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GROOVED ROLL FOR PAPER-MAKING

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7 Claims

ABSTRACT OF THE DISCLOSURE

A roll having a plurality of grooves in the exterior surface thereof, said surface consisting of a nonwoven mat wrapping said roll and bonded with a thermosetting resin. Preferred mats for the present invention are acrylic nonwoven mats. The preferred thermosetting resin is an epoxy resin.

BACKGROUND OF THE INVENTION

Grooved rolls have an important function in industry and in particular in the paper industry webs of material such as paper are passed along the various steps of the manufacturing process at high speed under precise conditions and it is necessary to employ grooved rolls in a number of instances to properly transport and process the webbed material.

Prior art grooved rolls have been manufactured from iron for a number of years, although recently, it has been possible to groove steel rolls. Also, rubber covered rolls which contain grooves have been employed in various parts of the paper making process and in other industries.

However, metal rolls are expensive to manufacture and are not resistant to corrosion to any degree. Stainless steel and other metals which resist corrosion are particularly difficult and expensive to groove thereby raising the cost of the roll to a point which becomes prohibitive.

Rubber grooved rolls or other synthetic materials of that type are relatively easy to groove but are not capable of sustaining high speed high nip pressures and are therefore limited to applications which are restricted to low speeds and/or low nip pressures.

Particular areas where a grooved roll becomes important are in the forming zones of relatively new forming devices for paper machines and in the press area in a number of industries such as paper, textiles and the like. In a press section, two or more rolls are placed in operative relationship with each other so as to define a nip between which the material such as a web is passed. To most efficiently process the web, it oftentimes is necessary to achieve substantially high speeds and nip pressures, such as up to 6,000 feet per minute of web travel with nip pressures in excess of 400 pounds per linear inch of roll. Up until this time, however, no material has been found which is suitable for both high speed high nip pressure applications at an economical cost.

It is particularly important at these high speeds and high nip pressures that the rolls be grooved, as for example, in an instance where a traveling web of material passes between a nip and contains moisture or other fluids associated with the nip. This moisture, which is being pressed so that the moisture may be removed, oftentimes rewets the web after the web passes through the nip. Grooved rolls, on the other hand, substantially lessen the rewetting of the web, thereby permitting the higher speeds and pressures.

Another area in which the grooved rolls have become more and more important is in the forming zone of a paper machine. As a jet of paper stock is introduced into a nip formed by two rolls, around each of which an endless wire is wrapped, a phenomenon known as pumping occurs. Pumping is, briefly stated, an occurrence whereby a high velocity of a wire leaving a roll creates a vacuum

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or suction effect, thereby adversely affecting the materials contained on the web. This can be appreciated when considered in light of the particular sensitivity of a paper stock being formed into a paper mat. Any outside influences upon the draining rate can adversely effect distribution of the fibers to result in poor formation of paper. Use of grooved rolls substantially lessens this pumping effect by permitting a passage which breaks the vacuum or suction created by the wire departing from the roll. Again, however, metal rolls are expensive and are subject to corrosion while rubber grooved rolls are unable to operate at high pressures and speeds.

THE INVENTION

It has now been discovered that grooved rolls may be prepared which are capable of operating at high speeds and at high nip pressures without substantial expense in their manufacture. The rolls are relatively impervious to chemical attack and are stable under extreme loading conditions. Basically, the invention comprises the use of a roll having a plurality of grooves in the exterior surface thereof, the rolls consisting of a nonwoven mat wrapping the roll and bonded with a thermosetting resin. It is oftentimes desirable to machine the surface of the roll to achieve the proper smoothness. Grooving of the roll is a relatively simple tooling operation and may be accomplished with a high degree of accuracy.

Typical groove dimensions for use in a wide variety of applications are as follows. The grooves are preferably from approximately 0.005 inch to about 0.080 inch wide. A preferred range of groove width ranges from 0.015 to 0.025 inch. The depth of the groove may range from as little as 0.025 inch to as great 0.400 inch or greater. Preferably, the groove depth will range from 0.050 to 0.150 inch. The number of grooves per inch of axial length of the roll will vary, depending upon the particular application and the other dimensions of the groove. Normally, it is preferred to have from two to 32 grooves per inch of longitudinal length, while a more preferred range is from six to twelve grooves per inch of axial length.

The rolls of the present invention may be manufactured from any fiber substance that may be formed into a nonwoven mat. It is preferred, however, that the mat itself has a tensile strength of at least five pounds per inch. Typical examples of materials which may be formed into suitable fibrous mats are nylon fibers, paper or paperboard of sufficient strength, acrylic fibers, polyester fibers, cellulose acetate and other acetate fibers, asbestos fibers, cotton and sisal fibers, polyamide fibers, rayon fibers, polyolefin fibers, and the like. Particularly suitable rolls have been prepared from acrylic nonwoven mats.

