Recent Advances in Rubber Roll Covers for Improved Paper Machine Performance and Reduced Energy Requirements

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ABSTRACT

Rubber elastomers have been used to cover paper machine rolls for over 100 years. Continuous improvement of the materials has led to covers with better abrasion resistance, toughness, chemical resistance, and surface properties. Press rolls[1] can now run longer than ever at higher loads. Size press rolls can provide more even coating at the size press through surface modification of the rubber. Yankee pressure rolls have been designed that do not harden and have excellent toughness and abrasion characteristics. New coater backing rolls have been designed that have improved mark and crack resistance and better hardness stability. Most of these rolls can now be run non-water cooled, which provides a measureable benefit to the papermaker through energy efficiency and provides the mill with an added "green" approach to water conservation. In addition, these material advancements have led to longer run time intervals along with improved papermaking efficiency and quality. The improved material properties will be discussed, as well as case histories illustrating the roll cover's benefits to the papermaker.

INTRODUCTION

Paper mills have been using rubber covered rolls in different stages of the paper making processes for many years. The success of rubber roll covers depends on optimal physical and mechanical properties of the cover composition. For example, a cover with improved abrasion resistance increases the operating time between regrinds. Dynamic modulus and hysteresis properties are critical when determining if a cover material will run successfully in a given set of nip conditions. Several new covers have been introduced for press, size press, Yankee pressure, and coater backing applications. These new covers are listed in Table 1. Additionally, most of these rolls can now run non-water cooled, which provides a measurable benefit to the papermaker through energy savings. SMART™ technology (dynamic nip measurement technology) and it's benefits when used with rubber covers will also be illustrated.

Trade name	Application	Benefit
Superwear Xtreme	Press roll	Low hysteresis, abrasion and crack resistance
Supersize XL®	Size press	Even coating distribution, abrasion resistance
Xtreme TS	Tissue pressure roll	Low hysteresis and better hardness resistance
Hyperpress-X	Tissue pressure roll	Hardness stability and abrasion resistance
Hypercoat	Coater backing roll	Abrasion resistance and impact resistance
Lifegard II	High temperature base	"Green" base allows water cooling to be eliminated

Table 1: Newly Developed Premium Rubber Covers

PRESS SECTION

The typical hardness for rubber covers in the press roll position is 15-45 P&J (Pusey and Jones Hardness). The required properties are:

- *Low hysteresis to run cool* - Hysteresis is power loss in the form of heat during deformation and recovery of the cover through the nip cycle.
- *High tear strength* - Superior toughness to withstand impact at high loads without cracking.
- *Superior abrasion resistance* - Maintains crown and venting profile. This will also increase the time between regrinds.
- *Superior bonding system* - The cover must stay well bonded to the shell and intermediate layers

The above requirements led to the development of a premium cover as shown in Table 1. The cover has very high tear strength and low hysteresis as shown in Figures 1 &2. High tear strength provides a cover with extreme toughness that is needed for press roll covers to minimize or eliminate cracks from impact or localized loading issues. Low hysteresis helps the cover to operate at lower temperatures under dynamic conditions.

