The present invention relates to cellulosic and para-aramid pulp for use as reinforcement material in products such as seals and friction materials. The pulp comprises (a) irregularly shaped, cellulosic fibrous structures, (b) irregularly shaped, para-aramid fibrous structures, and (c) water, whereby cellulosic fibrils and/or stalks are substantially entangled with para-aramid fibrils and/or stalks. The invention further relates to processes for making such cellulosic and aramid pulp.
CELLULOSIC AND PARA-ARAMID PULP AND PROCESSES OF MAKING SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

This invention relates to a process of making cellulose and para-aramid pulp for use as reinforcement material in products, such as seals and friction materials. The invention further relates to processes for making such pulp.

[0002] 2. Description of Related Art

Fibrous and non-fibrous reinforcement materials have been used for many years in friction products, sealing products, and other plastic or rubber products. Such reinforcement materials typically exhibit high wear and heat resistance.

Asbestos fibers have historically been used as reinforcement materials, but due to their health risks, replacements have been made or proposed. However, many of these replacements do not perform as well as asbestos in one way or another.

Research Disclosure 74-75, published February 1980, discloses the manufacture of pulp made from fibrillated KEVLAR® brand para-aramid fibers of variable lengths and use of such pulp as a reinforcement material in various applications. This publication discloses that pulp made from KEVLAR® brand para-aramid fibers can be used in sheet products alone, or in combination with fibers of other materials, such as NOMEX® brand meta-aramid, wood pulp, cotton and other natural celluloses, rayon, polyester, polyolefin, nylon, polytetrafluoroethylene, asbestos and other minerals, fiberglass, and other ceramics, steel and other metals, and carbon. The publication also discloses the use of pulp from KEVLAR® brand para-aramid fiber alone, or with KEVLAR® brand para-aramid short staple, in friction materials to replace a fraction of the asbestos volume, with the remainder of the asbestos volume being replaced by fillers or other fibers.

U.S. Pat. No. 5,811,042 (to Hoiness) discloses a composite friction or gasketing material made of a thermoset or thermoplastic matrix resin, fiber reinforcing material, and substantially fibril free aramid particles. Poly(p-phenylene terephthalamide) and poly(m-phenylene isophthalamide) are preferred fiber reinforcing materials, and the fibers can be in the form of floc or pulp.

U.S. Patent Application 2003/0022561 (to Kusaka et al.) discloses friction materials made from a friction modifier, a binder and a fibrous reinforcement made of a mixture of (a) a dry aramid pulp and (b) wet aramid pulp, wood pulp or acrylic pulp. Dry aramid pulp is defined as an aramid pulp obtained by “the dry fibrillation method”. The dry fibrillation method is dry milling the aramid fibers between a rotary cutter and a screen to prepare the pulp. Wet aramid pulp is defined as an aramid pulp obtained by “the wet fibrillation method”. The wet fibrillation method is milling short aramid fibers in water between a rotary disc to form fibrillated fibers and then dehydrating the fibrillated fibers, i.e., the pulp. Kusaka et al further disclose a method of mix-fibrillating fibers by first mixing plural types of organic fibers that fibrillate at a definite ratio, and then fibrillating the mixture to produce a pulp.

[0009] There is an ongoing need to provide alternative reinforcing materials that both perform well in products, such as seals and friction applications, and that are low in cost. Despite the numerous disclosures proposing lower cost alternative reinforcement materials, many of these proposed products do not adequately perform in use, cost significantly more than currently commercial products, or have other negative attributes. As such, there remains a need for reinforcement materials that exhibit high wear and heat resistance, and that are comparable or less expensive than other commercially available reinforcement materials.

BRIEF SUMMARY OF THE INVENTION

[0010] The invention relates to a first embodiment of a process for making a cellulose and para-aramid pulp for use as reinforcement material, comprising:

[0011] (a) combining pulp ingredients including:

[0012] (1) cellulose fiber that retains at least 10% of its weight when heated in air to 700° C. at a rate of 20° C. per minute, the fiber being 10 to 90 wt % of the total solids in the ingredients, and having an average length of no more than 10 cm;

[0013] (2) para-aramid fiber being 10 to 90 wt % of the total solids in the ingredients, and having an average length of no more than 10 cm; and

[0014] (3) water being 95 to 99 wt % of the total ingredients;

[0015] (b) mixing the ingredients to a substantially uniform slurry;

[0016] (c) co-refining the slurry by simultaneously:

[0017] (1) fibrillating, cutting and masticating the cellulose fiber and the para-aramid fiber to irregularly shaped fibrillated fibrous structures with stalks and fibrils; and

[0018] (2) dispersing all solids such that the refined slurry is substantially uniform; and

[0019] (d) removing water from the refined slurry to no more than 60 total wt % water,

[0020] thereby producing a cellulose and para-aramid pulp where the cellulose fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.

[0021] The invention is further related to a second embodiment of a process for making a cellulose and para-aramid pulp for use as reinforcement material, comprising:

[0022] (a) combining ingredients including water and a first fiber from the group consisting of:

[0023] (1) cellulose fiber that retains at least 10% of its weight when heated in air to 700° C. at a rate of 20° C. per minute, the fiber being 10 to 90 wt % of the total solids in the pulp; and

[0024] (2) para-aramid fiber being 10 to 90 wt % of the total solids in the pulp;

[0025] (b) mixing the combined ingredients to a substantially uniform suspension;
(c) refining the suspension in a disc refiner thereby cutting the fiber to an average length of no more than 10 cm, and fibrillating and masticating at least some of the fiber to irregularly shaped fibrillated fibrous structures;

(d) combining ingredients including, the refined suspension, the second fiber of the group of (a) (1 and 2), and water, if necessary, to increase the water concentration to 95-99 wt % of the total ingredients;

(e) mixing the ingredients, if necessary, to form a substantially uniform suspension;

(f) co-refining the mixed suspension by:

(1) fibrillating, cutting and masticating solids in the suspension such that all or substantially all of the cellulosic and para-aramid fiber is converted to irregularly shaped fibrillated fibrous structures with stalks and fibrils; and

(2) dispersing all solids such that the refined slurry is substantially uniform; and

(b) removing water from the refined slurry to no more than 60 total wt % water,

thereby producing a cellulosic and para-aramid pulp where the cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.

