Carbide Doctor Blades on Ceramic Press Rolls

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Technical White Paper Series
EXECUTIVE SUMMARY

Ceramic press rolls have become popular choices for improving papermaking efficiency and product quality. The proper selection and use of ceramic-tipped doctor blades and cleaning shower systems is critical in getting the highest performance from these rolls. This paper summarizes the basis for selecting and operating modern ceramic press roll doctors.

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The papermaker spends most of his time and capital on the paper machine’s forming and press sections. In many cases, these areas provide the greatest return on investment in papermaking operations. The forming section determines the most value that can be achieved from the stock that is supplied to the machine. The press section is the next most impactful operation on the paper machine. It is responsible for consolidating the wet web, thereby determining the ultimate potential for sheet strength and surface properties. It is also the last process for mechanically removing water. After that, the web is turned over to the dryer section, for thermal dewatering, at a much higher cost per unit of water removed.

It is not surprising that many suppliers to the paper machine pay the most attention to the wet end sections, whether they are supplying rolls, fabrics, or doctoring equipment. What is not achieved by the end of the forming section and press section becomes very difficult, expensive, and often impossible to achieve or correct in subsequent sections.

This paper is focused on one element of the wet end operations that is critical to success: Pressing with ceramic covered press (center) rolls. A ceramic cover is a general term that refers to metal oxide coatings that are applied to press rolls. Ceramic covers are the most common type of covers used to replace granite body press rolls.

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CERAMIC PRESS ROLL COVERS

The first press roll that contacts the sheet directly is usually the center press roll. The bottom side of the sheet contacts the outer surface of this roll. This press can be followed by another single-felted press nip, generally a 4th press nip, in which the top side of the sheet contacts the outer surface of the roll (see figure on page 4). The surface characteristics of the center press roll and the top roll of a 4th press are critically important to the performance of the machine. The surface must be sufficiently open to allow the sheet to be pulled from the surface with the least amount of force and remain clean and open in operation.

For many years, the only material that was suitable for these press roll positions was granite (a naturally occurring igneous rock). Granite, however, has low tensile strength, is brittle, and its properties are not uniform. A solid block of granite is heavy, stiff, and prone to vibrations.

Press roll bodies with polymeric roll covers were developed for center and 4th press roll positions, and worked well in many such applications. In some applications, however, the adhesion and release qualities were not adequately balanced. In other applications, the poly cover life was limited by vibration, cover delamination, and surface corrugation.
Ceramic press rolls were first introduced in the early 1990s as replacements for granite body rolls and for polymeric covers. These press rolls had roll bodies similar to those used on polymeric covered rolls except that the roll surface had a thin (1 mm) thermal spray ceramic layer.

The first commercially viable ceramic roll covers were developed by paper machinery builders including Metso (formerly Valmet and Beloit) and Voith. With the development of the ceramic cover, as with many new products, there was a learning curve as these covers were installed in more demanding applications.

**CERAMIC PRESS ROLL COVER WEAR**

A ceramic roll has little or no wear, it releases the sheet well, and it offers good doctor blade life. The life of a ceramic roll cover can be so long that the limiting factor becomes the life of the roll bearings. This assumes that the surface of the ceramic cover can be maintained without damage or contamination.

The point to be made here is that the ceramic roll surface is, by design, porous in nature and in the absence of wear (i.e., cleaning) it begins to contaminate. To derive maximum benefit from the ceramic roll, attention needs to be paid to proper doctoring and showering. The roll cover, doctor, and shower together form a symbiotic system. Each component has to be correctly selected, designed, installed, and functional to achieve optimal press performance.
The performance of a ceramic press roll is usually characterized by the amount of force required to pull the sheet from the surface of the roll and transfer it to the next press or the dryer section. This force is generated by the difference in speed of the press roll and the speed of the next set of rolls. This speed differential is called draw. If the center roll surface speed in a Twinver® 3rd press configuration is 3000 fpm and the 3rd press surface speed is 3030 fpm, then the draw would be listed as either 30 feet or 1%. For modern machines, draw is usually listed as a percentage of machine speed.

