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CALENDERING & EMBOSSING OF NONWOVEN COTTON WEBS

D. Steve Gunter
BF Perkins
Sanford, NC

Abstract

As far as the Calendering of a cotton web is concerned, except for the differences of fabric handling the Calender/Embossing Machine does not distinguish between circular or warp knit, or various woven or nonwovens or other formed fabrics. Special attention will be given to the blending of cotton with other fibers both natural and synthetic to form composites and laminates. Also discussed will be the post finishing of needled, stitch and chemical bonded webs and the lamination of these webs to films and other woven or knit formed webs.

As far as the Calendering of a Cotton Web is concerned, except for the differences of fabric handling, the calender machine does not distinguish between circular or warp knit, or various woven or non-wovens or other formed fabrics.

Calendering by definition is mechanical finishing process for fabrics or webs to obtain or produce a special effect. Such special effects could be luster, compacting, glazing, moiré, Schreiner and embossed patterns. In this operation, the fabric is passed between the calender rolls at a calculated speed [dwell time in the nip]; under precise pressure [PLI or pounds per lineal inch] and often these rolls are heated to a predetermined temperature to obtain the desired or more lasting effect. Therefore, three mechanical operating parameters must be controlled: speed, temperature and pressure.

In addition to these three parameters, consideration must also be given to back-up roll design and filler, wear resistance of top rolls and filled rolls, effects of fabric finishing chemicals on rolls, web tension and control and profile of roll temperature, Also, resins or chemicals are used in the fabrics to obtain higher gloss or often, to instill the permanency of the special effects. Care must be taken to match the Calendering operating parameters with these fabric-finishing chemicals so that burst strengths and other properties can be maintained.

Cotton and other naturally occurring fibers react first and foremost from mechanical deformation where you must physically “break the back” or defeat the physical memory of the fiber. Whether still in the as grown fiber/staple form or after a pulping process where you might convert the cotton staple into a paper type web the ability of the cotton to form a web is totally dependent on the inter-fiber cohesiveness of the cotton itself to hold itself together. For this reason most Calendering processes utilize high pressures in the presence of some heat in order to achieve the various Calendering objectives. When embossing, patterns must be selected that are deeper than the web is thick and require the back-up roll to actually push the web into the pattern. This type of embossing is known as “geared” embossing and the roll diameters must be perfectly matched circumferentially and also kept in timing with one another.

Rolling Calender

The function of a rolling calender is to provide a smooth or gloss fabric surface as well as to improve hand. It can process all types of cloth, but predominantly is used on high content cotton woven/non woven fabrics or knits **[Photo 1]**. This operation is very effective to improve the drape in a latex impregnated cotton web.



Photo 1. Three Roll Rolling Calender

The unit can operate at speeds of up to 150 yards per minute, although NonWovens generally run at 30-35 yards a minute. Nip loading is 500-2,500 PSI. This is an open frame type calender with bottom loading and a bearing type of double row spherical rollers. It has hydraulic rams that develop up to 3,000 PSI maximum with integral jackscrews.

Normally, the unit comes as a three roll calender with alternate steel and filled rolls, although it may also come with two, four or five rolls. The intermediate resilient roll is of wool felt paper, cotton, khaki wool and resilient wool and cotton blends.

The main roll, which is the top steel roll, is driven by a variable speed motor, either directly or through a roller chain drive, while the intermediate filled roll can be driven with off nip drive. When required, the steel roll can be heated by gas, hot oil, electric or steam up to 410 degrees F.

Among the special features of the unit is an oil circulating system for bearing boxes that is required for roll heating systems over 300 degrees F. A freestanding console is provided for the hydraulic and electric systems control as per OSHA regulations.

Silk Finishing Calender

The main function of the silk finishing calender is to provide a smooth fabric surface, light luster and improved hand. It can process all types of fabrics, but it is used mostly for high content cotton and coated or impregnated webs. The unit can operate at speeds of up to 100 yards per minute, although knits are normally run between 30-35 yards per minute. Nip loading is 400-700 PLI **[Photo 2]**. The wide nip flexes and releases the web causing a disruption between the bond points which serves to “soften the hand” of the web but can also strengthen the web by enhancing the inter fiber cohesion.

