

[54] CALENDER ROLL COVER

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 18,380, March 13, 1970, abandoned, which is a continuation of Ser. No. 686,422, Nov. 29, 1967, abandoned.

[57]

ABSTRACT

A calender roll comprising a polymeric roll cover adapted to be secured in frictional engagement with a rigid mandrel under static conditions is provided that will permit relative movement between the roll and the cover under operating conditions.

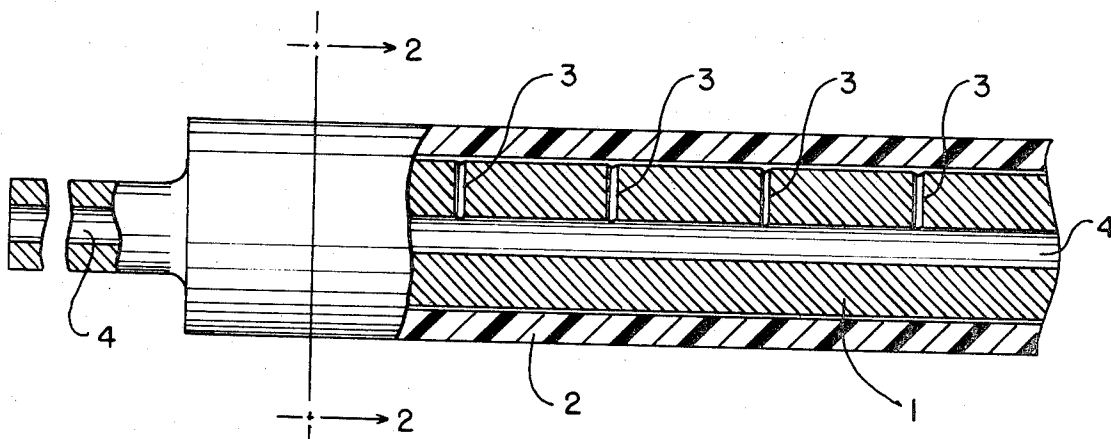
[52] U.S. Cl. **29/129.5, 29/132**
[51] Int. Cl. **B21b 31/08**
[58] Field of Search 29/129.5, 132, 116 R

References Cited

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3,091,173 5/1963 Koch 29/132 X

5 Claims, 2 Drawing Figures



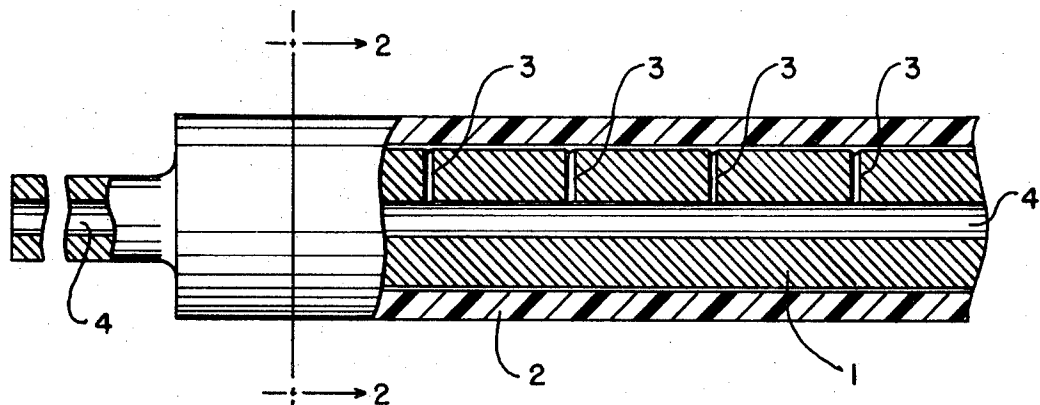


FIG. 1

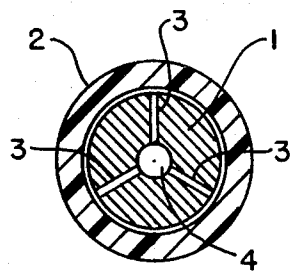


FIG. 2

CALENDER ROLL COVER RELATED APPLICATIONS

This application is a continuation-in-part of my application Ser. No. 18,380 filed Mar. 13, 1970, which in turn is a continuation of application Ser. No. 686,422 filed Nov. 29, 1967 both now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a calender roll used in calendering, supercalendering and related treatments of webs of paper, textiles and the like, and is particularly directed to a novel roll design that provides for increased operational life of the roll cover.

