ADVANCEMENTS IN COMPOSITE ROLL COVER TECHNOLOGY FOR CALENDER APPLICATIONS

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ABSTRACT

This paper will discuss the latest developments in composite calender roll cover technology. The developments that will be discussed are improved wear resistance, impact resistance, temperature resistance, and barring resistance. The focus will be on the physical material improvements in the covers and how these improvements affect the performance of the cover in the calender. In addition, this paper will discuss the impact that these improvements will have on improving grind intervals and reducing unplanned roll changes. The impacts of these changes will be shown for all types of calenders. (soft calender, supercalender and Multi-nip calenders) This paper will also discuss the use of the latest nip monitoring technology in calendering cover applications. A few success stories will be included in this paper.

INTRODUCTION

Composite calender roll covers have been used in calender applications since the late 1980's. Prior to that time only cotton filled rolls were available for calender applications. Since that period of time there have been many improvements to the materials, and the manufacturing of the composite calender roll covers. There have also been many improvements in the calender operations.

The original composite calender roll covers had a large number of issues. The covers were susceptible to impact damages. The covers did not have very good wear resistance. This caused the grind intervals for the original composite covers to be shorter than the cotton rolls that were the cover of choice at the time. The poor wear resistance caused the profiles of the rolls to become poor very quickly. The main advantage of the early composite covers was the ability of the cover to handle higher temperatures and loads than the cotton roll cover.

The original composite calender roll covers used resin without reinforcing fiber. The resin did not contain any fillers. As the calender roll covers advanced, fillers were added to the resin cover in order to improve the operation of the covers in the calenders. The original fillers were as large as 4-5 micrometers compared with fillers that are now as small as 5 – 15 nanometers. The fillers that are added to the composite cover help the cover to achieve longer grind intervals due to improved wear and impact resistance. Because of the initial large size of the filler particles the cover surface would lose some of its smoothness when the filler would eject from the cover. This is a phenomenon called "orange peel". It generally shortened the grind interval for the composite covers because of the roughening of the cover surface affected paper quality.

The resins that were originally used have been improved through significant research and development. The original common filler type was wollastonite which helped to improve the wear and impact resistance of these covers. The filler materials have changed from a clay type of material to silicon carbide and to titanium dioxide. These new fillers are significantly harder and tougher than the earlier clay type materials. These new materials have significantly improved the wear and impact resistance of the composite covers.

Originally, there were issues with the viscosity being too high when additional fillers were added to the resin. This was especially true when the filler content became higher. The resin and fillers were mixed initially using torsion and/or paddle mixers. These mixers worked fine for the original mixture of fillers. However, when additional fillers, and especially when smaller fillers were added to the resin the resin became too viscous for the resin to flow onto the roll cover surface. Because of this it became necessary to use a shear mixer with blades. This shear mixer helped to overcome the thixotropic properties of the resin mixture. The thixotropic property is the affect where a fluid is thick under normal conditions, but becomes less viscous and will flow when shaken or agitated. Because of this phenomenon, new mixing machines were required and the time needed to mix the resin went from 4 hours up to 12 hours.

The original composite calender covers were manufactured using a process called flat pass wrapping technology. Flat pass wrapping technology is a process where the Kevlar is wrapped using a method where the wrapping machine passes back and forth in a flat fashion to build up the cover until the cover reaches the desired diameter. This method gave the roll cover an excellent surface finish and good strength. The issues associated with this wrapping method are that the wrapping machine would have issues called resin rich areas or dry edges. Resin rich areas are areas of the roll where the fiber tension is too high, and the resin is heavier in one area compared with other areas on the roll. This causes a weaker area in the cover compared to other areas on the roll cover. These areas are susceptible to damages from events that normally would not cause any issues with the roll cover. Dry edges is a situation where parts of the cover have less resin than desired and it causes the edges of the Kevlar fiber to be exposed and cause rough areas in the cover of the roll. These rough areas of the roll affect the paper quality, and require that the cover be removed and reground.