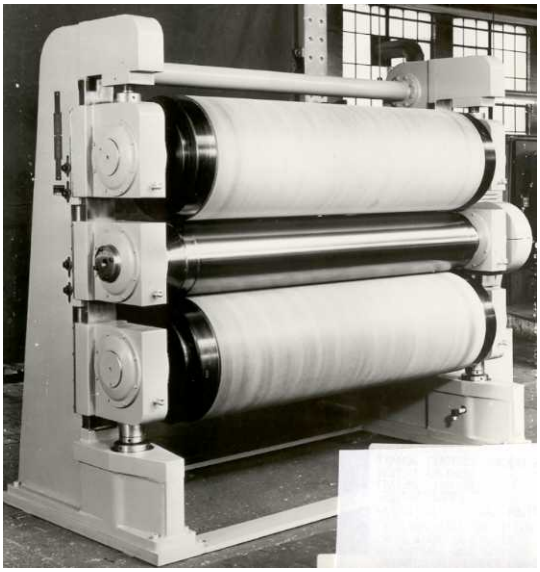


Photo 2. Silk Finishing Calender

This unit is also an open front frame with bottom loading with double row spherical roller bearings. It has hydraulic rams with a maximum of 3000 PSI with integral jackscrews.

The silk finishing calender has a three-roll configuration with a top and bottom filled roll and a steel middle roll. The filling is of cotton/wool blends.

The main steel roll, which is driven by a variable speed motor and roller chain, can be heated by gas or steam to surface temperature of 350 degrees F. Optionally, the two auxiliary filled rolls can be driven off nip drives. The unit has a circulation system for the bearing boxes which are required for roll heating systems over 300 degrees F.

Friction Calender- Not for Cotton NonWovens

The main function of a friction calender is to polish Cotton fabric surfaces to a very high gloss or "Down Proofing" and water resistance. It is normally used on apparel fabrics of natural yarns such as cotton that are woven and on linen drawing cloths. These fabrics must be very strong and withstand tremendous tension in the Calendering nip

A friction calender can operate at speeds up to 35 yards per minute; it has a nip loading of up to 2,500 PLI with the average being 1,500 PLI. This is also an open front frame type calender having a bearing type double row spherical roller. This hydraulic ram type can generate a maximum of 3,000 PSI with an integral jackscrew.

This is a three-roll calender and the intermediate roll has a filling of 100% heat resistant cotton (HRHC). The main drive to the top roll is by a mechanical variable speed motor and roller chain while the auxiliary roll is driven by a roller chain drive from top to bottom usually with a 2.1 rotating in the same direction.

Both the top and bottom roll are heated with the top roll heated to 350-420 degrees F. and the bottom roll to a maximum of 150-250 degrees F. The unit features a jaw clutch from top to bottom roll to disengage the drive when the machine is to be used as a rolling calender **[Photo 3]**.

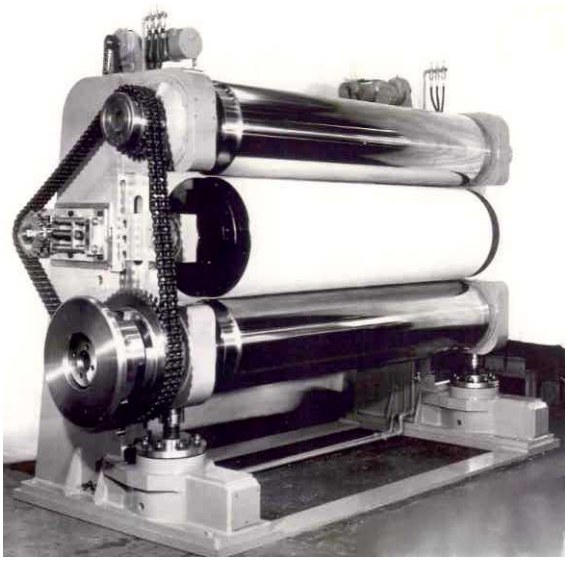


Photo 3. Friction Calender with Clutch

This clutch actually "brakes" the Bottom roll and because the co-efficient of friction of the web, cotton roll and the bottom roll are similar - they stick together as the top, smoother, roll slides by at twice the speed.

Schreiner Calender

The function of the Schreiner calender is to texture fabric surface to obtain a controlled opacity, a desired softness, luster and translucency, which are obtained because of a change in light reflectance. The Schreiner derives its name from the pattern which is 260 lines per inch at a 26 ½ degree angle and only .001" of an inch deep. This pattern physically can consolidate the filament/fibers by as much as 4% to 16%. The unit can handle natural, synthetic and blended apparel fabrics that are both knit and woven. For knits, a Schreiner calender provides improved hand, surface texture and more cover, while for woven goods it offers more texture and drape. It is also used for softening latex impregnated Cotton non-woven webs.

