United States Patent

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[54] **RELATIVELY LONG MACHINERY ROLL HAVING HIGH STRENGTH-TO-WEIGHT RATIO**
14 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **29/132**
[51] **Int. Cl.** **B21b 31/08**
[50] **Field of Search** 29/132, 130

[56] **References Cited**

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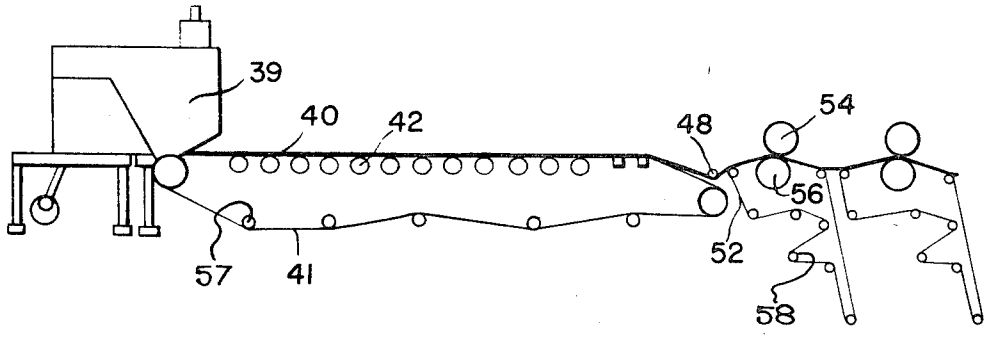
ABSTRACT: A machinery roll, particularly for use in paper-making machinery, has a mandrel, characteristically composed of a two-phase system having an external phase containing a synthetic polymeric matrix and an internal phase containing aligned continuous carbon fibers. The high tensile strength of the carbon fibers and the compatibility of the polymeric matrix therewith cooperate to permit the construction of relatively long thin rolls which, for example in paper-making machines, enable wider construction and higher speed operation.



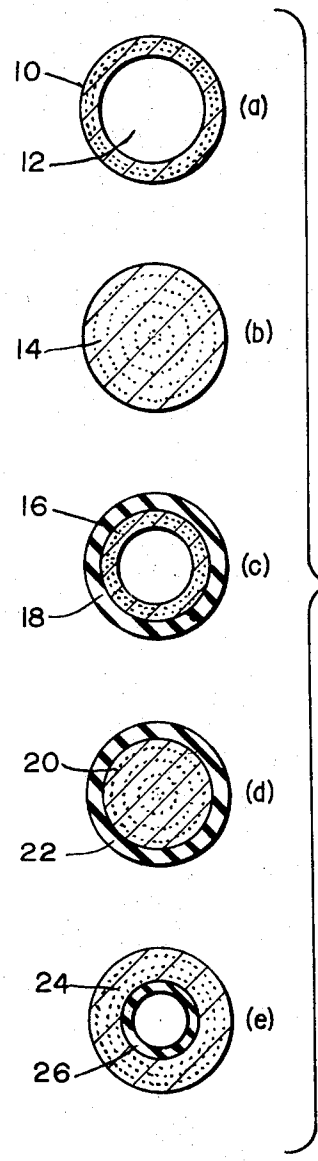


FIG. 1

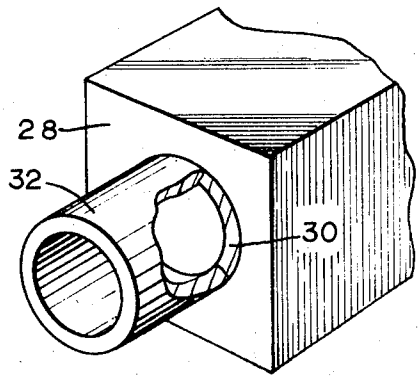


FIG. 2(a)

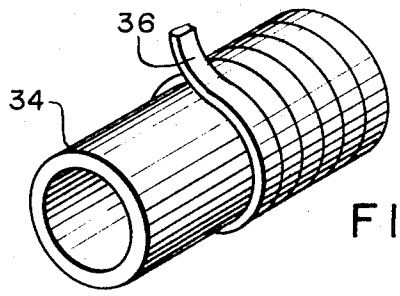


FIG. 2(b)