2. Description of the Prior Art

In calendering and related treatments of webs of paper, textiles and like material, the web to be calendered is threaded between the nip of a pair of rolls, one of which usually has a soft and the other a hard cover. The rubbing or embossing action upon the surface of the web as it passes through the nip imparts desired surface characteristics or embossed patterns to the web.

In recent years, synthetic polymeric materials have begun to be used in place of the pressed paper or rubber covers conventionally employed in the paper and textile industries. Such plastic covers on calender rolls have worked well and have produced superior paper and textile finishes, but certain characteristics of the plastic materials limit the life of the roll covers and hence their acceptance for many applications.

The aforementioned limitations arise primarily because of the rather low thermal conductivity of suitable plastics and their related inability to dissipate heat build-up in localized areas. As an example, when ridges running lengthwise of a web of material pass through a nip between rolls, or when other variations in web thickness or variations in the cover or mandrel diameter or alignment are present, localized regions of greater pressure are created across the nip. These areas of localized high pressure result in a temperature build-up as the roll cover material is repeatedly compressed and decompressed during a calendering operation. As the temperature builds up in a cover which is tight on the mandrel and hence cannot expand axially thereof, an outwardly projecting bulge begins to develop. The bulge is subjected to still greater compression and decompression which increases the amount of heat and expansion. It is in this manner that a temperature runaway condition can develop which will result in localized melting of the plastic cover and its resultant destruction.

Further, it has now come to be recognized that as the resilient cover is squeezed at the nip, a force is generated which tends to cause circumferential relative movement between the mandrel and cover. This force, if unrelieved, can result in the destruction of the cover.

Recognition of the advantages of polyamides and other thermoplastic materials has led to numerous efforts to solve the problems described above. One of the more fruitful of these efforts was the development of a loose-fitting cover for a roll. This type of roll is essentially comprised of a cover which is loosely fitted on the mandrel with a small clearance between the inside diameter of the cover and the outside diameter of the mandrel. The purpose of this clearance is to permit expansion of the cover material primarily in an axial direction, and it thus relieves the localized hot spots

which tend to develop during a calendering operation.

Although the roll construction described above represents a satisfactory solution to the hot spot problem, it involves rather difficult and, consequently, rather expensive machining operations to obtain the close tolerances required. This is due to the fact that the cover is always intended to be loose on the mandrel and therefore cannot be machined when it is mounted on the mandrel. Both the inside and outside diameters of the cover must therefore be machined prior to mounting the cover on the mandrel and care must be taken to ensure that the cover is a true cylinder of uniform wall thickness.

SUMMARY OF THE INVENTION

With the foregoing in view, an object of this invention is the provision of a novel roll design which results in prolonged cover life, but which eliminates the disadvantages, noted above, of the prior proposals.

Another object of this invention is the provision of a roll cover attaining the above-mentioned object which provides for the relief of localized cover stresses.

Still another object of this invention is the provision of a cover attaining the foregoing objects which is free for movement on the mandrel at operating temperatures.

Further objects of this invention are the provision of techniques which permit on-the-mandrel finishing and refinishing, closer tolerances, elimination of surface irregularities, and simplified cover manufacture.

In carrying out the objects of this invention, the cover of the calender roll is shrunk-fit onto the mandrel prior to the final machining of its surface. A feature of the invention resides in the provision of an interference fit between the cover and the mandrel of such character that although the cover is sufficiently tight on the mandrel to permit the final machining operations at room or ambient temperatures, under operating temperature conditions the cover will expand and free itself by the action of thermal expansion forces. A great advantage of this technique lies in the fact that when the cover is machined on the mandrel upon which it is to be used, much closer machining tolerances can be maintained than when the cover is machined off the mandrel. Because of this, surface irregularities, which in themselves cause differences in pressure across the nip and result in hot spots, are minimized. By way of example, wall thickness tolerances as low as ± 0.001 inch can be obtained, as compared to tolerances of ± 0.010 inch under previous methods.

Another great advantage of the use of the techniques of this invention becomes apparent when the surface of the cover becomes marred during use. When this occurs, as for example when a web breaks and the torn edge wraps itself around the roll, the cover and mandrel may be removed from the calender stack as a unit and the cover remachined while it remains on the mandrel. Again, closer finished tolerances can be obtained in a manner which is much simpler to accomplish than when the cover is machined off the mandrel and, in addition, the steps of removing the cover and later remounting it are eliminated.

Although the cover may be dimensioned so that at operating temperatures its inside diameter is appreciably greater than the outside diameter of the mandrel, it has been found that when the forces of attachment of the cover are reduced to a point where axial move-

ment can be accommodated when local areas of the cover material begin to expand, very effective results are obtained. It is found that the theoretical ideal exists when the interference fit between the cover and the mandrel approaches zero at operating temperatures.

