliable operation. The precondenser (spray condenser, shell and tube, or spiral type) is very effective ahead of the vacuum pumps, as long as cooling water is at least 20°F below stock temperature. With a precondenser, vapor removal efficiency is 65 to 90%, reducing the size and power consumption of the vacuum pumps. Systems without precondensers can usually reduce vacuum system horsepower requirements by adding this equipment to the process.

STOCK CLEANING CHALLENGES. Similar to changes in deaeration performance, stock cleaning will deteriorate over time unless routine steps are taken. Many times, stock cleaning systems are poorly balanced and operate inefficiently, but mills will just adjust the systems and increase reject flows to maintain sheet cleanliness. However, this can increase the fiber loss from the system by as much as 500%.

This performance measurement—fiber loss—often has the highest impact on operating costs in a system. A stock cleaning system does not require much maladjustment to yield an additional one tpd of fiber loss. With the true cost of fiber at $200 to $300/ton, this totals to almost $100,000/yr.

Two main problems are found with cleaner systems: incorrect operating pressures and improperly maintained cleaners.

Correcting the operating pressure. Operating pressures are often incorrect. Each type of centrifugal cleaner has a specific pressure drop to create the ideal energy for separating contaminants from the fiber. This pressure drop is the difference between the feed pressure and the accepts pressure.

Often, gauges and/or pressure transmitters are not calibrated. Many cleaners are set up to operate at specified pressures, but cannot operate properly due to bad gauges and instrumentation. Also, when cleaners are installed on the Deculator, the feed pressure must take

TABLE 1: *Ideal operating vacuum levels at various stock temperatures*

Stock Temperature		Operating Vacuum Level (in. HgA)	Operating Vacuum Level (in. Hg Vacuum)
100°F	37.8°C	2.248	27.673
105°F	40.6°C	2.558	27.363
110°F	43.3°C	2.884	27.037
115°F	46.1°C	3.310	26.611
120°F	48.9°C	3.761	26.160
125°F	51.7°C	4.271	25.650
130°F	54.4°C	4.841	25.080
135 °F	57.2°C	5.481	24.440
140 °F	60.0°C	6.197	23.724

TABLE 2: *When cleaners are installed on the Deculator, the feed pressure must take into account the operating vacuum level. This table provides the conversion for common vacuum levels from inches of mercury to psi.*

Operating Vacuum Level (in. HgA)	Operating Vacuum Level (in. Hg Vacuum)	Equivalent Accepts Pressure (psi)
7.92	22	10.8
6.92	23	11.3
5.92	24	11.8
4.92	25	12.3
3.92	26	12.8
2.92	27	13.3

FIGURE 1. *Operating vacuum is based on vapor press of stock at a normal temperature, plus a margin for partial air pressure.*

Stock Temperature:	125°F (51.7°C)
Vapor Pressure (of water) at 125°F:	3.596 in. HgA (26.325 in. Hg Vacuum)
Addition of Margin:	+ 0.315 in. Hg
Ideal Operating Vacuum:	3.911 in. HgA (26.010 in. Hg Vacuum)

into account the operating vacuum level.

For example, assume the cleaners require a 26-psi pressure drop, are installed on the Deculator, and the vacuum level is at 26 in. Hg. The accepts pressure is the operating vacuum level and is a negative value. It should be converted from inches of mercury to psi. Table 2 provides this conversion for common vacuum levels.

At 26-in. Hg vacuum, the cleaner accepts pressure is 12.8 psi. Therefore, feed pressure must be 13.2 psi to obtain the total pressure drop of 26 psi. Many systems are found with feed pressures that are too high, resulting in excessive flows and wasted pumping horsepower. The excess stock just passes over the overflow weir and back to the primary fan pump suction, or in old systems, to the silo where it eventually gets mixed with white water.