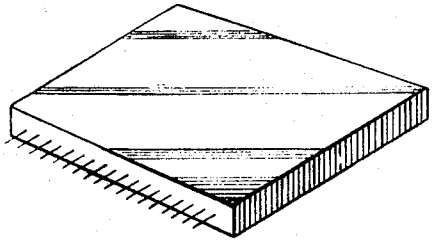


FIG. 2(c)

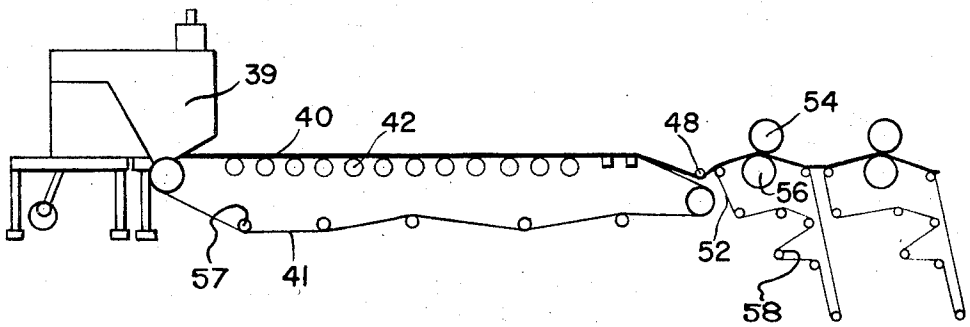


FIG. 3

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RELATIVELY LONG MACHINERY ROLL HAVING HIGH STRENGTH-TO-WEIGHT RATIO

BACKGROUND AND SUMMARY

The present invention relates to rolls for machinery and, more particularly, to rolls of the type used, for example, in papermaking machinery. Frequently, such machinery requires extremely rigid rolls of great length and small diameter, which under ordinary circumstances tend to whip or vibrate laterally with respect to the roll axis when in use, for example, as a support, in a fourdrinier machine, for an advancing paper web directly or for a wire carrier for the paper web.

The primary object of the present invention is to provide a roll ranging from 25 to 70 in length-to-diameter ratio, with high-bulk modulus and tensile strength, by virtue of a two-phase composition having an external phase containing a synthetic polymeric matrix and an internal phase containing generally parallel, continuous carbon fibers. The present invention is particularly applicable to so-called table rolls, and fly rolls, felt rolls and wire return rolls in papermaking machinery. It is found that such rolls are stronger and lighter than corresponding steel rolls, in consequence of which, they can be operated at unusually high speeds without tending to vibrate or to whip laterally when dynamically in contact with an advancing paper web. In other words, small diameter rolls operate more efficiently by reducing the suction on the bottom of the wire to improve uniformity of drainage from the bottom of the fourdrinier wire. Decreased suction also decreases drag on the wire and decreases stock "jump" on the wire. As papermaking machine widths and speeds are increased, conventional carrying roll diameters in the past have been increased to avoid whip. Such rolls are less efficient than the small diameter rolls of the present invention. It is to be understood that although the following disclosure is made in reference primarily to papermaking machinery, the principles of the present invention are applicable to a variety of rolls for use in other types of equipment.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the device, products and processes, together with their components, parts, steps and interrelationships, which are exemplified by the following disclosure, the scope of which will be indicated in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the present invention, reference is made to the following detailed description, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 illustrates, in exaggerated cross section, several different rolls embodying the present invention;

FIGS. 2 (*a*), (*b*) and (*c*) illustrate materials undergoing processes for producing rolls in accordance with the present invention; and

FIG. 3 is a schematic illustration of parts of a papermaking machine, comprising rolls constructed in accordance with the present invention.

