PROPER DESIGN AND USE OF SUCTION ROLL SEALING STRIPS IN SUCTION ROLL OPERATION

DAVID W. WITHERS AND THOMAS S. GARDNER

OBSERVING SIX SIMPLE STEPS CAN IMPROVE SUCTION ROLL EFFICIENCY AND SEAL LIFE WHEN OPERATING A PAPER MACHINE.

A MODERN PAPER MACHINE CAN CONTAIN HUNDREDS of rolls from the wet end to the final reel. Among these, the suction roll is a complicated and important component used in the manufacture of paper. Almost every paper machine will have at least one suction roll, and most machines will have two or more such rolls.

The suction roll consists of two primary components:

- A rotating shell
- A stationary vacuum box.

As the shell rotates around the vacuum box, a vacuum inside the box pulls through a gap in the top of the box and through the holes in the shell opposite this gap. Water is then pulled from the paper and its carrying wire or felt as a mating roll presses against the outside diameter of the shell at this point. Figure 1 shows the configuration of a typical suction roll seal.

Transferring the vacuum in the vacuum box through the holes in the rotating shell requires a seal between the stationary box and the rotating shell. The vacuum opening to be sealed is typically rectangular and extends in the cross direction (CD) from one edge of the paper to the other—the trim width—and in the machine direction (MD) from a few inches wide up to half the diameter of the roll. The width depends upon the width of the nip with the mating roll and the degree of wrap the sheet has against the suction roll.

SUCTION ROLL SEAL

Suction roll seals are critical elements in the function of a suction roll and sometimes the paper machine itself. If the seal fails, the vacuum is lost in the suction roll. The dewatering capacity of the nip may then decrease to a level for which downstream components cannot compensate. This would force the paper machine to stop.

Improper use of the seal can cause inefficient suction roll operation resulting in less vacuum pressure in the roll. This causes higher energy use downstream to remove the moisture that could have been removed less expensively by the suction roll.

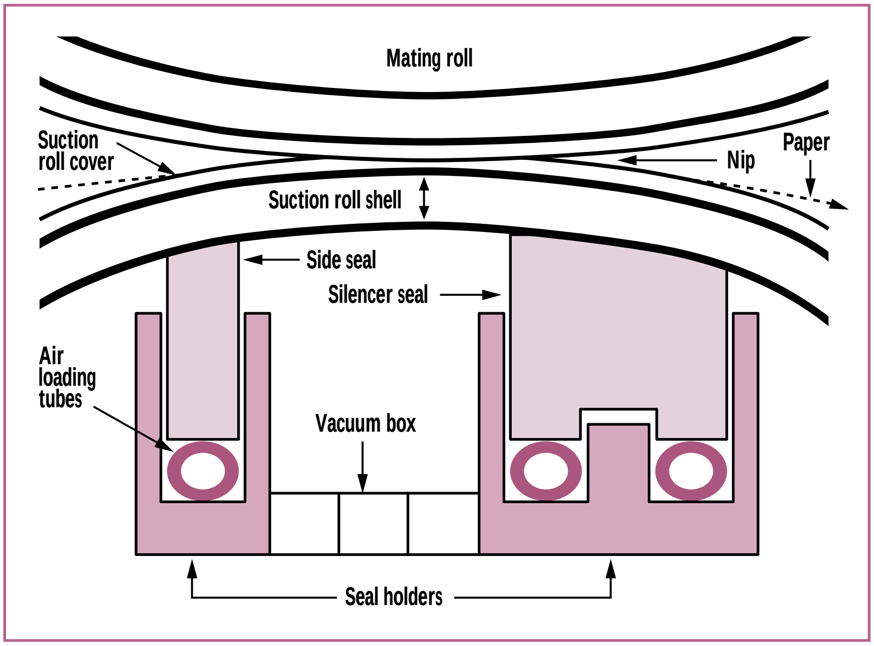
The suction roll seal typically consists of three primary components:

- Side seal
- Silencer seal
- End deckles.

The common name for the seal used in the CD on the leading edge as the paper approaches is the side seal. The trailing edge seal running parallel in the CD is typically the silencer seal. It is often wider than the side seal but the same length. End deckles are the typical designations for the seals used in the MD at each end of the vacuum opening. In most modern designs, the side and silencer seals raise and lower relative to the inside of the suction roll shell by inflating air loading tubes that lie under the seals in a U-shaped holder. The end deckles can be either fixed-in-place or movable up and down like the side and silencer seals. The configuration depends on the manufacturer of the suction roll.