A Schreiner calender can operate at speeds up to 30 yards a minute with a nip load normally at about 1,200-1,500 PLI with 1,500 PLI maximum. This, too, is an open front frame type unit with a bearing type double row spherical roller; the hydraulic ram type generates 3,000 PSI with integral jackscrew **[Photo 4]**.



Photo 4. Three Roll Schreiner

This calender is usually a two or three roll machine, with the third roll added to smooth the filled roll and reduce crowning requirements. The top roll of forged steel is engraved with 250-300 lines per lineal inch at 26 1/2-degree

angles to the horizontal. This roll is normally chrome plated with no crown. The Schreiner pattern is 0.001-0.002 inch deep.

The bottom, or intermediate roll [when using a three-roll configuration], has a filling usually of wool felt paper. For high content cotton fabric, a heat resistant cotton roll is preferred and in many cases, where picking is not a problem, resilient wool and cotton is preferred to gain added resiliency in the filled roll. The bottom roll, when the calender has three rolls, is of forged steel.

A variable speed motor and roller chain drive the main top roll while the auxiliary filled roll is driven off a nip drive. This is standard in the two-roll unit and optional on the tree roll machine. This is used to maintain rotation when the nip is open to prevent localized burning. It is also used in jumping seams or to assist in rewind drive when opening and closing the nip to prevent roll scuffing or abrasion of the surface.

The top roll, or the bottom roll on a three roll machine, can be heated to 350 degree F. for high content cotton and cotton blend fabrics. This is usually obtained with high-pressure steam, gas or circulating oil. For synthetic or high content synthetic blends, the roll can be heated to 450 degrees F. This normally requires a gas or hot oil system.

This unit, too, has an oil circulating system for the bearing boxes required for roll heating systems over 300 degrees F.

Embossing Calender

The function of an embossing calender is to impart a texture or pattern to the surface of the fabric. It can be accomplished on all types of fabrics including woven, non-woven and knitted cloth. Embossing calendars can operate at speeds up to 50 yards per minute and have a maximum nip loading of 1,500 PLI. Cotton NonWovens as do wood cellulose webs require that the pattern be such that it will “break the memory” of the fiber thru the use of pressure and a pattern that will displace the fiber into the desired shape.

An open front, frame type calender with bottom loading arms, the unit features a bearing type double row spherical roller. It is a hydraulic ram type with a maximum of 3,000 PSI with integral jackscrew.

Embossing calendars are two roll machines using a forged steel top roll and a filled bottom roll with the filling of wool felt paper, resilient wool/cotton or, in the case of signature or "Kiss" embossing. **[Photo 5]**



Photo 5. Two Roll - Steel on Steel Embosser

Where a slight glaze or luster is preferred, a higher cotton content filling in the back up roll is required. A synthetic shelled bottom roll can be used in lieu of a fiber roll.

Drive to the top roll is by variable speed motor and roller chain. Frequently, gearing drives the filled roll from top roll usually in a two to one ratio. A gear head motor in the absence of gears can also used for an off nip drive where localized burning must be prevented with the nip open.

The top roll can be heated by either high-pressure steam or gas or closed loop circulating hot oil systems. For natural fibers such as cotton and cotton blends, the roll can be heated to 350 degrees F., while for synthetic woven goods and knits, it can be heated up to 450 degrees F. **[Photo 6, 7, & 8]**.



