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THE MECHANICS OF CALENDERING AND EMBOSSING COTTON WEBS

D. Steve Gunter
BF Perkins
Sanford, NC

Abstract

Calendering by definition is a mechanical leveling, and segmenting process for "finishing" fabrics or webs to obtain or produce a special effect. Such special effects could be flattening, luster, compacting, glazing, moiré, Schreiner and other embossed patterns.

The three basic mechanical parameters of this operation are that the fabric is passed between or around the calender rolls: 1) at a calculated speed [dwell time in the nip]; 2) under precise pressure [PLI or pounds per lineal inch] and 3) often these rolls are heated to a predetermined temperature to obtain the desired or more lasting effect. Therefore, these three mechanical operating parameters of speed, temperature and pressure must be controlled.

In addition to these three parameters, consideration must also be given to back-up roll design and type, wear resistance of top rolls and resilient 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 pulp 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.

Photo 1

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Rolling Calender

The function of a rolling calender is to provide a smooth or gloss fabric surface as well as to improve hand. The basic mechanical action of this type of Calender is to cause the cotton fibers to not only reshape but to also possibly flatten or deform around one another as it also causes the fibers to nestle or more tightly stack around one another. It can process all types of cloth, but Photo 1. Three Roll Rolling Calender predominantly is used on high content cotton woven/non woven fabrics or knits. This operation is very effective to improve the drape in a latex impregnated cotton web.

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. The basic mechanical action for this type of Calender can be the same as for the rolling but with the selection of special fiber rolls that are comparatively soft another mechanical action is afforded. The 78 shore D fiber rolls when loaded against a smaller diameter steel will create a very wide nip between the rolls which will not only extend the web but also flexes any bonds from coatings or stiffness from the weaving, knitting or yarn forming process. 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 Photo 2. Silk Finishing Calender 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. 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

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 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. The basic mechanical action of this type of Calender is similar to a Rolling Calender with the addition of a polishing action cased by 6-8 Rms smooth heated metal rolls passing across the web as it is being held against a fiber type roll under moderate pressure. 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].

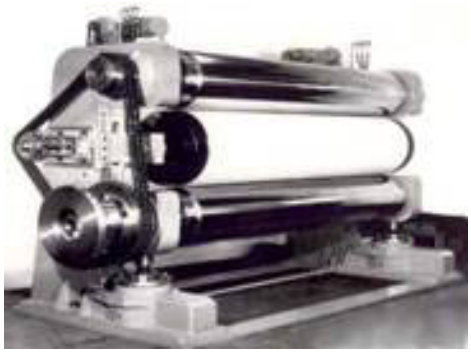

Photo 3. Friction Calender with Clutch

This clutch actually "brakes or retards" the Bottom roll and because the co-efficient of friction of the web and the cotton roll and the bottom roll are similar to one another - they stick together as the top, smoother, roll slides by at twice the speed. Various ratios of speed differentials can be utilized but offer little or no difference than the 2:1 ratio.

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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 differentiating mechanical action of the schreiner is the pattern that is engraved on the heated steel roll. 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 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 woven knitted and 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°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. The mechanical action is the same as that of the rolling Calender but with the addition of a pattern engraved upon the steel roll...

A schreiner Calender is a specific kind of an embossing Calender distinguished by its pattern. 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-SYNTHETICS ONLY

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.

Hi-Dwell - 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 affix 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. The mechanical distinction of Cotton webs is that they typically require temperature protection treatments that must be removed after printing. (Such as 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.

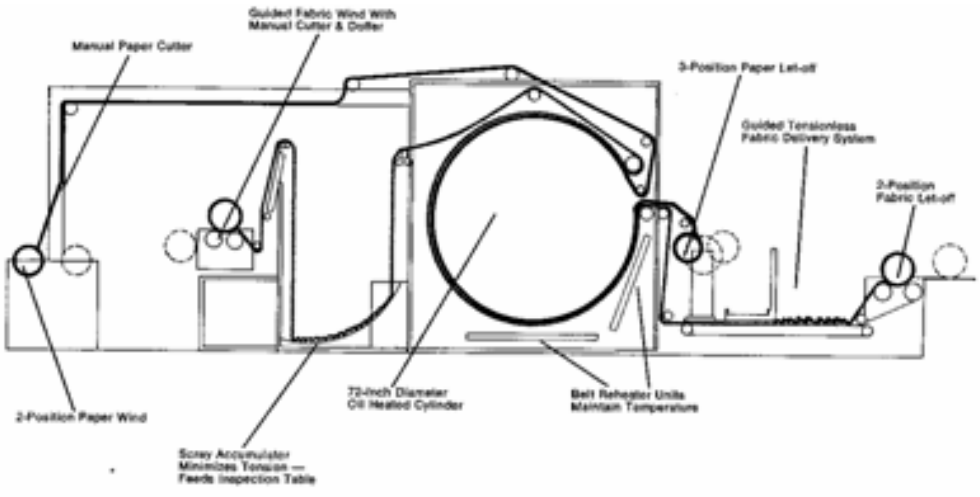


Figure 10. The design of the Hi-Dwell machine

This design utilizes an endless belt which 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.