DETAILED DESCRIPTION

Generally, each of the rolls illustrate herein as embodying the present invention is a cylindrical mandrel of high-bulk modulus and high tensile strength, characterized by a composition containing an external phase in the form of a synthetic polymer and an internal phase in the form of continuous carbon fibers, each composed of contiguous carbon filaments. In one form, the polymeric matrix is composed of an epoxy or an imide. In one form, the carbon filaments are characterized by the presence of a linear carbon chain and an absence of noncarbon substituents. Such carbon filaments, for example, are produced by carburizing a synthetic polymer such as acrylonitrile. Preferably, the two-phase composition contains, by total weight from 30 to 70 percent resin matrix and from 70 to 30 percent carbon filament.

Details of various configurations of rolls, constructed in accordance with the present invention, are shown in FIG. 1. In FIG. 1 (*a*), the roll is shown as having an annular cross-sectional configuration, characterized by an outer annulus 10 and an inner hollow 12. Annulus 10 is composed of a polymeric matrix and carbon fibers in accordance with the present invention. In FIG. 1 (*b*), the roll is shown as having a solid circular configuration 14, characterized by a synthetic polymeric matrix and parallel continuous carbon fibers. In FIG. 1 (*c*), the roll is shown as having annular mandrel 16 of the type shown at 10 in FIG. 1 (*a*) and an outer elastomeric veneer 18, composed for example, of a natural or synthetic rubber. In FIG. 1 (*d*), the mandrel 20 is shown as having the same configuration and composition as in FIG. 1 (*b*) and is covered with an elastomeric veneer 22 of the type shown at 18 in FIG. 1 (*c*). In FIG. 1 (*e*), the roll is shown as having an annular configuration 24 of the same composition as that at 10 in FIG. 1 (*a*) and an inner annular mandrel 26 composed of a paper, for example a paper impregnated with a sizing agent, a plastic, for example a heat-resistant polymer such as a phenolic, or a metal, for example aluminum. In each of these cases, the roll is characterized by a length to diameter ratio within the range of from 25 to 70.

One method of fabricating annular mandrels of the type shown in FIGS. 1 (*a*) and (*c*) is shown in FIG. 2 (*a*) as involving an extrusion die 28 having an extrusion slit 30, through which a composition of unpolymerized matrix and carbon fibers are extruded as a 32. Another method of fabricating a roll of the foregoing type is to coil, around a form 34, or apply in parallel with the axis of form 34 a continuous strip 36, composed of unpolymerized matrix and carbon filaments 31 of the type shown in FIG. 2 (*c*). Following polymerization under appropriate heat and pressure, the resulting coat is self-supporting and the form 34 is either removed as in FIG. 1 (*a*) or is retained as in FIG. 1 (*e*).

By way of example, a typical application of the rolls described above is illustrated in a papermaking machine, shown in part in FIG. 3. In a typical papermaking process, a dilute aqueous slurry of cellulose fiber, first is cast onto an endless wire screen through which water is drained, next is advanced onto an endless felt, with which it passes between a series of so-called press rolls that squeeze and withdraw water therefrom, next is advanced by itself between a series of press rolls and then is advanced over heated drying cylinders. Difficulties have been encountered as a result of a tendency of certain of these rolls to whip transversely as they rotate in contact with the web. The reason for this tendency to whip is insufficient rigidity of the core.

More particularly, in the illustrated papermaking process, the initial wet sheet 40 is formed by casting a dilute, aqueous slurry 39 of cellulose fibers onto an endless wire screen 41. In accordance with the present invention, endless wire screen 41 is supported on a series of small diameter but long so-called table rolls 42, the small diameter being necessary in order to effect optimum drainage rate. From table rolls 42, web 40 is advanced into contact with a so-called fly roll 48, before it advances onto a series of endless felts 52. Endless felts 52 and sheet 40 advance onto engagement between a series of press rolls 54, 56. In order to preclude whipping of the narrow diameter table rolls and fly roll, as well as wire return rolls 57 and felt rolls 58, these rolls in accordance with the present invention are composed of a composite of polymeric matrix and carbon fiber to exhibit higher bulk modulus and tensile strength than mild steel.

The following nonlimiting example further illustrates the process for fabricating the product of the present invention.