The invention is further directed to a cellulosic and para-aramid pulp for use as reinforcement material, comprising:

(a) irregularly shaped, cellulosic fibrous structures that retain at least 10% of their weight when heated in air to 700°C at a rate of 20°C per minute, the cellulosic fibrous structures being 10 to 90 wt % of the total solids;

(b) irregularly shaped, para-aramid fibrous structures being 10 to 90 wt % of the total solids; and

(c) water being 4 to 60 wt % of the entire pulp,

whereby the cellulosic and the para-aramid fibrous structures having an average maximum dimension of no more than 5 mm, a length-weighted average of no more than 1.3 mm, and stalks and fibrils where the cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.

The invention is further directed to a friction material, comprising a friction modifier; optionally at least one filler; a binder; and a fibrous reinforcement material comprising the pulp of the present invention.

Moreover, the invention is directed to a sealing material, comprising a binder; optionally at least one filler; and a fibrous reinforcement material comprising the pulp of the present invention.

BRIEF DESCRIPTION OF THE DRAWING(S)

The invention can be more fully understood from the following detailed description thereof in connection with accompanying drawings described as follows.
“Length-weighted average” means the calculated length from the following formula:

\[
\text{Length-weighted average} = \frac{\sum (\text{Each Individual pulp length})^2}{\sum \text{Each Individual pulp length}}
\]

“Maximum dimension” of an object means the straight distance between the two most distal points from one another in the object.

“Staple fiber” can be made by cutting filaments into lengths of no more than 15 cm, preferably 3 to 15 cm; and most preferably 3 to 8 cm. The staple fiber can be straight (i.e., non-crimped) or crimped to have a saw tooth shaped crimp along its length, with any crimp (or repeating bend) frequency. The fibers can be present in uncoated, or coated, or otherwise pretreated (for example, pre-stretched or heat-treated) form.

**DETAILED DESCRIPTION OF THE INVENTION**

The invention is directed to processes for making a cellulosic and para-aramid pulp for use as reinforcement material. The invention is also directed to cellulosic and para-aramid pulp, that can be made by the processes of the invention, for use as reinforcement material. The invention is further directed to products, such as scaling materials and friction materials, incorporating the pulp of this invention, and processes for making them.

**I. First Embodiment of the Inventive Process**

In a first embodiment, the process for making a cellulosic and para-aramid pulp comprises the following steps. First, pulp ingredients are combined, added or contacted together. Second, the combined pulp ingredients are mixed to a substantially uniform slurry. Third, the slurry is simultaneously refined or co-refined. Fourth, water is removed from the refined slurry.

**Combining Step**

In the combining step, the pulp ingredients are preferably added together in a container. The pulp ingredients include (1) cellulosic fiber, (2) para-aramid fiber, (3) optionally substantially or completely fibril-free, granular, para-aramid particles, (4) optionally other minor additives, and (5) water.

**Cellulosic Fiber**

The cellulosic fiber is added to a concentration of 10 to 90 wt % of the total solids in the ingredients, preferably 25 to 60 wt % of the total solids in the ingredients, and most preferably 25 to 55 wt % of the total solids in the ingredients.

**Para-Aramid Fiber**

The cellulosic fiber useful in this invention is an ash-forming cellulosic fiber. By “ash-forming”, it is meant that the cellulosic fiber retains at least 10 percent of its weight when heated in air to 700°C. at a rate of 20°C. per minute. Such cellulosic fibers preferably have 10 percent inorganic compounds incorporated into the fibers. Such fibers, and methods for making such fibers, are generally disclosed in U.S. Pat. No. 3,565,749 and British Patent GB 1,064,271.

A preferred ash-forming cellulosic fiber for this invention is a fiber containing silicon dioxide in the form of a polysilicic acid, or salt of the acid, in a cellulosic supporting structure, wherein the polysilicic acid contains aluminum silicate sites. This fiber is made by spinning a viscose containing an even distributed quantity of a silicon dioxide alkaline solution into a fiber, and in a subsequent step, treating the fiber with an aluminum solution. The silicon dioxide alkaline solution is preferably an aqueous solution of silicon dioxide and sodium hydroxide, preferably made by dissolving essentially soluble silicon dioxide to the level of 0.5 to 25 percent by weight in an aqueous solution of sodium hydroxide at a concentration of 10 to 25 percent by weight. The viscose containing the silicon dioxide alkaline solution is spun in an acid spin bath, where the viscose is regenerated into cellulose fibers and the silicon dioxide alkaline solution is precipitated and evenly distributed in the cellulose as polysilicic acid, which is a water-containing form of silicon dioxide. The polysilicic acid is precipitated in such a manner that its primary particles, regularly distributed in the cellulose, form into larger agglomerations with a diameter measurable in nanometers. The fiber, once formed, is preferably drawn and washed and is then treated with an aqueous aluminum solution, such as sodium aluminate at a concentration of 0.1 to 10 percent by weight, at a temperature of 0 to 100 degrees Celsius, preferably 20 to 60 degrees Celsius. On modification with the aluminum solution, the surface of the polysilicic acid agglomerations in the cellulose supporting structure is converted to aluminum silicate. The aluminate anions in the sodium aluminate react with the silanol groups on the surface of the polysilicic acid to form aluminum silicate sites and the surface of the fiber receives a charge that is neutralized by sodium cations. Other salts of aluminum can be used for the modification, in which case the aqueous solution made from them, with the aluminum in a suitably reactive form, is used in the same manner as the aluminum solution after spinning the fiber. These preferred fibers, and methods for making such fibers, are generally disclosed in U.S. Pat. No. 5,417,752 and International Patent Application WO9217629. Further, representative fibers preferably have approximately 31 (+/−3) percent inorganic material, such as sold under the trademark VISIL® by Sateri Oy Company of Finland. The ash-forming fibers of this invention, when incorporated into the pulp of the invention, provide improved heat resistant performance compared with cellulosics not having added inorganic constituents.

The cellulosic fiber preferably has an average length of no more than 10 cm, more preferably 0.5 to 5 cm, and most preferably 0.6 to 2 cm. Prior to combining the pulp ingredients together, any cellulosic fibers in the form of continuous filaments can be cut into shorter fibers, such as staple fibers or floc.

**Para-Aramid Fiber**

The para-aramid fiber is added to a concentration of 10 to 90 wt % of the total solids in the ingredients, preferably 40 to 75 wt % of the total solids in the ingredients, and most preferably 40 to 55 wt % of the total solids in the ingredients. The para-aramid fiber preferably has a linear density of no more than 10 denier, more preferably 0.5 to 10 denier, and most preferably, 0.8 to 2.5 denier. The para-aramid fiber also preferably has an average length along its longitudinal axis of no more than 10 cm, more preferably an
average length of 0.65 to 2.5 cm, and most preferably an average length of 0.65 to 1.25 cm.