The thermosetting resins employed to bond the nonwoven mat are broadly defined as condensation polymers or copolymers formed through the reaction of the functional groups of the organic compound, with the possible elimination of water or similar by-products. A wide variety of thermosetting resins may be employed. An example of these are phenolic resins which are the reaction product of phenols with aldehydes, such as phenol and formaldehyde.

Urea and melamine resins are also suitable and are formed from the reaction between the hydrogen of the amine groups of urea or melamine and the hydroxyl of the hydrated formaldehyde.

Two other closely related classes of thermosetting resins which may be employed are alkyds and polyesters, otherwise known as modified and unmodified polyester resins. Polyester resins are prepared by reacting a polybasic acid such as adipic acid, sebacic acid, etc. with a polyfunctional component such as glycol, glycerol, and the like. Modified or alkyd resins are formed by the reaction of a fatty glyceride or fatty acid such as linoleic acid with the unmodified resin.

The most preferred class of thermosetting resins are the epoxy resins. Epoxy resins are formed from a basic epoxide which contains epoxy groups which are then cured with either diamines or diabasic anhydrides. Epoxides are prepared in a number of ways, such by the reaction of phenol and acetone to produce Bisphenol-A, which in turn is reacted with epichlorohydrin to yield the epoxy intermediate. Diamine or diabasic anhydride then reacts with the intermediate to produce the final resin.

Another preferred class of thermosetting resins are the acrylic resins. Acrylic resins are acrylate or methacrylate ester polymers, although they may include acrylonitrile and chloroacrylate polymers. These polymers are polymerized alone or with other comonomers to give the acrylate resin.

As has been stated above, the nonwoven mat is wrapped around the roll core after being saturated with the resin in a conventional manner. Polymerization of the resin to bond a nonwoven mat results in the formation of the roll. Simple machining of the surface and conventional grooving may then be done to yield a grooved roll. For a more complete understanding of the operation of the grooved rolls, and for a better understanding of the necessity for resistance to corrosion and high nip pressures and speeds, reference is hereby made to the drawings in which:

FIG. 1 represents a perspective view of the roll according to the present invention;

FIG. 2 is an enlarged sectioned view of some of the grooves in a typical roll;

FIG. 3 is a partially sectioned schematic diagram of a press section employing two rolls according to the present invention; and

FIG. 4 is a partially sectioned schematic diagram of a forming zone in a paper machine employing two rolls according to the present invention.

With reference to FIG. 1, a journal 12 supports a core 14 of a roll shown generally by numeral 10. The outer surface of the roll 10 is a nonwoven mat 16 which wraps the roll core 14 and which is bonded with a thermosetting resin. A plurality of grooves 18 have been tooled into the surface 16 of the roll.

FIG. 2 shows an enlarged sectioned view of the roll in FIG. 1. The grooves 18 have a depth shown by the dimension 20, which may range as set forth herein previously of from 0.025 inch to 0.040 inch or greater. The width of the grooves 18 is shown by the reference 22. Again, the dimensions of the groove would have been previously set forth herein. Dimension 24 of FIG. 2 is shown to indicate the number of grooves per inch of axial length along the roll. In this instance, purely by way of example, three grooves per linear inch have been employed.

Shown in FIG. 3 is a press section employing two rolls according to the present invention. Rolls 28 are shown in section so that the reference numeral 30 indicates the bottom of the grooves and the reference 28 represents the ungrooved surface of the roll. Passing between the nip defined by the two rolls 28 is a top felt 32 which passes through the nip defined by the roll 28 after first passing around a guide roll 33. A web W is conveyed on a lower felt 34 through the same nip and water contained in the web W is passed from the web W and into the felts 32 and 34. The bottom felt 34 is then withdrawn through guide roll 35.

Due to the high nip pressure between the rolls 28, a substantial quantity of moisture is removed from the web W. Because of the grooves 30 in the rolls 28, most of this moisture passes through the felt 32 and felt 34 and is expelled in the direction shown generally by arrows 36 and 37. If these rolls were ungrooved, most of the moisture passed through the felts would be contained on the surface of the roll and would rewet the felts 32 and 34, thereby destroying a great part of the efficiency of the apparatus.