Photo 6. Two Roll Light Duty Embosser



Photo 7. Turret Embosser - Four Pattern Rolls

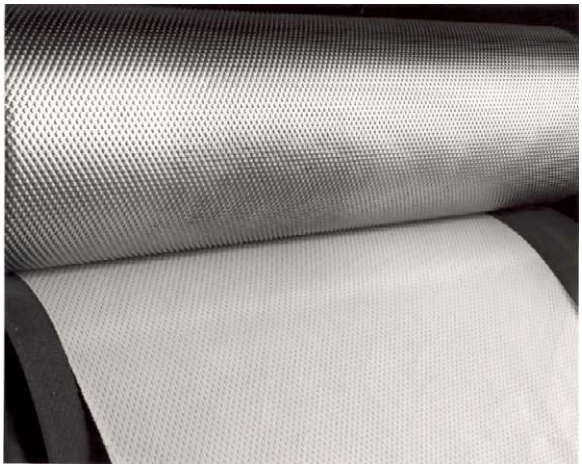


Photo 8. Engraved on Rubber Embosser

Ciré Calender-primarily Synthetics

The Ciré calender is used for glazing and glossing fabric surfaces using both high temperatures >425 F and high pressures >1500 PLI. Some porosity reduction and compaction is also obtained through this process. All types of fabrics can be processed, but usually they are of 100% synthetic fiber or high synthetic fiver content blends. The units can operate between 30-35 yards a minute and have a maximum nip loading of 1,500-3,000 PLI.

An open front frame type machine with bottom loading and has a bearing type double row spherical roller. It has hydraulic rams with a maximum of 3,000 PSIG.

This is a two or three roll calender **[Photo 9]**

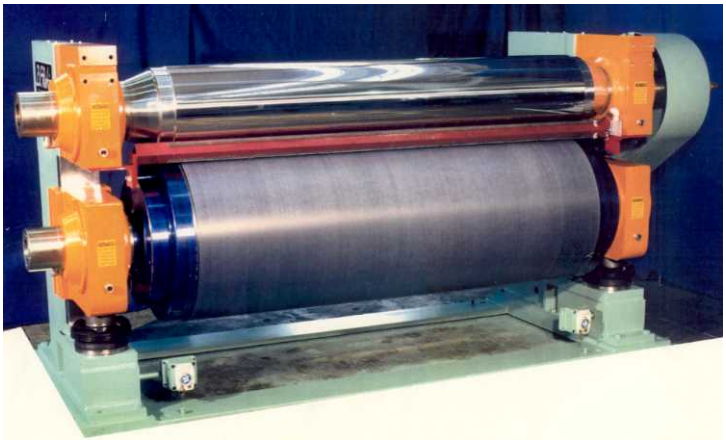


Photo 9. Two Roll Ciré

Depending on the width of the calender face with the rolls of steel on filled roll and the filling is usually cotton. In a few instances Nylon or Urethane shells are used. The top or main steel roll is driven through a variable speed motor and roller chain with an optional drive to the auxiliary roll, which can be driven off the nip drive. In few applications, steel on steel nips are used to create a “celluloid” type of web used for specialty insulators.

The steel rolls can be heated to a surface temperature of between 350-500 degrees F. gas or hot oil. The unit has an oil circulating system for bearing boxes that is required for roll heating systems over 300 degrees F.

Heat Transfer Printing Calender

The purpose of this calender is to place printed pattern on the fabric. This is accomplished by placing the cloth and a printed-paper in close contact. Through a dwell time the dies on the pre-printed paper are allowed to sublimate

and fix themselves onto the fabric surface. This can be achieved on fabrics with high content polyester or nylon as well as with some cotton blends, depending on the paper used. Cotton webs typically require temperature protection treatments that must be removed after printing. (I.e. formaldehyde)

Transfer printing calendars can operate at speeds up to 30 yards a minute with normal mechanical operating temperature of 410 degrees F. using a blanket pressure of up to 70 PSI; a blanket to drum pressure of 18 PSI can be developed.

Hi-Dwell calendars come in a variety of main drum diameters up to 72 inches with a calender face usually of 80 inches. Calender faces of up to 200 inches can be made available.