[0064] Para-Aramid Particles

[0065] Optionally, in one embodiment, the pulp ingredients further include substantially or completely fibril-free, granular, para-aramid particles. If these particles are added, they are added to a concentration of no more than 50 wt % of the total solids in the ingredients, preferably 20 to 50 wt % of the total solids in the ingredients, and most preferably 25 to 35 wt % of the total solids in the ingredients. Being made of para-aramid, they contribute superior wear resistance and dispersibility to the pulp being produced. Because the particles are substantially fibril-free, they also serve as a compounding agent to assist in dispersing the other ingredients in the mixture and slurry. Particles that perform this function are often known as processing agents or aids. The substantially or completely fibril-free, granular, para-aramid particles have an average maximum dimension of 50 to 2000 microns (0.05 to 2 mm), preferably 50 to 1500 microns, and most preferably 75 to 1000 microns. Particles below about 50 microns, however, lose effectiveness in friction and sealing applications. Particles above about 2000 microns do not adequately stay dispersed in the water with the other ingredients when mixed. FIG. 3 is an image of a photomicrograph of para-aramid particles capable of being used as an ingredient to the process of the present invention.

[0066] Aramid Polymer

[0067] Polymers suitable for use in making the aramid fiber and aramid particles of this invention are synthetic aromatic polyamides. The polymers must be of fiber-forming molecular weight in order to be shaped into fibers. The polymers can include polyamide homopolymers, copolymers, and mixtures thereof which are predominantly aromatic, wherein at least 85% of the amide (—CONH—) linkages are attached directly to two aromatic rings. The rings can be unsubstituted or substituted. The polymers are para-aramid when the two rings are para oriented with respect to each other along the molecular chain. Preferably copolymers have no more than 10 percent of other diamines substituted for a primary diamine used in forming the polymer or no more than 10 percent of other diacid chlorides substituted for a primary diacid chloride used in forming the polymer. Additives can be used with the aramid; and it has been found that up to as much as 13 percent by weight of other polymeric material can be blended or bonded with the aramid. The preferred para-aramids are poly(para-phenylene terephthalamide)(PPD-T) and its copolymers.

[0068] Optional Other Additives

[0069] Other additives can optionally be added as long as they stay suspended in solution in the mixing step and do not significantly change the effect of the refining step on the mandatory solid ingredients listed above. Suitable additives include pigments, dyes, anti-oxidants, flame-retardant compounds, and other processing and dispersing aids. Preferably, the pulp ingredients do not include asbestos. In other words, the resulting pulp is asbestos free or without asbestos.

[0070] Water

[0071] Water is added to a concentration of 95 to 99 wt % of the total ingredients, and preferably 97 to 99 wt % of the total ingredients. Further, the water can be added first. Then other ingredients can be added at a rate to optimize dispersion in the water while simultaneously mixing the combined ingredients.

**Mixing Step**

[0072] In the mixing step, the ingredients are mixed to a substantially uniform slurry. By “substantially uniform” is meant that random samples of the slurry contain the same wt % of the concentration of each of the starting ingredients as in the total ingredients in the combination step plus or minus 10 wt %, preferably 5 wt % and most preferably 2 wt %. For instance, if the concentration of the solids in the total mixture is 30 wt % cellulosic fiber plus 50 wt % para-aramid fiber, then a substantially uniform mixture in the mixing step means each random sample of the slurry has (1) a concentration of the cellulosic fiber of 50 wt % plus or minus 10 wt %, preferably 5 wt % and most preferably 2 wt % and (2) a concentration of para-aramid fiber of 50 wt % plus or minus 10 wt %, preferably 5 wt % and most preferably 2 wt %. The mixing can be accomplished in any vessel containing rotating blades or some other agitator. The mixing can occur after the ingredients are added or while the ingredients are being added or combined.

**Refining Step**

[0073] In the refining step the pulp ingredients are simultaneously co-refined, converted or modified as follows. The cellulosic fiber and the para-aramid fiber are fibrillated, cut and masticated to irregularly shaped fibrous structures having stalks and fibrils. If para-aramid particles are added with the other ingredients, at least some of the para-aramid particles are masticated into smaller, rounder, substantially fibril-free, particles. All solids are dispersed such that the refined slurry is substantially uniform. “Substantially uniform” is as defined above. The refining step preferably comprises passing the mixed slurry through one or more disc refiners, or recycling the slurry back through a single refiner. By the term “disc refiner” is meant a refiner containing one or more pair of discs that rotate with respect to each other thereby refining ingredients by the shearing action between the discs. In one suitable type of disc refiner, the slurry being refined is pumped between closely spaced circular rotor and stator discs rotatable with respect to one another. Each disc has a surface, facing the other disc, with at least partially radially extending surface grooves. A preferred disc refiner that can be used is disclosed in U.S. Pat. No. 4,472,241. If necessary for uniform dispersion and adequate refining, the mixed slurry can be passed through the disc refiner more than once or through a series of at least two disc refiners. When the mixed slurry is refined in only one refiner, there is a tendency for the resulting slurry to be inadequately refined and non-uniformly dispersed. Conglomerates or aggregates entirely or substantially of one solid ingredient, or the other, or both, or all three if three are present, can form rather than being dispersed forming a substantially uniform dispersion. Such conglomerates or aggregates have a greater tendency to be broken apart and dispersed in the slurry when the mixed slurry is passed through the refiner more than once or passed through more than one refiner.

[0074] Because a substantially uniform slurry containing multiple ingredients is co-refined in this step of the process, any one type of non-pulp ingredient (for example, para-
aramid fiber) is refined into a pulp in the presence of all the other types of non-pulp ingredients (for example, aramid material pieces and optionally para-aramid particles) while those other ingredients are also being refined. This co-refining of non-pulp ingredients forms a pulp that is superior to a pulp blend generated by merely mixing two pulps together. Adding two pulps and then merely mixing them together does not form the substantially uniform, intimately connected, fibrous components of the pulp generated by co-refining of non-pulp ingredients into pulp in accordance with the present invention.