Wood loaded with springs was the construction for early suction roll seals. Later seals consisted of ultra high molecular weight polyethylene, asbestos, and fibrous materials like Micarta and Kevlar. The common material today for most modern seals for high-speed machines is a rubber graphite composite material. To understand the logical progression of the suction roll seal design to this point, it is important to understand first the purpose of the seal strip in the operation of the suction roll.

In a perfect environment, the suction roll seal never contacts the roll shell even when the air loading tubes are inflated. A film of water forms between the top of the seal and the rotating shell to close the vacuum. The theoretical clearance between the rotating shell and the seal when the air loading tubes are inflated is approximately 0.020 in. This is small enough for the elasticity of water to close the void and allow the seals to hydroplane against the shell. Water from a lubricating shower provides the necessary sealing water on the side seal. Process water provides the lubrication on the silencer and the end deckles.



1. Typical suction roll seal configuration

The modern paper machine is unfortunately far from a perfect environment. The suction roll seals often contact the roll shell for many reasons. For example, a nozzle on the lubricating shower can plug, leaving unlubricated gaps on the side seal. Another instance is the application of excessive air pressure to the air loading tubes closing the gap for lubrication between the seal and the shell. Improper installation is also a common problem especially with end deckles. This can cause the seals to run against the shell like a brake increasing the horsepower required to turn the roll and even causing grooves in the shell. It is therefore critical to pick the correct material and use the seals correctly.

IMPORTANT SEAL PROPERTIES

There are three important properties in a suction roll seal:

- Coefficient of thermal expansion
- Percentage of water absorption by volume
- Maximum operating temperature.

Each property is important for different reasons. Low thermal expansion ensures that the seals will not grow too long as the suction roll warms to operating temperature. If the seals expand into the ends of the seal holders, the seals will bow up into the shell and wear prematurely. There is typically a gap between the ends of the seals and the ends of the seal holders to accommodate thermal expansion. Using seals with low thermal expansion should minimize this gap, however. Any gap at the ends of the seal holder or in the joints of seals installed in sections can become a trap for abrasive fillers in the process materials and cause abrasion to the suction roll shell.

Too much water absorption can cause similar problems if the seal material swells or distorts in the holder. Suction roll seals operate in a warm environment—up to 180°F. Heat will accelerate the tendency of most materials to absorb water over time. Any dimensional swelling from water absorption can cause a seal to become stuck in the holder and prevent the air loading tubes from maintaining the proper position of the seal to hold vacuum.

The most important property is maximum operating temperature. This characteristic closely relates to the life expectancy of the seal strip itself. Most suction rolls run between six months and a year between seal changes. Some mills now try to extend that time to two years. Most seal materials on the market today should have no problem running for two years, if the suction roll itself is functioning properly for that long.

One must exercise caution when discussing suction roll seal strip life expectancy because long life for the seal can be a two-edged sword. Although a titanium seal would last for considerable time, it would not be very forgiving to the roll shell on contact. Seal life, therefore, must always be tempered by the fact that the seal should be the sacrificial material upon contact with the shell. The designers of most suction rolls intend the seals—not the shell of the roll—to wear regularly and require replacement.

Some seal materials defeat this design criteria by being so hard and abrasive that they damage the shell. The grooves in suction roll shells commonly found opposite the end deckles are one obvious result. The same wear happens to the entire inside diameter of the roll shell over time. It is not so obvious, however, because the entire shell is wearing evenly. The only way to find this kind of wear is with a shell bore profile taken at each rebuild. Too much emphasis on seal life has occasionally produced very hard and long lasting materials that contradict the designed purpose of the seal and damage the roll.

This problem led to the development of self-lubricating materials in the 1980s. Most such materials contain graphite as a lubricating agent. The graphite attempts to substitute for the lubricating water when it is absent. The graphite in the seal releases upon wear of the seal so the seal cannot lubricate a dry area indefinitely. A self-lubricating seal can greatly delay what might otherwise be an immediate failure, however.

Wear of the seal is also the only mechanism available for removing heat from the area where the seal contacts the shell. Locally high temperatures of several hundred degrees can result from the dry friction of suction roll sealing strips running unlubricated against a suction roll shell. Such temperatures can damage the rubber or polyurethane covers on the outside diameter of the shell. Temperatures as low as 250°F can cause the bond of the roll cover to the shell to fail, leading to a catastrophic failure in the paper machine. Even with the self-lubricating materials, if the base seal material holding the graphite remains hard as the temperature increases, the seal may not wear fast enough to release adequate graphite to lubricate the shell or dissipate the heat.