Preferably, freedom of movement of the cover relative to the mandrel is enhanced by the lubrication of the mandrel surface and, suitably, passageways in the mandrel which lead to its surface may be provided through which a lubricant may be introduced at periodic intervals.

An additional advantage of a substantially zero interference fit lies in the fact that the roll can be run in a double nip arrangement, that is, with it positioned between two hard rolls. This is impractical when the cover is originally loosely mounted on the mandrel because upon its expansion under operating conditions the cover is forced to assume an elliptical configuration (called looping) by being pressed against the mandrel at two diametrically opposed nips. The stresses arising from such distortion lead to destruction in a relatively short time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view, partially in elevation and partially in section and with parts broken away, of a calender roll incorporating the instant invention; and

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1 looking in the direction indicated by the arrows.

DETAILED DESCRIPTION OF THE DRAWINGS

The figures of the drawing illustrate the construction of a soft calender roll in accordance with this invention. The roll comprises a steel shaft or mandrel 1 upon which is mounted the cylindrical plastic cover 2, as will hereinafter be more fully described. Lubricating means to provide a coating of lubricant between the mandrel and the cover are advantageously provided. Such lubricating means is shown in diagrammatic form as consisting of radially extending passageways 3 which lead from a hollow core passageway 4 to the outer surface of the mandrel. A supply of lubricant under pressure is delivered to core passageway 4 by any suitable means (not shown). Preferably, the passageways 3 are repeated at intervals along the length of the mandrel to ensure lubrication of the entire contacting areas of the mandrel and cover as indicated in FIG. 1. Also, if desired, the mandrel may be provided with longitudinally extending grooves (not shown) on its outer surface which are in communication with aligned passageways 3. In such event the number of sets of the radial passageways may be limited.

Although the invention in its broadest aspects is applicable to the provision of rolls having covers made from a wide variety of materials, the covers are preferably made from polymeric materials such as polycarbonates and polyamides (for example, nylon 6, nylon 6/6 and nylon 11). Polyphenylenes, polysulfones and polyethylenes, as well as natural or synthetic rubbers, may also be employed. Polycarbonates, such as that sold by General Electric under the trademark LEXAN, and cast nylon such as sold by The Polymer Corporation under the trademark MONOCAST, have been found to possess excellent properties for roll covers. Glass-filled materials, especially glass-filled polycarbonates and polyamides, are unusually well suited for this use.

In preparing the roll cover for mounting on the mandrel, the inside dimension of the cover relative to the outside diameter of the mandrel is critical as the cover must be tight on the mandrel at room temperatures and must expand sufficiently so that it is free to move longitudinally at operating temperatures. By way of example, in a preferred construction in which a zero interference fit is to be obtained at operating temperatures, when the coefficient of linear thermal expansion and operating and room temperatures are known, it is possible to predict the amount of expansion. A rise in temperature from a room temperature of about 75°F to an operating temperature of about 175°F can be expected in normal calendering operations where the soft rolls are operated in conjunction with heated hard rolls. In the case where a cover made of unfilled polycarbonate is to be mounted on a 13.500 inch mandrel, and a zero interference fit is to be obtained at operating temperatures, then the following would apply:

Coefficient of linear thermal expansion		= 3.5×10^{-5} in/in/°F
Temperature differential		
175°F-75°F		= 100°F
Mandrel outside diameter		= 13.5 inches
Expansion = 3.5×10^{-5} in/in/°F		
$\times 100^\circ\text{F} \times 13.5$ inches		= 0.047 inch

Since the inside diameter of the cover at zero interference fit is 13.5 inches, the bore should be machined to 13.500-0.047 or 13.452 inches. A roll having dimensions as suggested above is suited for double nip as well as single nip operation.

In making the above calculations, the thermal expansion of the steel mandrel has not been taken into account and can be ignored. The mandrel has a relatively low coefficient of thermal expansion as compared with the cover and is a very large mass of material and can be expected to function as a heat sink. Thus, the rise in temperature is not appreciable and, in addition, the thermal expansion of steel is of an order of magnitude smaller than that of most of the materials from which it is contemplated that the cover will be made.

It has further been found that lubrication between the inside diameter of the cover and the outside diameter of the steel mandrel is of advantage where running at zero interference fit is contemplated, especially at high loadings and speeds in double nip operations. In addition, lubrication reduces the need for a perfect fit and makes it possible to use the cover over a wider range of operative temperatures.