Removing Step

[0075] Then water is removed from the refined slurry to no more than 60 total wt % water, preferably 4 to 60 total wt % water, most preferably, 5 to 58 total wt % water. The water can be removed by collecting the pulp on a dewatering device such as a horizontal filter, and if desired, additional water can be removed by applying pressure or squeezing the pulp filter cake. The dewatered pulp can optionally then be dried to a desired moisture content, and/or can be packaged or wound up on rolls.

FIGS. 1 and 2

[0076] This process will now be described in reference to FIGS. 1 and 2. Throughout this detailed description, similar reference characters refer to similar elements in all figures of the drawings.

[0077] Referring to FIG. 1, there is a block diagram of an embodiment of a ‘wet’ process for making ‘wet’ pulp in accordance with the present invention. Pulp ingredients 1 are added to container 2. Container 2 is provided with an internal mixer, similar to a mixer in a washing machine. The mixer disperses the ingredients into the water creating the substantially uniform slurry. The mixed slurry is transferred to a first refiner 3 which refines the slurry. Then, optionally, the refined slurry can be transferred to a second refiner 4, and optionally then to a third refiner 5. Three refiners are illustrated but any number of refiners can be used depending on the degree of uniformity and refining desired. After the last refiner in the series of refiners, the refined slurry is optionally transferred to a filter or sorter 6 that allows slurry with dispersed solids below a chosen mesh or screen size to pass and recirculates dispersed solids larger than a chosen mesh or screen size back to one or more of the refiners such as through line 7 or to a refiner 8 dedicated to refine this recirculated slurry from which refined slurry is again passed to the filter or sorter 6. Suitably refined slurry passes from the filter or sorter 6 to a horizontal water vacuum filter 9 which removes water such that the pulp has a concentration of water of no more than 75 wt % of the total ingredients. Slurry can be transferred from point to point by conventional method and apparatus such as with the assistance of one or more pump 10. Then the pulp is conveyed to a dryer 11 that removes more water until the pulp has a concentration of water of no more than 60 wt % of the total ingredients. Then the refined pulp is packaged in a bale 12.

[0078] Referring to FIG. 2, there is a block diagram of an embodiment of a dry process for making ‘dry’ pulp in accordance with the present invention. This dry process is the same as the wet process except after the horizontal water vacuum filter 9. After that filter, the pulp goes through a press 13 which removes more water until the pulp has a concentration of water of no more than 20 wt % of the total ingredients. Then the pulp goes through a fluffer 14 to fluff the pulp and then a rotor 15 to remove more water. Then, like the wet process, the pulp is passed through a dryer 11 and packaged in a bale 12.

II. Second Embodiment of the Inventive Process

[0079] In a second embodiment, the process for making the cellulosic fiber and para-aramid pulp is the same as the first embodiment of the process described above with the following differences.

[0080] Prior to combining all ingredients together, either the cellulosic fiber or the para-aramid fiber, or both the cellulosic fiber and the para-aramid fiber, may need to be shortened. This can be done by combining water with either the cellulosic fiber or the para-aramid fiber. Then the water and fiber can be mixed to form a first suspension and processed through a first disc refiner to shorten the fiber. The refiner cuts the fiber to have an average length of no more than 10 cm. The refiner will also partially fibrillate and partially masticate the fiber. The other fiber, that was not previously added, can optionally be shortened this way too forming a second processed suspension. Then the other fiber having an average length of no more than 10 cm (or the second suspension, if suspended in water) is combined with the first suspension.

[0081] More water is added before or after or when other ingredients are added, if necessary, to increase the water concentration to 95-99 wt % of the total ingredients. After all ingredients are combined, they can be mixed, if necessary, to achieve a substantially uniform slurry.

[0082] The ingredients in the slurry are then co-refined together, i.e., simultaneously. This refining step includes fibrillating, cutting and masticating solids in the slurry such that all or substantially all of the cellulosic and para-aramid fiber is converted to irregularly shaped fibrillated fibrous structures. This refining step also includes dispersing all solids such that the refined slurry is substantially uniform. Then water is removed as in the first embodiment of the process. Both processes produce the same or substantially the same cellulosic and para-aramid pulp.

The Inventive Pulp

[0083] The resulting product produced by the process of this invention is a cellulosic and para-aramid pulp for use as reinforcement material in products. The pulp comprises (a) irregularly shaped, cellulosic fibrous structures, (b) irregularly shaped, para-aramid fibrous structures, (c) optionally substantially fibril-free, granular, para-aramid particles, (d) optionally other minor additives, and (e) water.

[0084] The concentration of the separate ingredient components in the pulp correspond, of course, to the concentrations described beforehand of the corresponding ingredients used in making the pulp.

[0085] The irregularly shaped, cellulosic and para-aramid fibrillated fibrous structures have stalks and fibrils. The cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks. The fibrils are important and act as hooks or fasteners or tentacles which
adhere to and hold adjacent particles in the pulp and final product thereby providing integrity to the final product.

[0085] The cellulosic and para-aramid fibrillated fibrous structures preferably have an average maximum dimension of no more than 5 mm, more preferably 0.1 to 5 mm, and most preferably 0.1 to 3 mm. The cellulosic and para-aramid fibrillated fibrous structures preferably have a length-weighted average of no more than 1.3 mm, more preferably 0.7 to 1.3 mm, and most preferably 0.75 to 1.2 mm.

[0086] If para-aramid particles are included in the pulp, the cellulosic and para-aramid fibrous structures also additionally contact and are wrapped partially around at least some of these rounder, substantially fibril-free, para-aramid particles. These para-aramid particle also preferably have a dimension of at least 50 microns, more preferably, 50 to 100 microns, and most preferably 50 to 75 microns. Fibrils on and along the cellulosic and para-aramid fibrous structures can contact and form a partial cocoon around the rounder, substantially fibril-free, para-aramid particles.

[0087] The cellulosic and para-aramid pulp is without substantial aggregates or conglomerates of the same material. Further, the pulp has a Canadian Standard Freeness (CSF) as measured per TAPPI test T 227 om-92, which is a measure of its drainage characteristics, of 100 to 700 ml, and preferably 250 to 450 ml.

[0088] Surface area of pulp is a measure of the degree of fibrillation and influences the porosity of the product made from the pulp. Preferably, the surface area of pulp of this invention is 7 to 11 square meters per gram.

[0089] FIG. 4 is an image of a photomicrograph of cellulosic and para-aramid pulp made according to the process of the present invention.