A low draw requirement is typically an indication of a good roll cover. A clean roll with good release properties reduces the requirement for excessive consumption of expensive release coatings to reduce draw.

The paper properties are changed at each draw point. These changes, both positive and negative, are usually additive. Further, the paper web may not be able to absorb the cumulative draws. Once the pealing force exceeds the breaking strength of the weakest point of the sheet, a break occurs. In summary, lowering the force required to pull the sheet from the roll (i.e., lowering the draw) has the following beneficial effects:

- Fewer breaks in the press section
- Fewer breaks in the dryer section
- Less change to the sheet properties and property uniformity
- Less sheet edge contraction
- Improved (e.g., smoother) surface characteristics as a result of less fiber being pulled from the sheet surface
- Increased machine direction tensile strength

It is important that the ceramic roll surface remain clean and uniform, and this can only be accomplished with proper doctoring and showering. It is easier to keep a ceramic roll surface clean than it is to clean up a ceramic roll surface that has been contaminated. The latter has proven to be expensive or in many cases simply impossible, short of re-finishing (i.e., grinding) the roll surface.
CARBIDE-TIPPED DOCTOR BLADES

The doctor blade is expected to make and maintain uniform contact and loading across the width of the roll, during its entire lifetime on the machine. Selection of a durable holder and robust doctor back design is vital to doctor blade performance. Typically, a double-doctor design is selected and optimized for the particular position. A double-doctor consists of a primary sheet-shedding doctor blade loaded against the roll surface backed up by a second doctor blade for cleaning and conditioning the roll surface.

As machine speeds have increased, the void volume of the ceramic covers have become smaller and the furnish has become more aggressive. As a result, high quality carbon, abrasive, and carbide-tipped blades in precision holders on a double-doctor configuration became the norm. With these innovations in place, papermakers began to realize greater returns on their investment.

Carbide-tipped blades were preferred because they could be used without fear of damaging the wear-resistant surface of most ceramic rolls while keeping the roll surface clean. A non-wearing doctor blade coupled with a non-wearing ceramic cover is an optimal combination provided the surface of the ceramic roll does not change.

One fine paper mill in Southern U.S., for example, saved $250,000 per year with a carbide-tipped blade through the elimination of intermediate downtime between wash-ups to change blades. Another mill was able to run shutdown-to-shutdown without a blade change, saving 20 minutes of downtime per week.
CARBIDE BLADE TECHNOLOGY

Although significant attention is usually given to the ceramic roll, the carbide-tipped blade that keeps it clean is equally important.

The carbide-tipped blade in the leading position is typically loaded against the roll at an angle of 28 to 30 degrees. The blade tip loading is typically 2.5 to 3 pli across the entire roll face.

The carbide at the tip of the blade should be of the high quality thermal spray variety with actual carbide making up 80 to 95% of the matrix. The balance is softer metal that provides the anchor for the hard carbide particles. The actual choice of metal for the base may depend on the environment and the level of corrosion resistance required.

It is interesting to note that even though thermal spays have been around for a long time, there is a lot of variation in quality of the ceramic blade coating. Figures 1a and 1b show a good quality tungsten carbide coating and a mediocre quality coating, as deposited on a doctor blade.

There is a noticeable performance difference of these two doctor blades. A porous coating on the blade will tend to chip and fracture prematurely, providing lower doctoring performance and lower doctor blade life. A high quality coating presents a continuous, clean, and sharp leading edge to the roll surface; something that is critical to keeping the roll surface clean.

Fig 1a shows a high quality coating, while fig 1b shows a mediocre quality coating of tungsten carbide. Both used the same powder, demonstrating the influence of technique on coating quality.
The interface between the coating and the base blade is also important to the doctor blade performance and the doctor blade life. A good coating will form a seamless interface between the carbide and the metal as it wears. Figure 2 shows the polished cut cross section of a used carbide tipped blade and reveals a clean interface.

Shower water coverage at 200% is required for flushing away the contaminants removed from the roll surface, keeping the doctor blade clean. The showering aspect is often neglected and it is important to recognize that there is a price to be paid for this neglect in terms of higher blade wear, higher release chemical consumption, increased roll surface contamination, more sheet defects etc.