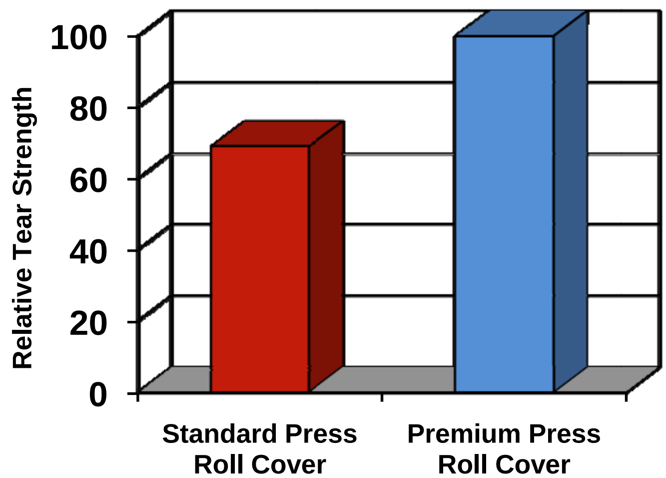

Figure 1: Tear Strength

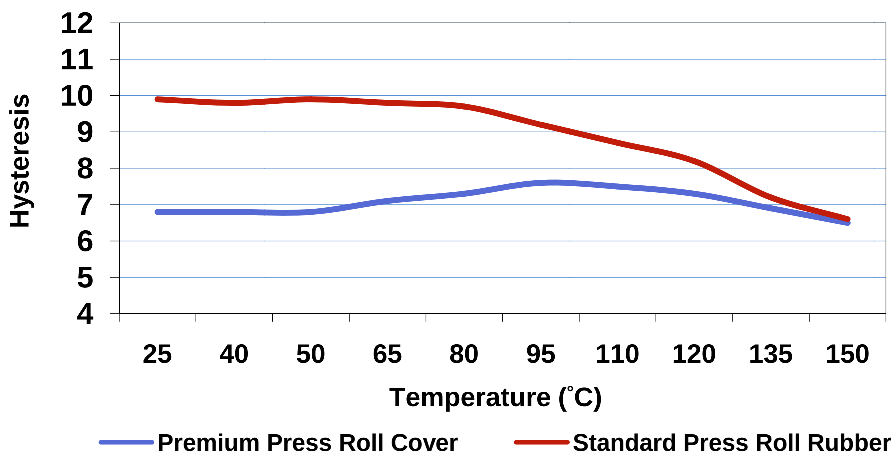

Figure 2: Hysteresis vs. Temperature

The combined development of these premium low hysteresis rubber press roll covers along with base to metal bonding layers that can operate at extremely high bond temperatures has led to the ability to operate these press roll covers without water cooling. The elimination of water cooling at a rate of 10 gpm can save a mill in access of 500 million gallons of water annually. This is often fresh water. While the benefits of removing water-cooling from the maintenance of the roll and the savings in water is evident, it should also be noted that the premature failure mechanism of thermally driven water diffusion into the cover is also eliminated.

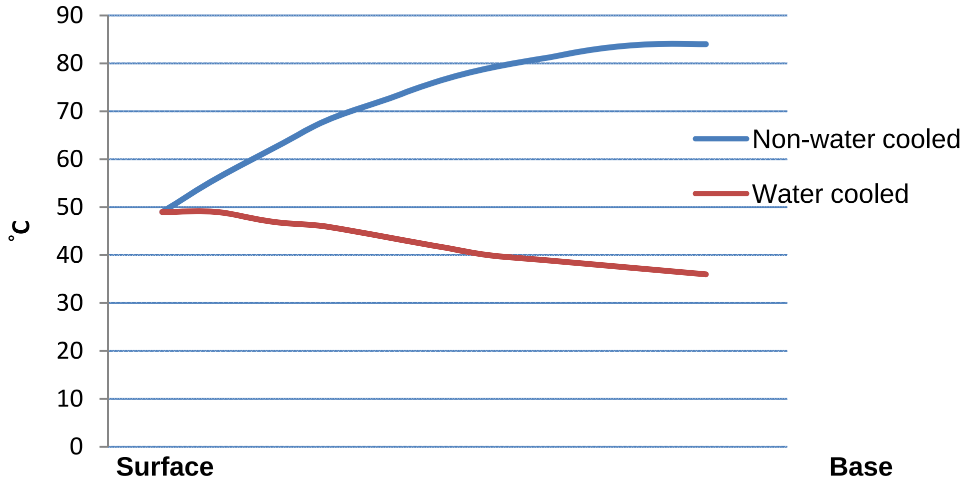

Figure 3: Temperature Gradient through Cover Thickness

Moisture diffusion failures are typically a result of large hot to cold thermal gradients from surface to core as seen in Figure 3 under water cooled conditions The temperature rise within the cover under non-water cooled conditions helps retard moisture diffusion.

CASE HISTORY

An Engineered Nip[2] study was performed on a pulp machine in Western Canada. The combination of cover hardness (dynamic modulus) and elimination of water cooling was studied to determine the effect on nip intensity and nip width. Table 2 summarizes the press conditions and water savings. Figures 4 and 5 show the reduction of nip intensity and increase of nip width in each press section.