[0090] It is believed that aramid particles and fibrous structures, dispersed substantially homogeneously throughout the reinforcement material, and the friction and sealing materials, provide, by virtue of the high temperature characteristics of the para-aramid polymer and the fibrillation propensity of the cellulosic and para-aramid polymers, many sites of reinforcement and increased wear resistance. When co-refined, the blending of the aramid materials is so intimate that in a friction or sealing material there is always some para-aramid fibrous structures close to the cellulosic structures, so the stresses and abrasion of service are always shared.

Sealing Material

[0091] The invention is further directed to sealing material and processes for making the sealing materials. Sealing materials are used in or as a barrier to prevent the discharge of fluids and/or gases and used to prevent the entrance of contaminants where two items are joined together. An illustrative use for the sealing material is in gaskets. The sealing material comprises a binder; optionally at least one filler; and a fibrous reinforcement material comprising the cellulosic and para-aramid pulp of this invention. Suitable binders include nitrile rubber, butadiene rubber, neoprene, styrene-butadiene rubber, nitrile-butadiene rubber, and mixtures thereof. The binder can be added with all other starting materials. The binder is typically added in the first step of the gasket production process, in which the dry ingredients are mixed together. Other ingredients optionally include uncured rubber particles and a rubber solvent, or a solution of rubber in solvent, to cause the binder to coat surfaces of the fillers and pulp. Suitable fillers include barium sulfate, clays, talc, and mixtures thereof.

[0092] The following test methods were used in the following Examples.

[0093] The pulp of the present invention can be used as a reinforcement material in friction materials. By “friction materials” is meant materials used for their frictional characteristics such as coefficient of friction to stop or transfer energy of motion, stability at high temperatures, wear resistance, noise and vibration damping properties, etc. Illustrative uses for friction materials include brake pads, brake blocks, dry clutch facings, clutch face segments, brake pad backing/insulating layers, automatic transmission papers, and friction papers.

Friction Material

[0094] The pulp of the present invention can be used as a reinforcement material in friction materials. By “friction materials” is meant materials used for their frictional characteristics such as coefficient of friction to stop or transfer energy of motion, stability at high temperatures, wear resistance, noise and vibration damping properties, etc. Illustrative uses for friction materials include brake pads, brake blocks, dry clutch facings, clutch face segments, brake pad backing/insulating layers, automatic transmission papers, and friction papers.

[0095] In view of this new use, the invention is further directed to friction material and processes for making the friction material. Specifically, the friction material comprises a friction modifier; optionally at least one filler; a binder; and a fibrous reinforcement material comprising the cellulosic and para-aramid pulp of this invention. Suitable friction modifiers are metal powders such as iron, copper and zinc; abrasives such as oxides of magnesium and aluminum; lubricants, such as synthetic and natural graphites, and sulfides of molybdenum and zirconium; and organic friction modifiers such as synthetic rubbers and cashew nut shell resin particles. Suitable binders are thermosetting resins such as phenolic resins (i.e., straight (100%) phenolic resin and various phenolic resins modified with rubber or epoxy), melamine resins, epoxy resins and polyimide resins, and mixtures thereof. Suitable fillers include barite, calcium carbonate, wollastonite, talc, various clays, and mixtures thereof.

[0096] The actual steps for making the friction material can vary, depending on the type of friction material desired. For example, methods for making molded friction parts generally involve combining the desired ingredients in a mold, curing the part, and shaping, heat treating and grinding the part if desired. Automotive transmission and friction papers generally can be made by combining the desired ingredients in a slurry and making a paper on a paper machine using conventional paper making processes.

TEST METHODS

[0097] The following test methods were used in the following Examples.

[0098] Canadian Standard Freeness (CSF) is a well-known measure of the facility for water to drain from a slurry or dispersion of particles. Freeness is determined by TAPPI test T 227. Data obtained from conduct of that test are expressed as Canadian Standard Freeness Numbers, which represent the milliliters of water which drain from an aqueous slurry under specified conditions. A large number indicates a high freeness and a high tendency for water to drain. A low number indicates a tendency for the dispersion
to drain slowly. The freeness is inversely related to the degree of fibrillation of the pulp, since greater numbers of fibrils reduce the rate at which water drains through a forming paper mat.

[0099] Length-weighted average is measured using a “FiberExpert” tabletop analyzer (also known as “PulpExpertFS”, available from Metso Automation of Helsinki, Finland). This analyzer takes photographic images of the pulp with a digital CCD camera as the pulp slurry flows through the analyzer and then an integrated computer analyzes the fibers in these images and calculates their length-weighted average.

[0100] Temperature: All temperatures are measured in degrees Celsius (°C).

[0101] Denier is measured according to ASTM D 1577 and is the linear density of a fiber as expressed as weight in grams of 9000 meters of fiber.

[0102] The denier is measured on a Vibroscope from Texttecho of Munich, Germany. Denier times (10/9) is equal to decitex (dtex).

[0103] ThermoGravimetric Analysis: The cellulosic fibers used in this invention retain a portion of their fiber weight when heated to high temperature at a specific heating rate. This fiber weight was measured using a Model 2950 Thermogravimetric Analyzer (TGA) available from TA Instruments (a division of Waters Corporation) of Newark, Del. The TGA gives a scan of sample weight loss versus increasing temperature. Using the TA Universal Analysis program, percent weight loss can be measured at any recorded temperature. The program profile consists of equilibrating the sample at 50 degrees C, placing the sample in a 500 microliter ceramic cup (PN 95208.910) sample container and ramping the temperature of the air, as measured by a thermocouple placed directly above the lip of the sample container, at 20 degrees C per minute from 50 to 1000 degrees C, using air as the gas being supplied at 10 ml/minute.

[0104] The testing procedure is as follows. The TGA was programmed using the TGA screen on the TA Systems 2900 Controller. The sample ID was entered and the planned temperature ramp program of 20 degrees per minute selected. The empty sample cup was tared using the tare function of the instrument. The fiber sample was cut into approximately 1/8" (0.16 cm) lengths and the sample pan was loosely filled with the sample. The sample weight should be in the range of 10 to 50 mg. The TGA has a balance, therefore the exact weight does not have to be determined beforehand. None of the sample should be outside the pan. The filled sample pan was placed onto the balance wire making sure the thermocouple is close to the top edge of the pan but not touching it. The furnace is raised over the pan and the TGA is started. Once the program is complete, the TGA will automatically lower the furnace, remove the sample pan, and go into a cool down mode. The TA Systems 2900 Universal Analysis program is then used to analyze and produce the TGA scan for percent weight loss over the range of temperatures.