EXAMPLE

A roll of the type shown in FIG. 2 (*b*) is fabricated by coiling an uncured polymer and carbon fiber composite strip about a steel cylinder **34**. Steel cylinder 34 is 6 inches in outer diameter and 240 inches long, with a wall thickness of ¼ inch. The composite strip, by total weight, contains 50 percent polymer and 50 percent carbon fiber. The polyester is a diglicidyl either of bisphenol, sold by Celanese under the trade designation **EPI-REZ 508**. The carbon filaments are composed of carburized polyacrylonitrile and have a tensile modulus greater than 70×10^6 p.s.i., an ultimate tensile strength of 325—350 $\times10^3$ p.s.i., a density of 1.95 to 2.10 gm. per cc. and a twist of no greater than one turn per inch. The coat formed by coiling the carbon strip about the tube is approximately ¼-inch thick. The entire tube is cured at 93 C. for 2 hours and then at 200 C. for 2 hours, at a constant pressure of 150 p.s.i. throughout the cure. The resulting roll has unusual bulk modulus and tensile strength, both higher than steel at considerable decrease in weight.

The present invention thus provides a novel roll construction in which an unusually long roll, preferably with a length-to-diameter ratio ranging from between **25** and **70**, is composed of synthetic polymer and carbon fibers, the bulk modulus and tensile strength being greater than the bulk modulus and tensile strength of steel with considerate decrease in weight. Since certain changes may be made in the foregoing disclosure, without departing from the scope of the invention herein involved, it is intended that all matter contained in the above described description or shown in the accompanying drawings, be interpreted in an illustrative and not in a limiting sense.

What I claim is:

1. A roll for machinery in the form of a cylinder ranging from 25 to 70 in length-to-diameter ratio, said cylinder being characterized by a two-phase composition having a synthetic polymeric matrix and continuous generally parallel carbon fibers.

2. The roll of claim **1** wherein said cylinder is hollow.

3. The roll of claim **1** wherein said cylinder is solid.

4. The roll of claim **1** wherein the periphery is constituted by an elastomer.

5. The roll of claim **1** wherein the polymeric matrix is composed of a member of the class consisting of epoxies and polyimides.

6. The roll of claim **1** wherein the carbon fibers are characterized by linear carbon chains without substituents.

7. In papermaking machine, a table roll in the form of a cylinder ranging from 25 to 70 in length-to-diameter ratio, said cylinder being characterized by a two-phase composition having a synthetic polymeric external phase and a carbon filament internal phase.

8. In a papermaking machine, the table roll of claim **7** wherein said synthetic polymeric external phase is composed of a diglycidyl ether of bisphenol and said carbon filament internal phase is composed of spaced elongated carbon filaments characterized by an absence of substituents.

9. In a papermaking machine, a fly roll in the form of a cylinder ranging from 25 to 70 in length-to-diameter ratio, said cylinder being characterized by a two-phase composition having a synthetic polymeric external phase and a carbon filament internal phase.

10. In a papermaking machine, the fly roll of claim **9** wherein said synthetic polymeric external phase is composed of a diglycidyl either of bisphenol and said carbon filament internal phase is composed of spaced elongated carbon filaments characterized by an absence of substituents.

11. In papermaking machine, a wire return roll in the form of a cylinder ranging from 25 to 70 in length-to-diameter ratio, said cylinder being characterized by a two-phase composition having a synthetic polymeric external phase and a carbon filament internal phase, said roll presenting a smooth periphery.

12. In a papermaking machine, the wire return roll of claim **7** wherein said synthetic polymeric external phase is composed of a diglycidyl either of bisphenol and said carbon filament internal phase is composed of spaced elongated carbon filaments characterized by an absence of substituents.

13. In a papermaking machine, a felt roll in the form of a cylinder ranging from 25 to 70 in length-to-diameter ratio, said cylinder being characterized by a two-phase composition having a synthetic polymeric external phase and a carbon filament internal phase, said roll presenting a smooth periphery.

14. In a papermaking machinery, the felt roll of claim **13** wherein said synthetic polymeric external phase is composed of a diglycidyl either of bisphenol and said carbon filament internal phase is composed of spaced elongated carbon filaments characterized by an absence of substituents.