The design of the Hi-Dwell machine **[Figure 1]**

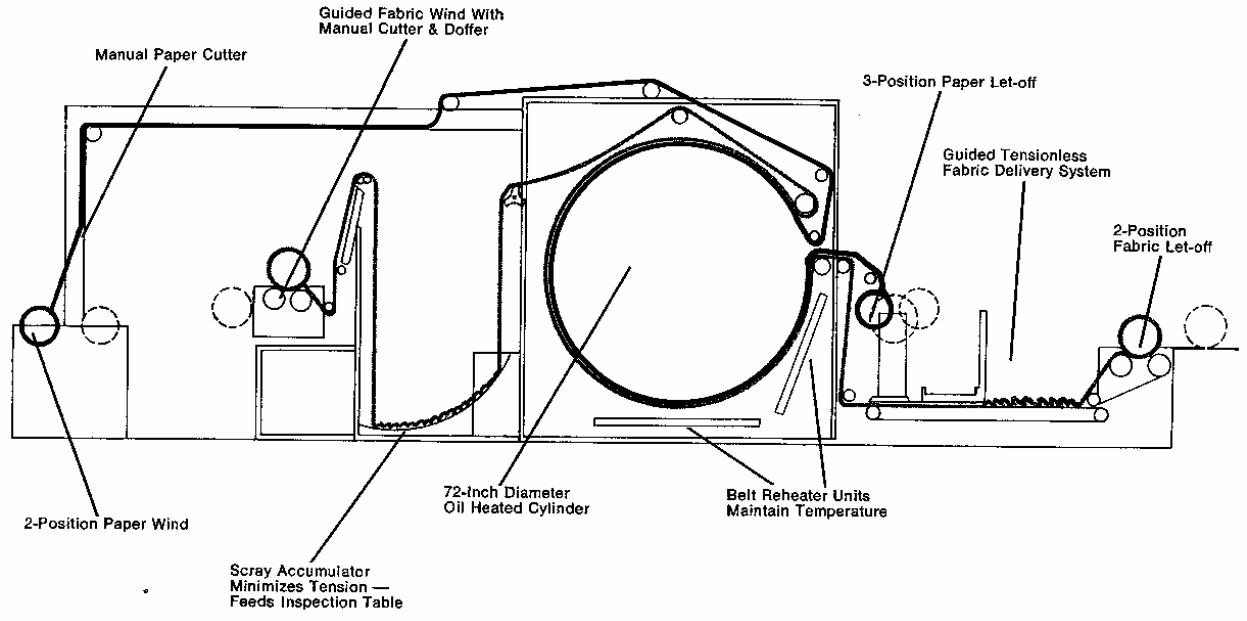


Figure 1. Hi-Dwell Calender System

This design utilizes an endless belt that is wrapped 270 degrees around the main drum's circumference to allow the required dwell time while placing the fabric and the transfer paper medium in close proximity. Drive to the main drum is through a variable speed motor with the actual processing speed dependent on the unit's ability to handle the fabric and the sublimation qualities of the dies. Main drum heating is best accomplished by double shell roll construction with a forced loop hot oil system.

Heating Systems

There are many types of heating systems available for calender roll heating. The following are the most popular type systems and their operating limitation. The typical maximum temperature for cotton fibers or pulp is 360 F.
Steam normally with steam, wider roll faces are required in order to obtain the middle roll profile necessary to get the desired BTU transfer. With a steam heated roll, which has a 2"-5" bore, a $\pm$ 10% variation in heating profile across the roll can be expected. Normal maximum temperature is 250 degrees F.

Electrical or cal-rod heating system: This system is very similar to steam heat insofar as profile, but while normally with steam heat the middle two-thirds of the roll face has a workable profile, with electric heating only the middle 50% of the roll face can be used. While steam heating has a gradual drop off in temperature at the end of the roll, the electrical heating systems have a more acute drop off. Normal maximum temperature is 450 degrees F. gas heating system. This normally uses a ribbon type burner and a four-inch bore steel roll. The middle 80 per cent of the roll surface can be used with this type of system because the gas heating system profile is normally a $\pm$5 percent

profile. Normal maximum temperature is 500 degrees F., special to 1600 degrees F. Profile able burners can achieve ±2 deg F profiles.

Hot Oil heating system. When using a spiral turbulator, the turbulator is fitted to a four-five inch bore steel roll and by using a closed loop hot oil system through rotary joints, the hot oil is turbulated or passed through the spiral and the journal bore. This is normally a good system for low BTU transfer applications. Between 90-95 per cent of the roll face can be used. Normal maximum temperature is 550 degrees F., special to 750 degrees F.
Hot oil circulating system: When using a double shell roll, **[Photo 10]**