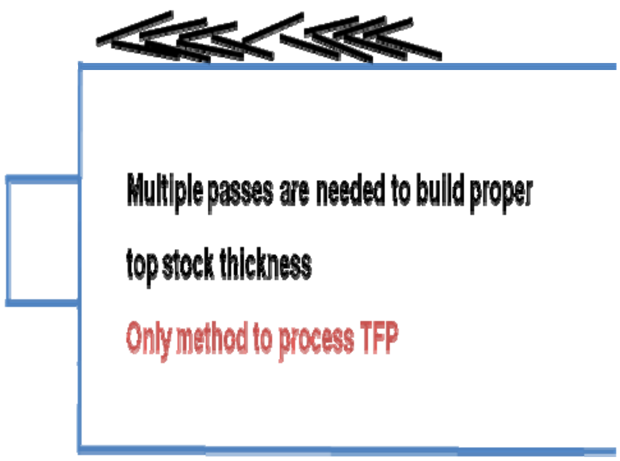

Fig. 1 Flat pass wrapping technique

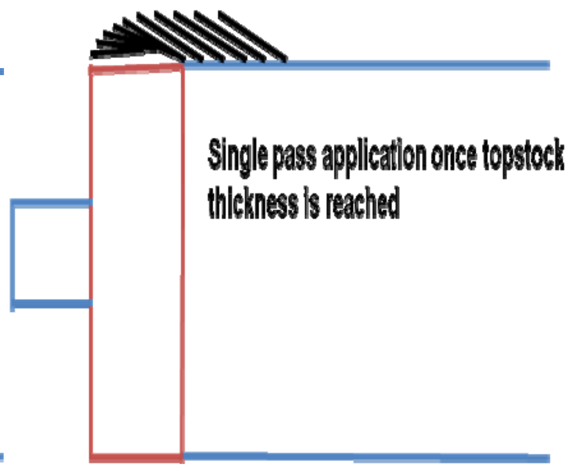

Fig. 2 Angle wrapping technique

The new covers are manufactured utilizing a process called angle wrapping. This is a method where the cover is built up to the desired thickness on a temporary can added to the roll. This temporary can is shown in red on figure 2. The Kevlar is turned at an angle and the entire top stock of the cover is manufactured in one pass of the wrapping station. This process gives the cover higher fiber fraction which in turns gives the cover additional strength and wear resistance. One additional benefit of this cover manufacturing method is that it produces a more consistent cover surface. The cover is more consistent because of the fact that the entire cover is in the same pass, and there is no variation in the passes.

Initially, the grind intervals for composite calender roll covers ranged from 7 – 90 days. Approximately 25% of all composite calender rolls were damaged annually. This made the use of composite calender rolls a costly proposition, both financially and in terms of maintenance hours. In addition, this performance affected the confidence of the operations staff in the use of composite calender roll covers.

CONCLUSIONS

The current composite calender rolls are now averaging grind intervals ranging from 30 – 365 days in the machine. Approximately 5% of all current covers are damaged annually. The use of cotton rolls has been eliminated in all applications with the exception of supercalenders, where there are a small percentage of mills that still utilize cotton rolls. All of these improvements have occurred at the same time that the speed of the machines have increased which means that actually rolls are running even more paper through the machine. What caused this tremendous improvement in composite calender roll operation?

The improvement in calender operation efficiency is a combination of improved cover materials, improved cover manufacturing, calender improvements, and improved calender operating procedures. The improved operating procedures include the operators being made more aware of the differences between cotton rolls and composite calender covers. In addition, operators have been trained to eliminate situations around the calender that in the past would cause issues that could lead to damaged roll covers.

There have been several calender improvements that have been developed to increase calender operating efficiency. Some of the factors that have been utilized in order to improve calender performance are as follows:

- Eliminate the paper wraps that occur during sheet breaks. Some of the methods that are used to accomplish this are sheet break detectors located throughout the machine with web cutters throughout the calender. Another method that is used to improve the operation is to incorporate quick opening software on the calender to prevent the web break from wrapping on a loaded roll.
- Another improvement is in calender technology that insures that the calender is closing evenly which eliminates uneven loading. Uneven loading causes roll cover and steel roll damage, additional machine wear, and other machine maintenance issues.
- The use of roll weight relief in multi nip calenders allows the calender to operate at a lower nip pressure because the top nips are loaded at the same pressure as the bottom nips.