Shown in FIG. 4 is a forming zone of a two wire paper machine employing two grooved rolls 28 as de-

scribed with reference to FIG. 3. Again the reference numeral 30 represents the bottom of the grooves while the reference numeral 28 depicts the surface of the roll in the ungrooved portion. A top wire 40 wraps the upper roll 28 and passes through a nip defined by the two rolls 28 while a bottom wire 41 wraps the roller of the two rolls in a similar manner and is withdrawn from the nip in a direction parallel to the upper wire. Suction boxes 42 and 43 are positioned to withdraw water through the wires to assist in the formation of paper. A headbox 44 distributes a stream of paper pulp stock 45 into the nip defined by the two rolls 28, which stock is then carried by the two wires 40 and 41 to the suction boxes 42 and 43 for formation into paper. If these rolls 28 were solid rolls, a considerable amount of pumping would occur which is in effect caused by the vacuum created by the sudden removal of the wire from the roll 28. However, since these rolls 28 contain grooves 30, a considerable amount of the vacuum caused by the rapid rate or speed of the wires 40 and 41 is dissipated, such as by air currents passing in the directions shown by arrow 46 and 47. By removing the vacuum force on the outsides of the wires 40 and 41, the stock 45 being carried by the wires 40 and 41 is not abruptly disturbed and uniform, controlled formation of the stock into paper is effected in the forming zone between the suction boxes 42 and 43.

To demonstrate the efficiency of the present invention in operating at high speeds and high pressures, a series of experiments were performed to compare a roll according to the present invention with several rolls having a grooved rubber cover. Obviously, such comparison between a stainless steel grooved roll and a roll of the present type would only be effective if the cost of manufacture were compared or if the relative corrosion or chemical resistance rates were measured. It should be understood that rolls according to the present invention are substantially superior to metal covered grooved rolls in the area of manufacturing costs and chemical resistance.

In the first experiment, a roll was prepared with a 0.5 inch covering of an acrylic nonwoven mat bonded with an epoxy resin. A pair of these rolls were operated at a speed of 6,000 feet per minute based on the speed of a web passing between the nip. The operating pressure was 600 pounds per linear inch as measured along the longitudinal axial length of the roll. The rolls performed quite suitably for an extended period of time and required 2.58 horsepower per axial foot of roll to maintain these conditions.

In a second experiment, a pair of 0.75 inch thick rubber covered grooved rolls were operating under similar circumstances. The rolls were rotated at a speed simulating 6,000 feet per minute of a web passing through the nip and at a nip pressure of 300 pounds per linear inch. Although it was possible to drive the rolls for a short period of time at this speed and nip pressure, it required 6.99 horsepower per foot of roll length and the rolls did fail in a short period of time.

In the third experiment, a slightly harder rubber covering was placed on a roll, wherein the covering was 0.68 inch thick. A pair of these rolls were operated at 6,000 feet per minute, based on the speed of the web passing through the nip, and at a nip pressure of 600 pounds per linear inch. Again, the rolls failed after a short period of operation, and even during operation, it required 13.8 horsepower per foot of roll length to drive the roll couple.

It can therefore be seen from the above experiments that the roll in experiment 1 which corresponds to a roll according to the present invention, is substantially superior to rubber covered grooved rolls. In each case, the roll depth was 0.10 inch, the grooved width was 0.020 inch, and there were eight grooves per inch of face. The roll having an outer surface consisting of acrylic mat wrapping the roll and bonded with an epoxy resin was capable of operating for sustained periods of time at 6,000 feet per minute and 600 pounds per linear inch while requiring only 2.58 horsepower per foot of roll length. The roll in the second experiment was not even capable of attaining

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such speeds and nip pressures, while the third roll failed after a short period of operation time. The horsepower requirements for the rolls of the third experiment were over five times as great.

Thus it can be seen the rolls of the present invention are superior to either metal grooved rolls or rubber covered grooved rolls in that they permit relative ease of manufacture, resistance to corrosion and operability at high speeds and nip pressures.

Having thus described the invention, what is claimed is:

1. A roll having a plurality of grooves on the exterior surface thereof capable of sustained rotation in contact with another surface at peripheral speeds up to 6,000 feet per minute and at a pressure up to 600 pounds per linear inch of contact area, said roll surface comprising a grooved composite material derived from wrapping said roll with a non-woven mat selected from the group consisting of acrylic fibers, polyester fibers and mixtures thereof, and bonding said mat to form said composite with a thermosetting resin of the epoxy group.

2. The roll of claim 1 wherein the grooves are from 0.005 to 0.080 inch wide.

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3. The roll of claim 2 wherein the grooves are from 0.015 to 0.025 inch wide.

4. The groove of claim 1 wherein said grooves are from 0.025 to 0.400 inch deep.

5. The roll of claim 4 wherein said grooves are from 0.050 to 0.150 inch deep.

6. The roll of claim 1 which has from two to 32 grooves per inch of longitudinal length.

7. The roll of claim 6 which has from six to twelve grooves per inch of longitudinal length.

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