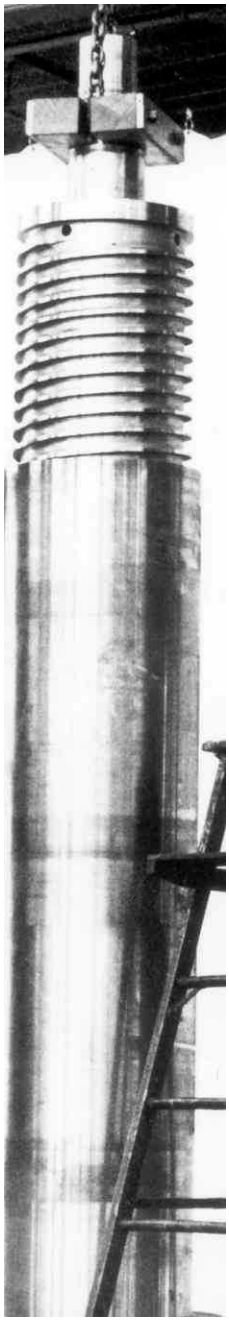


Photo 10. Double Shell Steel Roll

the roll is constructed by using solid inner core in which canals are machined into the face of the inner forging and then a press fitted outer shell is placed over the inner shell. When fully constructed this will allow hot oil to pass

through the shaft by a rotary joint and then spiral out around the inner face of the outer shell and go out the opposing shaft by a rotary joint. Reasonable, a ±1 degree F. differentiation can be expected anywhere on this roll surface. Therefore, 95% of the face of this designed roll can be used. The normal maximum temperature is 550 degrees F., with special application to 750 degrees F.

Resilient rolls

We now address ourselves to the various types of resilient rolls that are available and perhaps the most unusual of all applications for a COTTON NONWOVEN. These fiber filled rolls are commonly referred to as calender bowls. They are made in high tonnage presses as these rolls require up to 120,000 tons of pressure to compact to the required density in order to use them as calender bowls. By example a finished roll 24" in diameter by 90" face with a 12" thru shaft will have 2000 lbs. of cotton compressed in an area 1/8th of its relaxed space. These rolls are as hard as a Nylon or Polyurethane Shell but afford ability to Densify in a nip creating up to 40% more effective heat than the adjacent heated steel roll.

There are various types of calender roll fillings available, but all calender rolls are very similar in construction, **[Figure 2 & Photo 11]**.

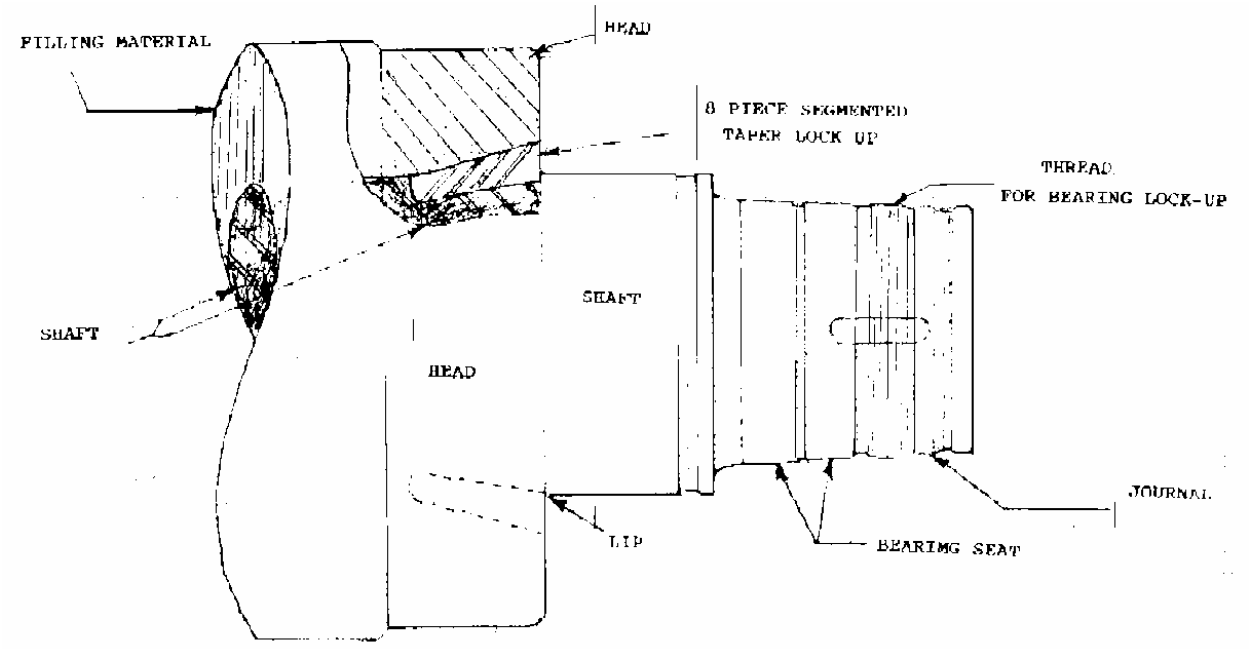


Figure 2. Fiber Roll Diagram



Photo 11. HRHC® Cotton Filling

The internal shaft is normally a minimum of 50 per cent of the outer diameter of the completed roll. The heads of the roll are normally one-half inch in diameter smaller than the outer diameter over the face of the filled roll. The actual filler of the roll is wafers or donut form, which are normally compacted in the press one inch larger than the finished roll diameter required. The area of the lock-up may vary from a screw ring to a taper type lock-up.