EXAMPLES

[0105] This invention will now be illustrated by the following specific examples. All parts and percentages are by weight unless otherwise indicated. Examples prepared according to the process or processes of the current invention are indicated by numerical values.

Example 1

[0106] In this example of the invention, the pulp of this invention was produced from a feedstock of para-aramid fiber and cellulosic staple. VILIS® brand staple having a cut length of 2 inches and having a filament linear density of 3 dpf (3.3 dtex per filament) was obtained from Sateri Oy of Finland. Para-aramid fiber in the form of commercially available KEVLAR® brand fiber, Style 1F178, having a 5/8" cut length, was obtained from E. I. du Pont de Nemours and Company with offices in Wilmington, Del., USA.

[0107] The cellulosic staple, para-aramid fiber, and water were fed simultaneously into a highly agitated tank and then simultaneously pumped through a Sprout-Waldron 12" Single Disc Refiner for approximately five (5) minutes. Cellulosic staple and water together were fed directly into a Sprout-Waldron 12" Single Disc Refiner using a 3 mil plate gap setting and pre-pulped to reach an acceptable processing length in the range of 13 mm.

[0108] The pre-pulped cellulosic fiber and the cut para-aramid fiber plus water were then combined into a highly agitated mixing tank at a solids concentration of 50 wt% para-aramid fiber and 50 wt% cellulosic fiber and mixed to form a uniform, pumpable slurry of about 2.5-3 wt% of the total ingredients concentration. The slurry was then recirculated and co-refined through a Sprout-Waldron 12" Single Disc Refiner.

[0109] The refiner simultaneously:

[0110] (1) fibrillated, cut, and masticated both the para-aramid fiber and the cellulosic fiber to irregularly shaped fibrous structures having stalks and fibrils.

[0111] (2) dispersed all solids such that the refined slurry was substantially uniform with substantially uniform as previously defined.

[0112] This refined slurry was then filtered using a filter bag and was dewatered through pressing and placed in large ZIPLOC® type storage bags. The resulting pulp structures had an average maximum dimension of no more than 5 mm and a length-weighted average of no more than 1.3 mm, as measured by FiberExpert®.

Example 2

[0113] This example illustrates another method by which a co-refined pulp can be made from a feedstock of para-aramid fiber and cellulosic fiber. Cellulosic fiber, having a cut length of 2 inches and having a filament linear density of 3 dpf (3.3 dtex per filament) available from Sateri Oy, is cut with a guillotine cutter two to three times at right angles in order to produce a random-length fiber with most fibers shorter than 3/4 inch (1.91 cm) and averaging about 5/8 inch (1.27 cm) long.

[0114] Para-aramid fiber in the form of commercially available KEVLAR® brand multifilament yarn, available from E. I. du Pont de Nemours and Company on bobbins, is prepared by cutting the para-aramid yarn to a nominal 5/8 inch (1.27 cm) cut length on a Lummus Cutter (available
from Lummus Industries with offices in Columbus, Ga.). Other KEVLAR® brand para-aramid fiber, which initially is not on bobbins and is of multiple long lengths, is cut by a guillotine cutter two to three times at right angles in order to produce a random-length fiber with most fibers shorter than 3⁄4 inch (1.91 cm) and averaging about ½ inch (1.27 cm) long.

[0115] The two ingredients prepared as described above plus water are then combined into a highly agitated mixing tank called a hydrapulper at a solids concentration of 50 wt % para-aramid fiber and 50 wt % cellulosic fiber and mixed to form a substantially uniform, pumpable slurry having a total solids concentration of about 2-3 wt % of the total ingredients. The slurry is pumped through a series of three refiners, as described in U.S. Pat. No. 4,472,241. The refiners simultaneously:

[0116] (1) fibrillate, cut, and masticate the cellulosic fiber and the para-aramid fiber into irregularly shaped fibrous structures having stalks and fibrils; and

[0117] (2) disperse all solids such that the refined slurry was substantially uniform. “Substantially uniform” is as defined above.

[0118] This refined slurry is then dewatered using a horizontal filter and dried in an oven to a desired moisture content of 50 total wt % for wet pulp. The wet pulp is then packaged into bales by a baler. When measured by FiberExpert®, the pulp structures have a length-weighted average of no more than 1.3 mm.

Example 3

[0119] This example illustrates further process steps and another embodiment of the pulp of this invention. The procedure of Example 2 is followed. However, after the pulp is dewatered on the horizontal filter, the pulp is pressed in a mechanical press to further remove water; and the pulp is then fluffed using a Fluffer (available from Bepex Corporation with offices at Santa Rosa, Calif.) to better separate the pressed wet pulp. The fluffed wet pulp is then dried in an oven to approximately 8 total wt % moisture and is then further processed in an ultrarotor (model IIIA available from Altenburger Maschinen Jackering GmbH with offices in Voisterhausen, Germany) as is disclosed in U.S. Pat. No. 5,084,136 to further fluff and disperse the dried pulp. The dried pulp is then packaged into bales. When measured by FiberExpert®, the pulp fibrous structures have a length-weighted average of no more than 1.3 mm.

Example 4

[0120] This example illustrates another embodiment of the pulp of this invention. The process of Example 2 is followed with the exception that one third by weight of the para-aramid fiber is replaced by para-aramid particles. The para-aramid resin particles are prepared by reacting para-polyphenylene diamine and tetrahydroxyl chloride continuously in a screw extruder as is generally disclosed in U.S. Pat. No. 3,884,881, but using N, methyl pyrrolidone/calcium chloride as the solvent, producing a crumb-like polymer that precipitates from the solvent. The solvent is extracted, and the polymer crumb washed and dried to a particulate powder of mixed particle size. The para-aramid resin particles are then treated substantially the same as the para-aramid fiber is treated in Example 2. However, the refiner not only refines the fibers but also cuts and/or masticates the para-aramid particles into rounder, substantially fibril-free particles. After dewatering, some of the resulting pulp having a moisture content of 50 total wt percent is then packaged into bales. The remainder of the resulting pulp is further pressed to a moisture content of approximately 8 total wt percent and then fluffed, dispersed, and packaged as in Example 3. When measured by FiberExpert®, the fibrous structures in the pulp have a length-weighted average of no more than 1.3 mm.