These are all important factors in the improvement of the calender efficiency, and contribute to the improved operating efficiency. But the largest factor that contributes to the improvement in the calenders is the continuous improvement that has transpired in the composite calender roll covers.

The first improvement in composite calender roll covers is in the fillers that are used in the resins that make up the covers. There are several resin improvements that have improved cover performance over the past 25 years. These improvements include the filler types which now include silicon carbide, and titanium dioxide to improve the wear resistance, and impact resistance of the cover. In addition, the filler size has been significantly reduced from 5 micrometers down to 5 nanometers.(see fig.4) In fact the fillers are now considered nano-particles. This is an important development because the smaller material size enhances the performance of the filler in the cover in several ways. One of the advantages of the smaller fillers is that the fillers can be more densely distributed throughout the cover. This improves the cover toughness, and improves wear resistance of the cover. Because the fillers are smaller, and more densely packed into the cover this helps to eliminate the propagation of any fractures that may occur in the cover. The smaller sized fillers also give the covers a better surface finish which gives better quality paper. In addition, the smaller particles all but eliminate the affects of “orange peel” that was an issue with earlier cover designs.

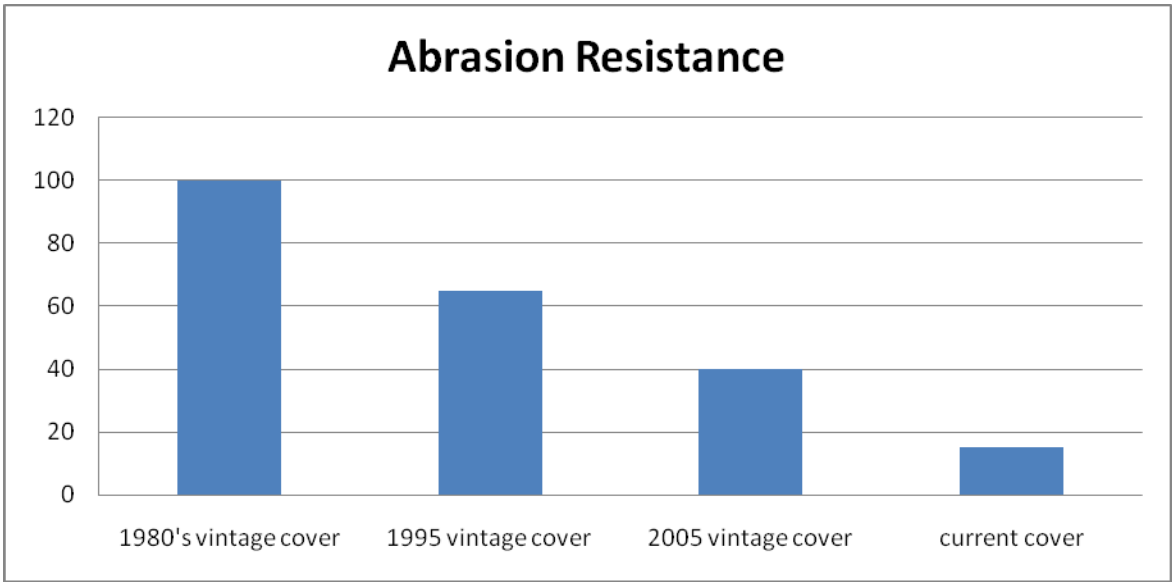

Figure 3 shows the improvement in abrasion resistance of composite calender rolls