Press	Line Load, Speed	Current conditions, water cooled	Proposed, non- water cooled	Water savings
1st press	96 kN/ m, 183 m/min	0 PJ Steel top/ 20 PJ Rubber cover	70 PJ top/ 20 PJ	12 L/min
2nd press	149 kN/ m, 183 m/min	20 PJ/20 PJ Rubber	30 PJ/30 PJ	14 L/min
3rd press	280 kN/ m, 183 m/min	18 PJ/18 PJ Rubber	21 PJ/ 21 PJ	16 L/min

Table 2: Press Roll Conditions and Water Savings

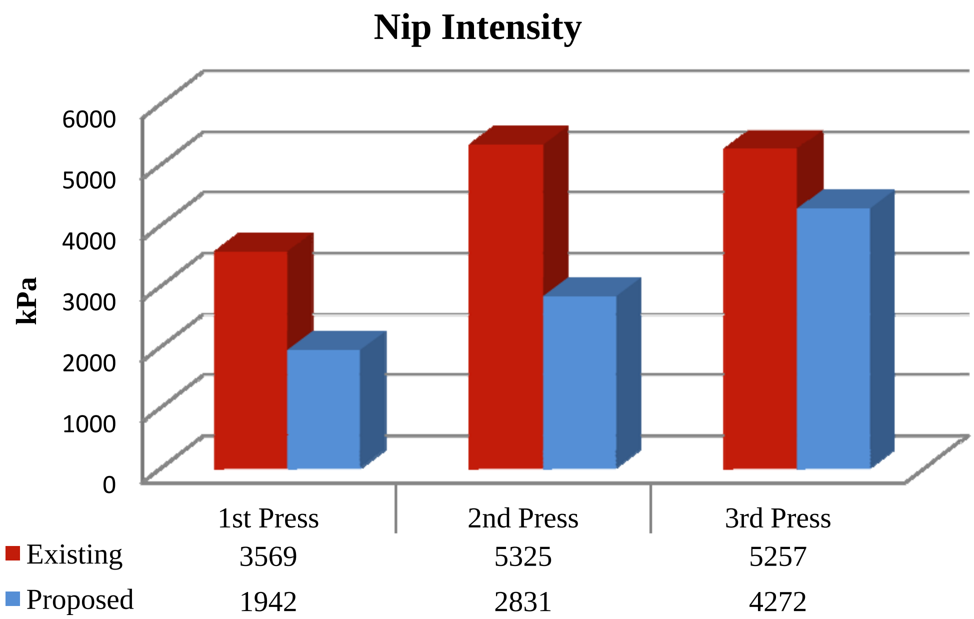

Figure 4: Reduction in Nip Intensity

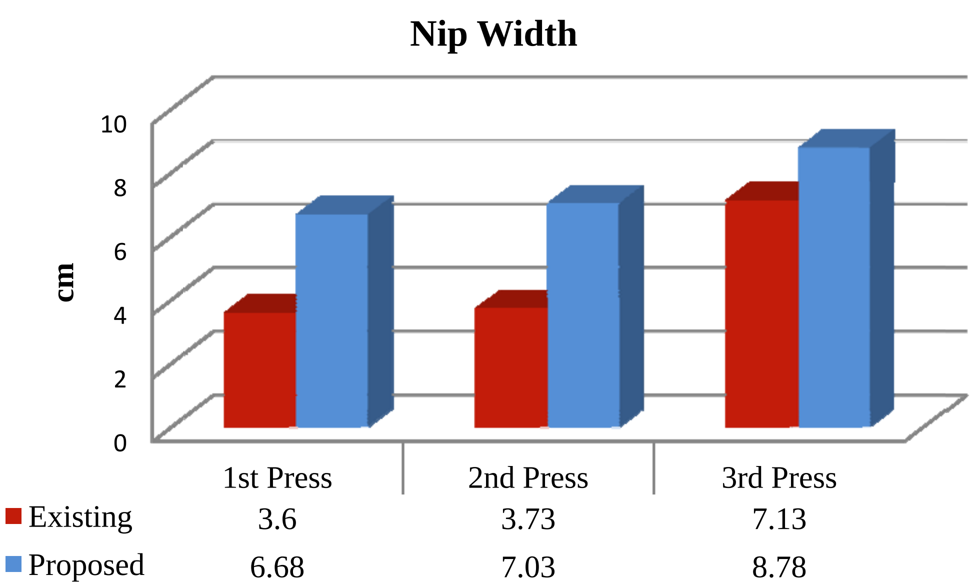

Figure 5: Increase in Nip Width

The results indicate 45%, 46%, and 18% reduction of nip intensities in 1^{st}, 2^{nd}, and 3^{rd} presses respectively. The increase in nip widths are 85%, 88%, and 23 % in 1^{st}, 2^{nd}, and 3^{rd} presses respectively.