Example 5

[0121] Disc brake pads incorporating the pulp of this invention were made in the following manner. Approximately 20 kilograms of a non-asbestos-containing base compound powder comprising a mixture of 7 wt % cashew nut shell resin, 17 wt % inorganic fillers, 21 wt % graphite, coke and lubricants, 18 wt % inorganic abrasives, and 16 wt % soft metals was mixed together for 10 to 20 minutes in a 50-liter Littleford mixer. The mixer had two high-speed choppers with blades of the “stars and bars” configuration and a slower rotating plough.

[0122] 5 kilograms of the well-blended base compound powder was then combined with the pulp of this invention (a co-refined pulp being 50 wt % para-aramid and 50 wt % cellulosic fiber) in an amount of 3.8 wt %, based on the combined weight of the compound powder and the pulp. The pulp was then dispersed in the base compound powder by mixing for an additional 5 to minutes. Once mixed, the resulting brake pad composition had a normal visual appearance with the fiber well dispersed in and completely coated with the base compound powders, with essentially no detectable balling up of the pulp or segregation of any constituents.

[0123] The brake pad composition was then poured into a single-cavity steel mold for a four-disc brake pad and cold pressed to a standard thickness of about ¾ inch (16 mm) then removed from the mold to form a pre-formed brake pad having an approximate weight of 200 grams. The pre-form had no excessive spring-back or swelling, and was robust enough to endure normal handling without damage. Twelve replicate pre-forms were made. The pre-forms were then placed in two multi-cavity molds, placed in a commercial press, and press-cured (the binder phenolic cross-linking and reacting) at 300° F. (149° C.) for about 15 minutes, with periodic pressure release to allow phenolic reaction gases to escape, followed by lightly constrained oven curing at 340° F. (171° C.) for 4 hours to complete the phenolic binder crosslinking. The cured, molded pad was then ground to the desired thickness of about half an inch (13 mm). When compared visually with a commercial brake pad containing an equivalent amount of all para-aramid pulp or cellulosic pulp, the test pad was indistinguishable and had good compound flow into the backing plate holes and no edge chipping.

[0124] A sample of the brake pad incorporating the pulp of this invention was then tested to determine its frictional performance. Coupons, typically one inch by one inch and about ½ inch (5 mm) thick, from test pads were assessed on the Chase Machine available from Link Engineering, Detroit, Mich., using test protocol Society of Automotive
Engineers (SAE) J661 to determine the hot and cold friction coefficient during constant pressure and controlled temperature drag tests against a heated steel drum. The sample was periodically measured for wear (thickness loss). This was repeated with two more test samples cut from other replicate pads. The samples of the brake pad incorporating the pulp of this invention exhibited hot and cold friction performance substantially equivalent to commercially available pads containing a substantially equivalent amount of all para-aramid pulp. The test further indicated the pad-to-pad uniformity and an average friction rating was also substantially equivalent.

Example 6

0125 The pad was then tested for friction and wear under various braking conditions using a dynamometer (single piston dynamometer with a rolling radius of 289.0 mm at Link Testing Laboratories, Inc., in Detroit, Mich.) using test protocol J2681 (ISO-SWG4). This test was comprised of seventeen scenarios of from 5 to 200 brake applications each, and measured coefficient of friction as a function of applied brake pressure, temperature, temperature, brake speed and deceleration rate. This test also had two high-temperature fade sections, during which the brake pad was subjected to increasingly high initial temperatures during constant deceleration, and reached temperatures exceeding 600°C. Wear was measured as the reduction in thickness and weight of the pad at the end of the test (608 brake applications.) Results for the pads made with the compound of this example showed very little fade and what fade there was recovered well (where fade is defined as the loss of friction at the highest temperature brake applications), acceptable coefficient of friction of 0.25 to 0.4 in non-fade sections, absence of pad surface cracking, and acceptable wear rates for both the pad and the rotor.

Example 7

0128 This example illustrates how the pulp of this invention can be incorporated into a beater-add gasket for sealing applications. Water, rubber, latex, fillers, chemicals, and the pulp of this invention are combined in desired amounts to form a slurry. On a circulating wire sieve (such as a paper machine screen or wire), the slurry is largely drained of its water content, is dried in a heating tunnel, and is vulcanized on heated calender rolls to form a material having a maximum thickness of around 2.0 mm. This material is compressed in a hydraulic press or two-roll calender, which increases the density and improves sealability.

0127 Such beater-add gasket materials generally do not have as good sealability as equivalent compressed-fiber materials and are best suited for moderate-pressure high-temperature applications. Beater-add gaskets find applicability in the making of auxiliary engine gaskets or, after further processing, cylinder head gaskets. For this purpose, the semi-finished product is laminated onto both sides of a spiked metal sheet and is physically fixed in place by the spikes.

0129 After mixing, the compound is then generally conveyed batchwise to a roll calender. The calender consists of a small roll that is cooled and a large roll that is heated. The compound is fed and drawn into the calender nip by the rotary movement of the two rolls. The compound will adhere and wrap itself around the hot lower roll in layers generally about 0.02 mm thick, depending on the pressure, to form a gasketing material made from the built-up compound layers. In so doing, the solvent evaporates and vulcanization of the elastomer commences.

0130 Once the desired gasketing material thickness is reached, the rolls are stopped and the gasketing material is cut from the hot roll and cut and/or punched to the desired size. No additional pressing or heating is required, and the material is ready to perform as a gasket. In this manner gaskets up to about 7 mm thick may be manufactured. However, most gaskets made in this manner are much thinner, normally being about 3 mm or less in thickness.

What is claimed is:
1. A process for making a cellulosic and para-aramid pulp for use as reinforcement material, comprising:
   (a) combining pulp ingredients including:
   (1) cellulosic fiber that retains at least 10% of its weight when heated in air to 700°C at a rate of 20°C per minute, the fiber being 10 to 90 wt % of the total solids in the ingredients, and having an average length of no more than 10 cm;
   (2) para-aramid fiber being 10 to 90 wt % of the total solids in the ingredients, and having an average length of no more than 10 cm;
   (3) water being 95 to 99 wt % of the total ingredients;
   (b) mixing the ingredients to a substantially uniform slurry;
   (c) co-refining the slurry by simultaneously:
   (1) fibrillating, cutting and masticating the cellulosic fiber and the para-aramid fiber to irregularly shaped fibrillated fibrous structures with stalks and fibrils; and
   (2) dispersing all solids such that the refined slurry is substantially uniform; and
   (d) removing water from the refined slurry to no more than 60 total wt % water,
   thereby producing a cellulosic and para-aramid pulp wherein the cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.
2. The process of claim 1, wherein
   the cellulosic fiber having a linear density of no more than 10 dtex; and
   the para-aramid fiber having a linear density of no more than 2.5 dtex.
3. The process of claim 1, wherein the pulp being without substantial aggregations of the same material.
4. The process of claim 1, wherein the cellulosic fiber contains silicon dioxide in the form of a polysilicic acid or salt of the acid.
5. The process of claim 4, wherein the cellulosic fiber further contains aluminum silicate sites.