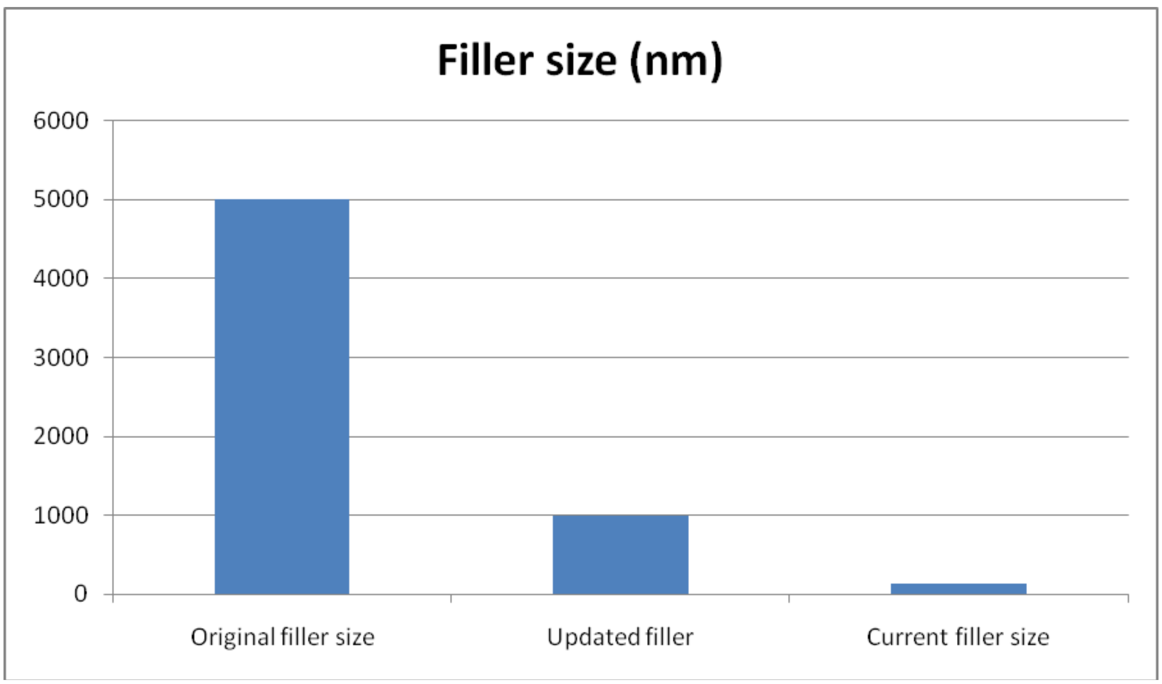

Figure 4 shows the reduction in filler size for composite calender roll covers.

The cover materials have also improved. The cover materials have been developed to create a more homogeneous temperature across the surface. This is critical because one of the largest issues with composite calender covers is temperature variation. This new resin allows for the temperature to be more evenly distributed across the face of the cover. In addition, Stowe Weavexx has developed the ThermaGuard base that allows the temperature that develops into the cover to be more evenly distributed to the roll body which acts like a large heat sink. Traditionally, base material has been mainly made from fiberglass which is an insulator. The new base allows for conductivity through the base material, this allows any heat that was built up to move from the top stock to the steel core that acts as a heat sink. The combination of these two materials has drastically improved the performance of composite roll covers in calender operations and virtually eliminated the issues of temperature variation in composite covers.

New cover material has also been developed that greatly enhances the ductility of the composite calender roll cover. This improved ductility allows the cover to dent without causing a fracture in the cover material. This also allows the cover to come back to its original position after it has been dented. This enhancement allows for the cover to be less likely damaged after it is involved in an incident where there is localized high loading or if foreign material is passed through the nip. This type of technology is especially critical for use in machines with older technology, because they do not have all of the safeguards that more modern machines have.This technology is utilized into the Genesis calender roll cover.

Another improvement in the cover manufacture is the method for applying the Kevlar fiber to cover. The new method utilizes a wrapping technique which is called angle wrapped. The angle wrapped covers are manufactured in a single pass of the wrapping machine. By manufacturing the cover in a single pass the cover surface is homogeneous which makes for a more consistent cover surface. The use of angle wrap technology has eliminated the issues of resin rich areas and dry edges on composite calender roll covers. An additional advantage of angle wrapped covers is the fact that the roll cover has more fiber fraction. This is due to the fact that there is more Kevlar per square inch than by using the flat pass method for wrapping a calender roll cover. The additional Kevlar gives the cover additional toughness, strength and improves the wear resistance of the cover.