**Fig 2.** The nature of the preferred interface between the carbide coating and the metal substrate. The curvature induced due to wearing on a roll surface is not noticeable because of the scale.

**ROLL SURFACE FINISH**

The use of carbide-tipped blades allows the roll surface finish to be maintained without the use of cumbersome devices. When the roll surface becomes contaminated, often resulting in an apparent change in surface finish, the sheet sticks to the roll and the draw increases. When the roll roughness increases, sheet holes and increased doctor blade consumption often result. Figure 3 shows the surface finish of a ceramic roll, running a carbide-tipped blade for 28 months. The surface remained clean, smoothness (Ra value) was maintained in the desired range over this entire period, and the roll did not have to come out of the machine to be resurfaced.
ROLL SURFACE GRINDING

The use of carbide-tipped blades also allows the roll grinding interval to be extended. This has multiple benefits. First, the down time associated with a roll change is eliminated. A typical center press roll change requires an extended outage that will tie up valuable maintenance resources. There is also the cost associated with grinding or super-finishing the roll surface and the loss of cover life due to premature grinding. Even when mills are taking inventory-related downtime, longer roll life reduces the risk of trying to stretch the run time to the next scheduled shutdown. Increasing roll life beyond its intended period often results in operating problems, such as breaks, holes, and linting, and degradations in sheet strength and surface quality. Even in challenging economic times, a better running roll can be the difference making money and losing money.

Fig 3. Roll surface roughness readings show consistency over a 28 month period while running a carbide-tipped blade.
ECONOMIC IMPACT

A modern ceramic cover offers the papermaker a very stable and consistent surface with excellent sheet-release qualities. Consistent operation of the cover provides significant reductions in downtime due to breaks.

There are two significant and negative results of a paper machine break: The first and most obvious is a loss of production that directly impacts profit. The second and just as significant is the upset to the papermaking processes. Depending on the storage capacities of the stock system and the length of down time, a single break can snowball into many hours of multiple breaks and off-quality product.

During sheet breaks, there is no evaporative load on the dryer cylinders and the resulting and undesirable temperature excursions make it more difficult to recover from a sheet break.

The most important benefit to consistent operation may be that fewer sheet breaks gives the papermaker time to focus on optimizing production and sheet quality rather than managing upset operations during and following sheet breaks.

An example of a ceramic cover running with carbide-tipped blades illustrates the potential impact that these component parts can have on the papermaking operation.

One mill was running a 3.2% draw between the press and the dryer sections with release agents on the composite cover. After installing a ceramic roll and carbide-tipped doctor blade, the mill reported the following:

- A reduction in draw was noticed immediately on start-up. The draw went from 3.2% to 1.5% with the machine running at 4000 fpm.
- The frequency of breaks was cut in half, resulting in a 2 hour per week reduction in down time. At $20,000 per hour, this equates to savings of $240,000 per year.
- After six months of consistent performance, the use of release agents was eliminated. This saved the mill approximately $100,000 per year.

By optimizing the doctoring and showering with the continued use of a carbide-tipped blade, the time between blade changes doubled compared to the previous doctoring configuration. This saved the mill 15 minutes per month, resulting in savings of $60,000 per year. The added cost of the coated blades was more than offset by the reduced usage.
CONCLUSIONS

Ceramic press rolls have become more common because of their ability to increase papermaking efficiency and improve product quality. With a proper and consistent ceramic press roll surface, the press draw can be reduced, the consumption of release coatings can be reduced, and the operating window can be correspondingly increased.

It is critical that the ceramic roll surface remain clean and uniform to achieve lower and consistent press draws. In order to maintain a proper and consistent roll surface, the ceramic cover must be properly and consistently cleaned. It is easier to keep a ceramic roll surface clean than it is to clean up a ceramic roll surface that has been contaminated. This makes the roll cleaning system an integral part of the machine operation.

Ceramic-tipped doctor blades and an appropriate cleaning shower system in this critical application will ensure that the highest performance is achieved from these rolls, with fewer press breaks, fewer dryer breaks, consistent sheet properties, and improved surface characteristics.