6. The process of claim 1, wherein the ingredients further comprise

substantially or completely fibril-free, granular, para-aramid particles being no more than 50 wt % of the total solids in the ingredients, and having an average maximum dimension of 50 to 2000 microns, and

in the refining step, masticating at least some of the para-aramid particles into smaller, rounder, substantially fibril-free, particles,

whereby in the produced cellulosic and para-aramid pulp, the cellulosic and para-aramid fibrous structures contact and are wrapped partially around at least some of the rounder, substantially fibril-free, para-aramid particles.

7. The process of claim 1, wherein in the combining step, the cellulosic fiber comprises 25 to 60 wt % of the total solids.

8. The process of claim 1, wherein in the combining step, the para-aramid fiber comprises 40 to 75 wt % of the total solids.

9. The process of claim 1, wherein after the removing step, the water being 4 to 60 wt % of the entire pulp, and the pulp having a Canadian Standard Freeness (CSF) of 100 to 700 ml.

10. The process of claim 1, wherein the refining step comprises passing the mixed slurry through a series of disc refiners.

11. A process for making a cellulosic and para-aramid pulp for use as reinforcement material, comprising:

(a) combining ingredients including water and a first fiber from the group consisting of:

(1) cellulosic fiber that retains at least 10% of its weight when heated in air at 700° C. at a rate of 20° C. per minute, the fiber being 10 to 90 wt % of the total solids in the pulp; and

(2) para-aramid fiber being 10 to 90 wt % of the total solids in the pulp;

(b) mixing the combined ingredients to a substantially uniform suspension;

(c) refining the suspension in a disc refiner thereby cutting the fiber to an average length of no more than 10 cm, and fibrillating and masticating at least some of the fiber to irregularly shaped fibrillated fibrous structures;

(d) combining ingredients including, the refined suspension, the second fiber of the group of (a) (1 and 2) having an average length of no more than 10 cm, and water, if necessary, to increase the water concentration to 95-99 wt % of the total ingredients;

(e) mixing the ingredients, if necessary, to form a substantially uniform slurry;

(f) co-refining the mixed slurry by simultaneously:

(1) fibrillating, cutting and masticating solids in the slurry such that all or substantially all of the cellulosic and para-aramid fiber is converted to irregularly shaped fibrillated fibrous structures with stalks and fibrils; and

(2) dispersing all solids such that the refined slurry is substantially uniform; and

(h) removing water from the refined slurry to no more than 60 total wt % water,

thereby producing a cellulosic and para-aramid pulp where the cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.

12. The process of claim 11, wherein

the ingredients further comprise:

substantially or completely fibril-free, granular, para-aramid particles being no more than 50 wt % of the total solids in the ingredients, and having an average maximum length of 50 to 2000 microns; and

in either the first or second refining step, masticating at least some of the para-aramid particles into smaller, rounder, substantially fibril-free, particles,

whereby in the produced cellulosic and para-aramid pulp, the cellulosic and para-aramid fibrous structures contact and are wrapped partially around at least some of the rounder, substantially fibril-free, para-aramid particles.

13. The process of claim 11, wherein after the removing step, the irregularly shaped cellulosic fibrous structures being 25 to 60 wt % of the total solids.

14. The process of claim 11, wherein after the removing step, the irregularly shaped, para-aramid, fibrous structures being 40 to 75 wt % of the total solids.

15. The process of claim 11, wherein after the removing step, the water being 4 to 60 wt % of the entire pulp, and the pulp having a Canadian Standard Freeness (CSF) of 100 to 700 ml.

16. A cellulosic and para-aramid pulp for use as reinforcement material, comprising:

(a) irregularly shaped, cellulosic fibrous structures that retain at least 10% of their weight when heated in air to 700° C. at a rate of 20° C. per minute, the cellulosic fibrous structures being 10 to 90 wt % of the total solids;

(b) irregularly shaped, para-aramid fibrous structures being 10 to 90 wt % of the total solids; and

(c) water being 4 to 60 wt % of the entire pulp,

whereby the cellulosic and the para-aramid fibrous structures having an average maximum dimension of no more than 5 mm, a length-weighted average of no more than 1.3 mm, and stalks and fibrils where the cellulosic fibrils and/or stalks are substantially entangled with the para-aramid fibrils and/or stalks.

17. The aramid pulp of claim 16, further comprising

substantially or completely fibril-free, granular, para-aramid particles being no more than 50 wt % of the total solids.

18. The pulp of claim 16, wherein

the irregularly shaped, cellulosic fibrous structures being 25 to 60 wt % of the total solids.
19. The pulp of claim 16, wherein
the irregularly shaped, para-aramid, fibrous structures
being 40 to 75 wt.% of the total solids.
20. The pulp of claim 16, wherein the cellulosic fibrous
structures contain silicon dioxide in the form of a polysilicic
acid or salt of the acid.
21. The pulp of claim 20, wherein the cellulosic fibrous
structures further contain aluminum silicate sites.
22. The pulp of claim 16, wherein the water being 4 to 60
wt.% of the entire pulp, and the pulp having a Canadian
Standard Freeness (CSF) of 100 to 700 ml.
23. A friction material, comprising:
a friction modifier;
a binder; and
a fibrous reinforcement material comprising the pulp of
claim 16.
24. The friction material of claim 23, wherein
the friction modifier is selected from the group consisting
of metal powders, abrasives, lubricants, organic friction
modifiers, and mixtures thereof; and
the binder is selected from the group consisting of ther-
mosetting resins, melamine resins, epoxy resins and polyl
imide resins, and mixtures thereof.
25. A sealing material, comprising:
a binder; and
a fibrous reinforcement material comprising the pulp of
claim 16.
26. The sealing material of claim 25, wherein
the binder is selected from the group consisting of nitrile
rubber, butadiene rubber, neoprene, styrene butadiene
rubber, nitrile-butadiene rubber, and mixtures thereof.