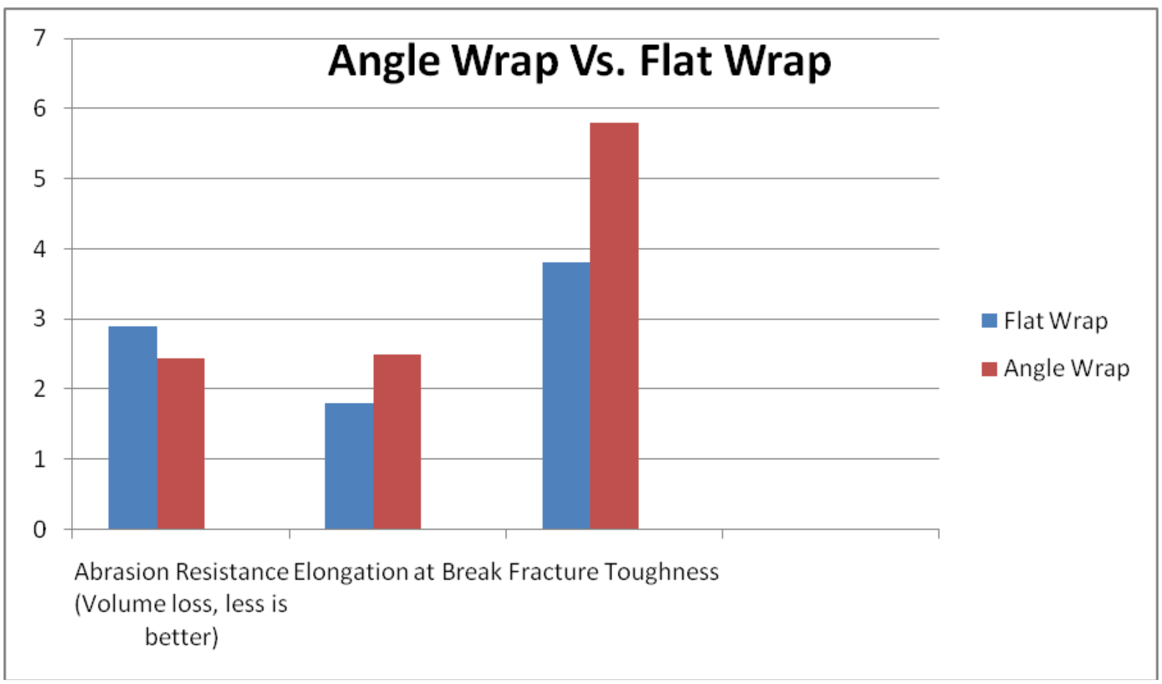

Figure 5 Plot showing the advantages of angle wrap technology compared with flat wrap technology

The manufacturing techniques have also improved the performance of composite calender roll covers. This includes the use of computerized controls on the roll wrapping machines. This improves the consistency of the cover that is produced. There is also much better tension control on the Kevlar fiber which helps to make a more homogeneous roll cover. Improved mixing machines have been implemented in the resin areas of the composite calender roll manufacturing. This new mixing technology allows for the use of nano-particle technology. These new mixing machines also allow for improved disbursing of the fillers evenly throughout the resin. All of these improvements help to insure that composite calender roll covers are more consistent and homogeneous.

The use of Stowe Weavexx's SMART roll technology has allowed for continuous monitoring of the roll cover while it is operating in the machine. This technology has been used in the press section of the machine for several years. This technology has been enhanced to allow it to be used in the higher loaded calender applications. The software was also revised to allow for the technology to operate in double nip applications that are seen in supercalenders and multi nip calenders. This technology has sensors embedded into the cover surface that are continuously monitoring the intensity of the nip. This is very useful in determining how flat a nip is, and how even the loading is across the face of the cover. This combination assists with making a good quality sheet as well as preventing damage to the cover surface. This technology has prevented a cover failure because during one run there was an issue with a loading cylinder that was detected, and prevented a roll cover failure.

One issue that has arisen from the improved cover performance is that there are more issues with barring on the composite calender roll covers. This is largely due to the fact that the covers are in the machine for a longer period of time. This barring shows up in the cover, but is normally created at a different location on the machine. The reason that this is showing up now is because of the fact that the covers are operating longer in the machine and the affects of barring is cumulative.

The improvements in calender roll cover technology have helped to improve the efficiency of calender operation as well as the quality of paper that is being manufactured. These improvements are allowing the paper industry to lower their costs and improve the quality of paper manufactured on the calenders.