Stock cleaning systems that are not installed under vacuum are a little easier to set up since accounting for the vacuum level is not required. However, the biggest problem with these systems occurs when the accepts pressure is operating at 0 psi or below. The accepts pressure at the cleaners (when these flows are not going to the Deculator) sees its lowest pressure at the accepts manifold, and this pressure increases as it flows to the basement. Accepts pressure for these fiber recovery stages should be set at 5 to 10 psi. The rejects pressure for pressurized reject cleaners should always be 2 to 3 psi lower than the accepts pressure.

Some fiber recovery stages require elutriation water. This should be clear filtrate from the Saveall and will dilute cleaner rejects right at the cleaner rejects cone. Various cleaner types refer to these setups as stocsavers (or rejectors or flush cones).

Difficulties with setting the operating pressure for elutriation water can result in poor cleaning system efficiency, and pressure that is too high literally chokes off the rejects flow and pushes most fiber and dirt out with the accepts. Normal elutriation water pressure is 10 psi for cleaners not operating under vacuum. In some cases, stocsavers are installed on Deculator-Cleaner stages and only require control to 2 to 3 psi. Modern fiber recovery cleaners have been improved and do not always require elutriation, which is helpful since some transmitters and control systems have difficulty maintaining the low pressures.

Extremely old cleaner systems had much higher pressure drops. These could be 40 to 50 psi and often involved 12-in.-dia. cleaners. Many of these systems are still operating and have an excellent potential for modernization.

First, older systems may now operate with increasing rather than decreasing feed consistencies from stage to stage. Secondly, the cleaners had thick walls that did not wear out, so the cleaner internals may be worn and require replacement. Thirdly, and most importantly, new, low-energy cleaner systems can save enough pumping energy to justify replacement.

For example, a system with 30,000 gpm of primary cleaner feed flow that can operate with 25 psi (or 58 ft or 172 kPa) lower feed pressure requires 550 less horsepower. This will save $210,000/yr at an electrical cost of $0.06/kWh ($380/hp-yr). Additional savings will occur for each cleaning stage.

Effectively maintaining cleaners. Cleaner wear and the conditions of the internal surfaces are other areas requiring investigation. This can make the difference between a system with good efficiency or one where it is poor.

Cleaners are made from various plastic materials and all have particular characteristics such as abrasion resistance, high- or low-temperature operation, and high or low cost. Stainless steel is another option for cleaner construction.

Usually, the internal surfaces of cleaners are not inspected until several failures occur. However, for new systems, they should be randomly inspected after a year or two of operation. Then, after wear rates are determined, programs to replace parts can be set up with 10 or 20% being replaced each year, for example.

Any time a cleaner plugs at the rejects outlet, it should be inspected for thin spots and/or grooves in the cones. The cone section should be replaced if grooves or other wear are found.

The mixing up of cleaner parts presents another potential problem. Some systems are designed with different reject tip sizes and cones for each stage. These parts often are stored in a cabinet near the cleaner system for easy access. Problems occur when a part is replaced with an incorrect item, so care must be taken to properly identify the required parts for each cleaner stage. Drawings and parts lists are useful when displayed with the rest of the cleaner parts.

Finally, under cleaner maintenance, it is important to be able to identify when a cleaner is partially plugged. Most systems have clear sight glasses at the rejects cone to allow observation of the rejects flow, and mill personnel usually do a good job of identifying a completely plugged cleaner. Such plugs have no visible flow in the rejects sight glass and are often vibrating while in operation. However, partially plugged cleaners may not be noticed and will eventually become fully plugged. This necessitates that the inspection process includes observation of the rejects flow to determine if there is a swirling or rotational flow passing through the sight glass.

All of the above and other changes in the approach system require a thorough evaluation of the entire stock approach system. It is essential to measure the air in stock, as well as dirt counts, prior to selection of new process equipment. A paper machine approach system audit requires a few days on site and typically offers excellent opportunities for improvement. In most cases, potential annual savings are in the hundreds of thousands of dollars. ■

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