Generally, the harder the roll, the less resilient the roll will be in operation. This decreases its ability to take a deformation and recover from a seam or a fabric imperfection. While the roll may be less resilient, a harder roll is more resistant to burn because of its increased density and in many cases, is far more durable.

The longer the fiber used in roll filling, the smaller the micronaire or diameter of the fiber. Therefore, fibers can be compacted into more dense filler. This takes advantage of the inter-fiber cohesion of these fibers and therefore, gives greater strength, heat resistance, and durability to a filled roll.

When cotton fibers are used in a filled roll, the most glazing is normally obtained. When the cotton fiber is scoured the more burn resistant the resulting roll will become because of the removal of impurities

Wool rolls at the same Durometer as cotton rolls are more resilient, but they are less strong. A normal rule of thumb is that "wool kills finish". This is because of the natural scales, which are found on wool fibers. Often it is found that these wool scales will pick or will be abrasive to synthetic staple or filament yarns and will most certainly dull the fabric face.

The next type of filler used is paper type filler. Paper fillers can be of wool felt paper. This is normally used in embossing calendars because the short wool fibers are easily broken and will retain the pattern that is pressed into it by the top engraved roll. Often a cellulosic fiber paper will be used because the cellulosic paper will give more glaze than the wool rolls. Cellulosic paper cannot be used in the same type of deep embossing [more than .002

inch] application as with wool paper. Paper type filled rolls are not as strong as fiber filled rolls, but frequently these types of fillers will be all that will be required in an operation.

Nylon shelled rolls are an alternate choice for a resilient roll, but should be carefully considered because they are expensive to buy and maintain. In spite of today's modern manufacturing techniques, nylon shells are unpredictable. However, when a nylon shell roll is matched properly to a process, tremendous success and long life are obtained and fiber roll Run-In is avoided.

Generally, the following parameters must be maintained for Nylon Rolls: less than 400 degrees F. at 50 yards per minute and 1,000 PLI. However, most nylon shell require 1000 PLI plus to flatten across and around the roll.

Variable crown rolls are said to permit operation at various tonnages, but generally this is not a daily production requirement. A nylon shell's greatest advantage over other resilient rolls is its resiliency and not its variable crown feature. If the same care and preparation were given to a filled roll after load parameters and temperatures are determined, then daily or weekly changes in crown levels will probably not be required. Because of the construction these Nylon Shells do not lend themselves to frictioning, silk and with only limited success to "wild" embossing.

Summary

All fabrics lend themselves for processing on rolling calendars for gloss, compaction and hand and on the silk finishing calender for light luster and with high cotton fiber content to obtain a mercerized or "hard hand" linen look. On a Cire calender, a high gloss or shine can be obtained, but in this case a high content thermoplastic fiber must be used. Fabrics can be processed on a compaction type calender to reduce coverage or obtain a suede look and reduce caliper or thickness of a fabric to a desired level after napping.

When considering the embossing of fabrics one must be careful to us the thermoplastic properties of polyester, polyamides and similar fibers. High content wool fabrics, because of the inherent resiliency characteristic of wool, do not lend themselves well to embossing. High content cotton or cellulosic fiber must be treated similar to a paper product where the fiber must be broken in order to transfer the pattern to the fabric. If an attempt is made to obtain permanency with a temperature transfer parameter only, the cotton fiber will become brittle from the heat before the heat setting occurs. If the pattern is transferred, often the laminating or coating of the fabric can obtain the permanency of the pattern in order to achieve dimensional stability as required.

Calendering is not an exact practice, but in many ways, an art or science. It is like many other textile processes where at times a theory presents the possibility, but experience is always the best teacher. The utilization of University and Manufacturer's development laboratory Equipment is strongly suggested.