Care must be taken in the selection of the lubricant, the important considerations being that the lubricant is not harmful to the roll cover material and that it is capable of withstanding the operating temperatures which will be encountered. A lubricant suitable for use with polycarbonate or nylon covers is a product sold under the trademark LUBRIPLATE-AERO, as produced by Fishe Bros. of Newark, N.J.

Although the lubricant can be applied prior to fitting the cover on the mandrel, it is of advantage to replenish the supply of lubricant, and for this purpose the passageways 3 through the mandrel leading to the outer surface of the mandrel from core passageway 4 which, in turn, is connected to a supply of the lubricant, may be employed, as previously described.

For single nip applications, the need for precision of the shrink fit is not quite so acute as is required for double nip operations, as the cover can come loose from

the mandrel at a temperature appreciably below the operating temperature without harmful effects. For example, in actual tests covers have been shrunk fit on the mandrel at room temperature and have been so dimensioned that they first come loose at a temperature of around 100°F. Such covers continue to expand as they heat up and have been operated successfully at temperatures ranging from 150° to 200°F.

The following detailed examples are illustrative of test runs wherein rolls formed in accordance with the invention were employed in single nip calendering operations.

EXAMPLE I

A LEXAN polyarylcarbonate tube 27 inches long, —inches in outside diameter, and slightly over 1.25 inches thick, was bored to have an inside diameter 0.010 inch less than the outside diameter of a mandrel approximately 10.5 inches in diameter. The roll cover was then heated to 200°F, positioned over the mandrel, cooled to room temperature and machined to an outer diameter of 13.000 inches. The roll performed successfully in a supercalender used in paper-making at 1,500 pounds per linear inch (pli) and 1,500 feet per minute (fpm). With a coefficient of linear thermal expansion of 3.5×10^5 in/in/°F, the inside diameter of such a cover can be expected to expand to 10.527 inches at an operating temperature of 175°F.

EXAMPLE II

A tube of cast nylon was made 60 inches long, 19.25 inches outside diameter, and 17.870 inches inside diameter. Although the tube was bored to the same size as the mandrel, due to boring in accuracies, it was smaller than the mandrel in many places and had to be heated to 200°F in order to put it onto the mandrel where it was machined. The roll was successfully used for three months in a cotton mill for calendering cloth at 800 pli and 700 fpm. With a coefficient of linear thermal expansion for the cover material of 5×10^5 in/in/°F, the inside diameter of the cover can be expected to enlarge to about 17.96 inches at an operating temperature of 175°F.

A number of factors contribute to the rise in temperature of the cover. The friction effects due to the calendering operating and the hysteresis losses due to the compressive loading are important factors. In addition, the paper or other web being calendered is often quite hot due to treatment and this heat is transferred to the roll cover. Moreover, it is common practice in certain

treatment operations to heat the mating hard roll, and when this is done, appreciable heating of the adjacent soft cover results. Where the mating hard roll is heated, operating temperatures of the adjacent soft rolls of 175° to 200°F are not uncommon. Where the mating hard roll is not heated, temperatures will be somewhat lower but still in excess of 100°F.

It is pointed out that in practicing the invention, the cover need not be loose in the sense that there is play between it and the mandrel at operating temperatures. It need only be free to move in the sense that the forces exerted due to expansion of the cover as a condition of localized heating develops are greater than the restraining forces which ordinarily prevent movement. It is in this manner that a yielding of the cover material takes place.

In conclusion, the invention provides a novel and effective means of eliminating hot spots in covers of plastic material. This prevents premature destruction of the cover. In addition, due to the uniformity of cover wall dimensions which can be obtained, improved calendering results. Roll covers made according to the techniques of the invention have produced excellent results in actual trial runs when used in both single and double nip applications.

I claim:

1. A roll adapted for calendering a continuous web of material comprising a mandrel and a tubular cover mounted directly over the mandrel by means of an interference fit between the inside diameter of the cover and the outside diameter of the mandrel, the amount of the interference being sufficient to cause the cover and the mandrel to be in secure frictional engagement with each other at normal room temperatures but insufficient to prevent axial movement of the cover relative to the mandrel at elevated operational temperatures at which the roll is used.

2. A roll according to claim 1 wherein the elevated operational temperature exceeds normal room temperature by at least 25°F.

3. A roll according to claim 1 wherein the cover is a synthetic polymeric material.

4. A roll according to claim 2 wherein the synthetic polymeric material is selected from the group consisting of polycarbonates and polyamides.

5. A roll according to claim 1 wherein means are provided to lubricate the interface between the cover and the mandrel.

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