What is the ideal maximum operating temperature of a suction roll seal strip material? It should always be less than the temperature where damage to the rubber or polyurethane cover could occur—usually 212–250°F. As the seal approaches such temperatures, the base material of the seal should begin to break down and wear faster to dissipate the heat and provide more lubrication. Although the seal may eventually fail, it is the only item that fails. There is no damage to the surrounding equipment as the designers of suction rolls had planned.

If the base material of the seal does not wear away, the whole area becomes hotter and hotter until something else fails. Although seal life is important, one must remember that the ultimate purpose of a suction roll seal is to fail. The failure of a self-lubricated suction roll seal from wear usually indicates that something else was wrong in the suction roll. The failed seal may have saved the cover on the suction roll and prevented a catastrophic failure of the paper machine itself.

EXTENDING SEAL LIFE

One can improve suction roll efficiency and seal life with a few simple steps:

- It may not be necessary to discard seals on every disassembly of the roll. Often seals have to wear in to match the profile of the roll shell. An apparently worn seal that has been running for nine months might run considerably longer because it has reached equilibrium with the dynamic internal profile of the shell. A new seal would quickly wear into the same shape and stabilize. If enough material remains from the original seal for the air loading tubes to push the seal up to the shell, one can reuse the seal. In most suction rolls, a seal is worn out if more than 0.250 in. of the original height of the seal has worn away. That is the designed operating range of most air loading tubes.
- Proper operation of the lubricating shower will greatly improve ideal seal operation. Water from the showers with process water pulled into the vacuum zone must provide a lubricating film inside the shell for the seals to run properly. Adequate lubrication is essential to extend the life of the seals as it is with any mechanical device.
- Replace the air loading tubes at every opportunity even if not replacing the seals. Many air loading tube materials age-harden. Contact with any petroleum product will eventually cause most air loading tubes to crack.
- Keep air pressure in the air loading tubes at 5–7 psi. A higher pressure is acceptable on startup to help seat the seals provided there is reduction to the minimum pressure required to maintain vacuum after a few hours. If more than 5–7 psi is necessary to maintain vacuum in the roll, the seals may be too short. The seal vendor can reverse engineer proper seal height. The height of suction roll seals often needs increasing as the suction roll ages or if there was any honing or boring. Short

seals decrease the vacuum efficiency of the suction roll and force expenditure of more energy downstream to remove moisture. High air pressure on the loading tubes will wear out the seals prematurely and use more horsepower to drive the roll.

- Inspect the shell bore regularly especially after each recovering. A regular bore profile with the inside diameter checked in three planes at a minimum of ten stations down the length of the shell is the best way to confirm whether a seal material is wearing the shell. A rough shell bore surface can also greatly reduce seal life. It is not uncommon to find burrs and even drill bits in the holes of the shell after recovering and redrilling. These items can turn the shell into a cheese-grater surface with a resultant very short seal life.
- End deckles—fixed or movable—should be hand fit at assembly of the roll to guarantee a 0.015–0.020 in. gap between the deckle seal surface and the rotating shell. Improperly fit end deckles can produce conditions where the gap between the end deckle and the rotating shell exceeds the elasticity of water. This creates a concomitantly inefficient loss of vacuum. If the end deckles are too tall, the deckles will contact the shell under great force upon reassembly of the roll especially on fixed end deckle designs. This may result in damage to the deckle, grooving of the shell, or the end deckle becoming a brake on the shell requiring more horsepower to turn the roll. It is also important to note that the primary purpose of spring loaded or movable end deckles is not to push the end deckle up against the shell. The movement allowed should only push the deckle down and aid the assembly or disassembly of the suction box into the shell. Even movable end deckles should have clearance with the shell when fully extended.
- When seals wear out especially very quickly after startup, do not automatically assume that the problem is with the seals. Remember that problems with suction roll seals are often an indication of a problem elsewhere in the roll. Good suction roll seals have often done exactly what they were designed to do even when they fail by preventing damage to the much more expensive shell or roll cover. TJ

Withers is president and Gardner is manufacturing manager at Coldwater Group, Suite 542, 2964 Peachtree Rd., Atlanta, GA 30305.