The engineered nip concept lowered the nip intensity in all three press nips, raised the cumulative nip width by 56%, and increased the dwell time by 89%. By doing so, the sheet has 0.85 -1.0 % less moisture entering into the dryer section. With these improvements, the mill has significantly reduced operating costs each year.

SIZE PRESS ROLLS

The typical application hardness for rubber covers in the soft size roll position is 20 - 45 P&J. The hard size press rolls are typically 0-1 PJ. The required properties are:

- *High abrasion resistance* - to maintain surface profile
- *Mark resistance* – to avoid sheet defects
- *Hardness stability* – to provide a consistent nip and coating
- *Crack and tear resistance* – for damage tolerance
- *Must be able to wet size* - without causing excess size build up
- *Surface release properties* - to ensure uniform film spilt with minimal misting

The above requirements lead to the development of a premium size press cover as listed in Table 1. This premium rubber cover size press material is based on synthetic rubber with a unique filler combination that helps achieve high abrasion resistance (longer grinding interval), tensile, tear, and surface properties. Again, many of these rolls are running non-water cooled using the high temperature bonding system mentioned above.

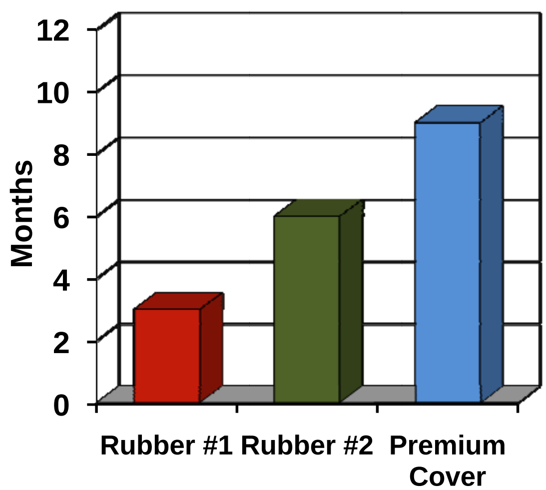

Figure 6: Grinding Interval

Figure 6 demonstrates the benefit of the development of these premium rubber size press materials and how they have taken run times from 3 months to 9 months in many size press roll applications. The roll changes are now less frequent and operating and energy efficiency are improved.

YANKEE PRESSURE ROLLS

The typical application hardness for rubber covers in Yankee pressure roll position is 25 – 45 P&J. Yankee pressure roll covers run at high speed and load and come in contact with the high temperature of the Yankee dryer. The major limitation of old generation Yankee pressure roll covers in this high temperature application is their hardening over time. Another shortcoming of the older covers was heat buildup within the cover due to high hysteretic properties of the rubber. The proper selection of rubber, fillers, and anti-oxidants enabled to development of the new tissue roll premium cover family listed in Table 1. These materials have excellent hardness stability ensuring a uniform nip over the life of the cover. In addition, due to the low heat generation, these covers can now be run under non-water cooled conditions. This practice was impossible prior to the development of these premium grade rubber covers and the high temperature bonding system. Energy efficiency improves because water cooling is no longer needed.

Figure 7 shows the comparison in hardness stability of the new rubber in a lab experiment. Test samples (5.0 cm. thick) were prepared and placed in a hot air oven at 100 °C. The hardness was measured every seven days for eight weeks. Note that lower P&J hardness indicates a harder material. It can be seen that the non-premium cover hardened almost eight units over this time, while the premium rubber hardened three units.