Resilient Rolls

There are various types of resilient rolls that are available and perhaps here we see 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. This is developed via the Hystereses Effect as the cotton fiber is densified and then releases as it goes thru the pressure of the nip. Because of this the heat transfer efficiency can be enhance and this

heat can in some instances be exerted through the web (ZD) causing increased bonding in the CD, MD and the aforementioned ZD.

There are various types of calender roll fillings available, but all calender rolls are very similar in construction, [Figure 11 & Photo 12].

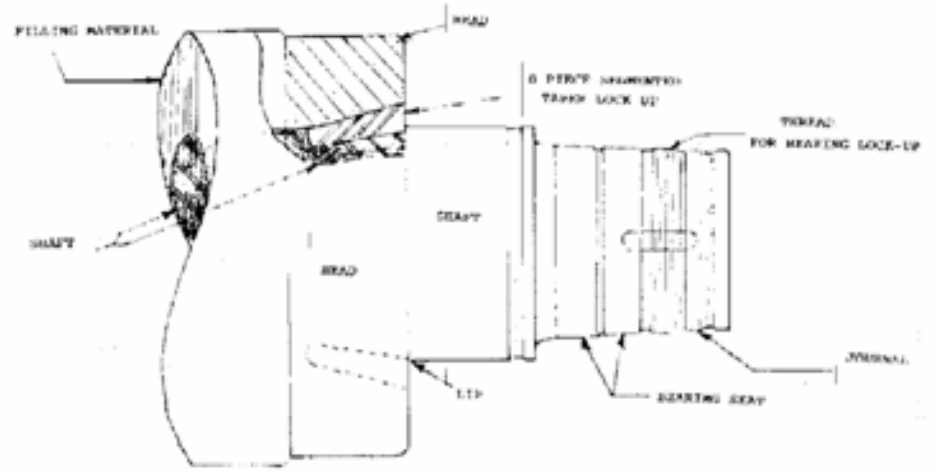


Figure 11. Fiber Roll Diagram

Photo 12. HR HC 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 & cotton blend rolls at the same Durometer as 100% 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 .020 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. These rolls are especially useful to obtain the increased deformation required to emboss cotton fiber webs.

Nylon shelled rolls are an alternate choice for a resilient roll, but should be carefully considered because they are expensive to buy and maintain and require additional devices. 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.

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 Ciré 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 cotton blended 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.

The cotton fiber properties & characteristics dictate that the use of pressure and/or the physical deformation of the fiber are required to get a permanent calendered result. Both the temperature to a maximum of 360 F will enhance the effect and the dwell time or change in speed will as well, but neither temperature or dwell time will afford any calendering effect without the use of pressure and or deformation.

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.

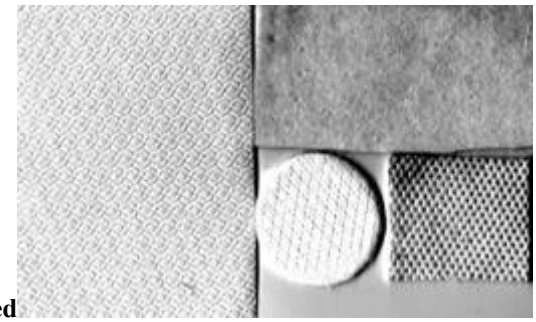
Addendum

Kenaf Core

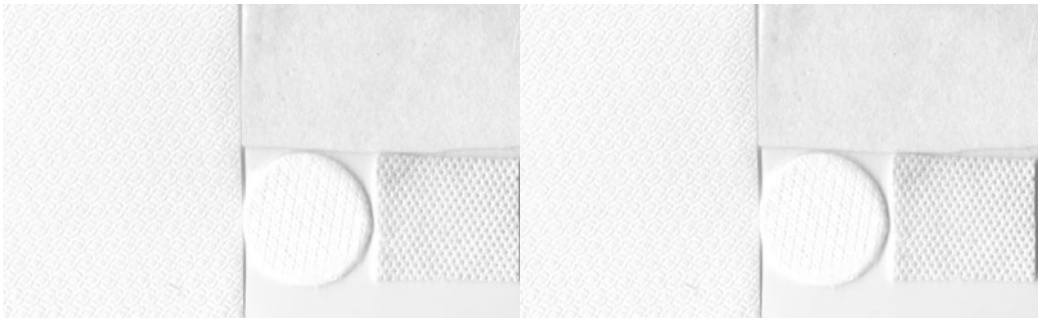
Kenaf Fiber

Kenaf Fines

Kenaf Cotton Blend



Kenaf Embossed



Cotton Embossed

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