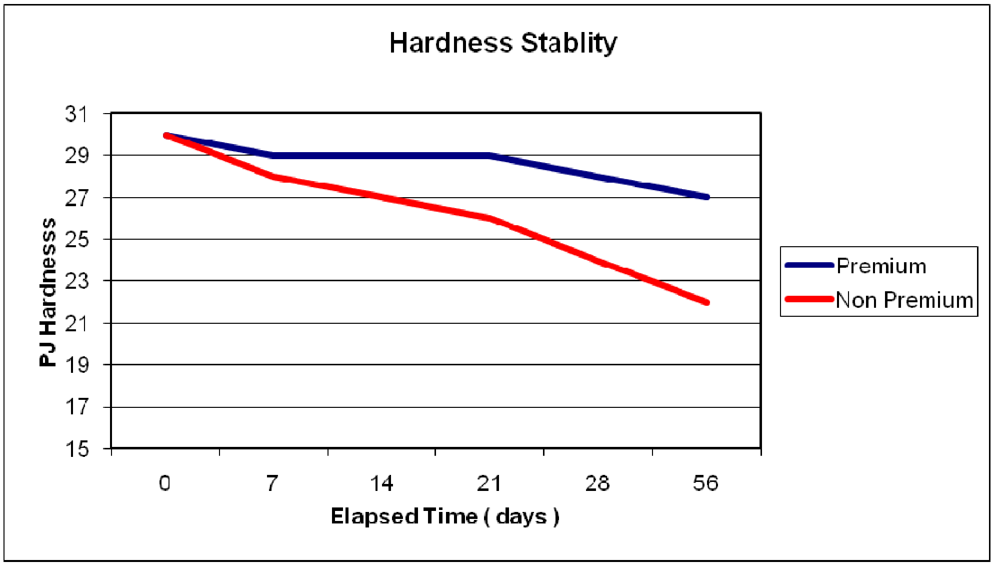

Figure 7: Hardness vs. Aging Days

CASE HISTORY

North American Tissue Machine

A typical North American tissue machine with the following operating parameters demonstrates the difference in the cover's bond line temperature between the non-premium and premium rubber covers. The machine parameters are as follows:

Machine Speed:	1860 m/min
Yankee Temperature	110 °C
Roll Loading:	79 kN/m
Pressure Roll Diameter:	88.6 cm
Yankee Diameter	457 cm
Number of Felts	1

The rubber covers are 30 P&J Dri-press drilled rolls. The nip dynamics that are predicted[2] are shown in Table 3.

Material	**Max Stress (kPa)**	**Max Temperature, bond line (°C)**	**Required cooling water**
Non-Premium	2015	89	24 L/ min
Premium	2005	76	None

Table 3: Nip Dynamics for North American Tissue Machine

The above results indicate that the premium cover provides the same maximum stress as the non-premium cover while operating 13 °C cooler. The cooler running cover will harden less over time providing a longer lasting cover while at the same time eliminating the mill's water cooling requirements. The savings are substantial.

COATER BACKING ROLLS

The typical application hardness for coater backing roll is 45-95 PJ. The required cover properties are:

- *High wear resistance* - to maintain surface properties
- *Resiliency* - to withstand the pressure impulse
- *Chemical resistant* – to be compatible with coating chemicals
- *Mark resistance* – to prevent sheet defects
- *Hardness stability* – to provide a consistent nip and coating
- *Crack and tear resistance* – to prevent damage
- *Surface release properties* - to provide uniform coating transfer

Traditionally, older generation backing roll covers have performed well. However, these covers were susceptible to damage and profile issues due to cover wear and denting resistance. Two sources of cover issues were wad damage and dry edges outsides the sheet run. The covers could mark and /or crack and needed to be removed. The covers would show cracking or burning on the cover edges from blades or rods wearing on the cover outside of the sheet area. With improved wear resistance and better tear and tensile properties, backing roll covers now have the ability to prevent these issues, and allow the cover to maintain the proper profile. These new premium covers allow the mill to extend the run time of the cover in the machine. This can be attributed to the improved abrasion resistance of the new cover as shown in Figure 8. The improvements are significant to mills because it allows them to extend roll changes and have more predictable roll change intervals. A few examples of the benefits of the premium coater backing roll cover shown in Table 1 are illustrated below:

1. A *board mill* increased the run time from 90 days to over 180 days. Previous covers had to be removed at 90 days due to edge cracking.
2. A *lightweight coated* mill had a normal run time of 90 days while the Hypercoat cover could run for over 180 days.
3. A Midwestern *coated mill* increased their run time from 45 days to over 75 days. In addition, the operators liked the fact that the cover could be sanded without hurting the profile of the roll.

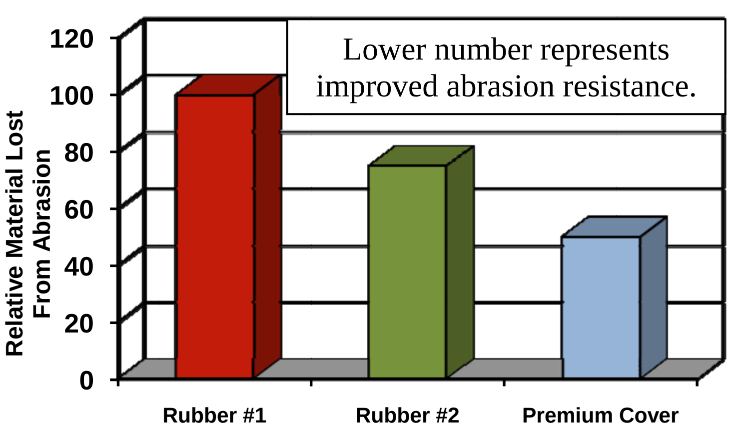

Figure 8: Abrasion Resistance

DYNAMIC NIP MEASUREMENT TECHNOLOGY:

Improved cover technology, Engineered Nip analysis (engineering optimum nip intensity and nip width as explained in the press section case history) and dynamic nip measurement technology are providing verifiable benefits to paper mills. Dynamic nip technology allows the measurement of the nip pressure in real time while the roll is running in the paper machine.

Case history: A soft press roll cover was used in a first press position with dynamic nip measurement technology for a bleached board machine running at 365 mpm and 45 kN/m load. The goals of this project were

- Engineer covers for optimum nip intensity and nip width
- Improve sheet solids
- Improve sheet bulk

The press configuration is shown in Figure 9

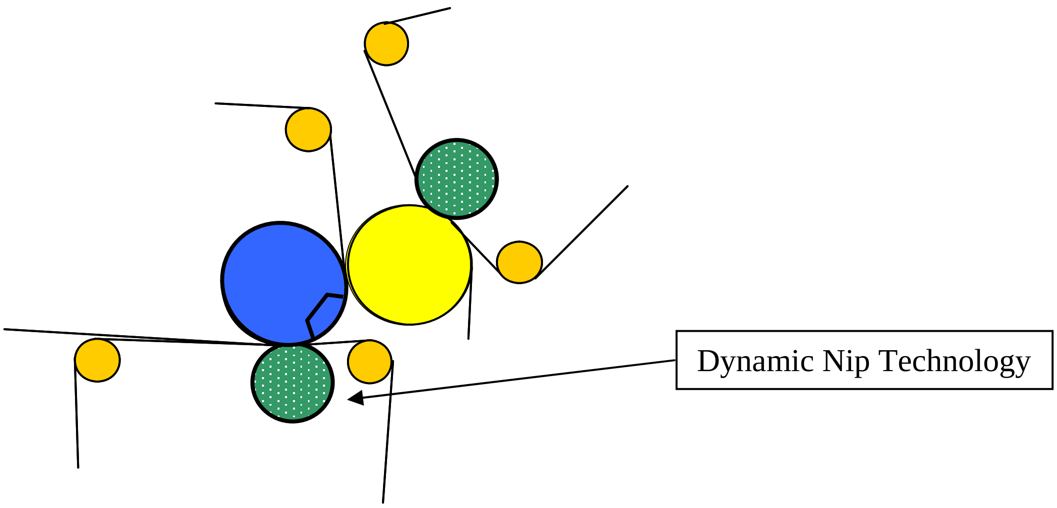

Figure 9: Press Configuration with Dynamic Nip Technology

An engineered nip study was done to evaluate theoretical dryness improvement potential of different cover hardness values. Based on those studies, a 40 PJ rubber roll having Dynamic Nip Technology was installed in the 1st bottom press. The dynamic nip technology allowed the monitoring of the nip in real time. The mill was able maintain a uniform profile at increased loading. The benefits realized by the mill are summarized below:

- Increase sheet bulk
- Reduced fiber usage by 3-4%
- Improved CD moisture and caliper profile
- Total operating saving of $700,000 due to less fiber use including savings due to longer life of the cover

CONCLUSIONS

The improved performance of rubber covers in press, size press, Yankee pressure, and coater backer rolls has been illustrated. By improving the material properties of the rubber covers used in these positions, real operational benefits are realized by the papermaker. While rubber covers have been used for paper machine roll covers for over 100 years, new developments continue to improve the performance of these covers. Improvements in wear resistance and toughness allow the covers to run longer and be more damage tolerant. Improvements in material dynamic properties and bonding systems allow the covers to run without water-cooling. This true “green” technology can save the papermaker operating costs and reduce water usage. Continued development of rubber technology will provide even further improvement of these cover materials in next several years.

References

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2. Moore, R.H. and C.C. Moschel, “ A Tool for the Engineered Nip”, TAPPI Engineering Conference, (1993).