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(54) Dry friction composition

(57) A composition suitable for use in preparing an asbestos-free friction material comprises a binder composition, chopped fiber glass and an aromatic polyamide fiber in pulp form. A friction material derived from the composition has good burst strength and its preparation involves an intermediate preform having good structural stability. The binder contains a thermosetting phenolic resin and usually also a natural or synthetic rubber.

Uses:- Clutch facings

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SPECIFICATION

Dry friction composition

This invention relates to a composition suitable for the preparation of a dry, asbestos-free friction material. More particularly, it relates to such a composition which is characterized by good burst strength and wear properties.

Still more particularly, it relates to such a composition which is useful in the preparation of a clutch facing and from which an unusually homogeneous preform can be prepared.

It is well known that friction materials which are intended for use in the preparation of clutch facings and the like must be formulated so as to withstand severe service conditions. In use, clutch facings are subjected to vigorous treatment by repeated and prolonged clutching applications which develop high temperatures, usually above 500°F, in the friction materials, these temperatures sometimes exceeding 1000°F on the friction surface of the material and progressively decreasing inwardly of such surface. These high temperatures require the formulation of the affected friction surfaces from materials which, of course, are capable of surviving such temperatures relatively unchanged.

Asbestos has long been used in the manufacture of articles whose use requires that they withstand heat. It has been the major component of friction elements such as those used in brake and clutch assemblies of automotive vehicles where severe operating temperatures and pressures must be withstood.

Since the passage of the Occupational Safety and Health Act of 1970, the Occupational Safety and Health Administration (OSHA) has set standards for occupational exposure to asbestos, and it appears that these standards will become increasingly rigid until, quite possibly, zero exposure will be required. The present OSHA standards limit the number of asbetos fibers per unit volume of air to which a worker may be exposed over a certain period of time. The imposition of such standards was brought about by evidence that exposure to asbestos might be carcinogenic to man.

Asbestos dust probably is present at highest concentrations, with the exception of asbestos mines, in asbestos textile plants where the asbestos fibers are prepared, corded, spun, woven, etc. Asbestos dust is also present, however, in plants at which friction materials are fabricated. Depending upon particular plant conditions, operation such as mixing, forming, pressing and baking asbestos-containing materials; grinding, sanding, cutting and drilling asbestos-containing articles; and bonding, riveting, inspecting and packing finished asbestos-containing friction elements may all contribute to the presence of airborne asbestos. It is, thus, highly advisable that asbestos be eliminated as a component of friction materials.

The use of glass fibers in friction materials has been suggested. Some of the earlier of these suggestions involved the use of glass fibers to reinforce asbestos-containing friction elements, first as backing materials for conventionally produced friction elements (e.g., U.S. 3,068,131 and U.S. 3,365,041), and then as part of the friction facing itself (e.g., U.S. 3,429,766, U.S. 3,526,306 and U.S. 3,600,258). The stated purpose for the use of glass fibers was to increase the burst strength of the friction elements. Burst strength is a measure of the centrifugal forces which can be withstood by a friction element without disintegrating. The test for burst strength generally is carried out at elevated temperatures.

According to U.S. 4,130,537 the "aggressive" behaviour of fiber glass in an asbestos-free friction material is reduced by the presence of an infusible organic fiber. The aggressiveness, it is said, is manifested as noise, vibration and/or erratic friction effects. The infusible organic fiber is defined broadly, and the preferred species appears to be cotton. Both natural and synthetic fibers are contemplated and jute, hemp, sisal, wool, viscose rayon, cuprammonium rayon, and homex fiber (a Du Pont trade name for an aramid) are specifically listed as illustrative species. The physical form of the glass fibers may vary widely, but the preferred form for the fabrication of clutch facings is a continuous yarn.

An SAE Technical Paper entitled "Asbestos Free Brakes and Dry Clutches Reinforced with Kevlar Aramid Fiber" by Loken teaches that aramid fibers contribute strength, thermal stability and non-aggressive wear characteristics to a friction material.

A Du Pont technical brochure entitled "Kevlar Aramid Pulo" contains a description of Kevlar aramid pulp. Kevlar is a Du Pont trademark which identifies a fibrous material derived from the condensation of terephthalic acid and p-phenylenediamine. This brochure notes that this pulp material can be a partial replacement for asbestos. Several applications are suggested, including disc, drum and block brake compounds.

The invention of the present application is a composition suitable for the preparation of a dry, asbestos-free friction material having good burst strength and wear properties comprising in combination (1) a binder composition, (2) an aromatic polyamide fiber in pulp form, and (3) chopped fiber glass. The friction material may be prepared conveniently from such composition by mixing with an organic solvent and extruding through a suitable die. Friction materials made heretofore with cut glass fibers have not been characterized by high burst strength and the good burst strength qualities of the present friction materials are unexpected.

The above friction materials are especially adapted for use in clutch facings, particularly in automotive clutch facings.

The aromatic polyamide fibers, commonly known as aramids, are commercially available in various forms, e.g., yarn, pulp, etc., identified by the trademarks "Fiber B," "Kevlar," "DP-01," "Nomex," and others.

Aramids is a generic expression denoting fibers made from the condensation product of isophthalic or terephthalic acids and m- or p-phenylenediamine. "Fiber B" and "Kevlar" are generally understood to identify products of the condensation of terephthalic acid and p-phenylenediamine, while "Nomex" is understood to identify the condensation product of isophthalic acid and m-phenylenediamine. The term aramid has been defined as a manufactured fiber in which the fiber-forming substance is a long-chain synthetic aromatic polyamide in which at least 85% of the amide linkages are attached directly to two aromatic linkages. More information is contained in U.S. 3,393,210 which is incorporated herein by reference. The aramid prepared from terephthalic acid and p-phenylenediamine is preferred.

The aramid fibers preferably are in pulp form, i.e., they are very short and highly fibrillated. The fiber length is within the range of from 0.2 to 12 mm, preferably within the range of from 1-6 mm.

The amount of aromatic polyamide fiber which should be used in the friction composition herein ranges from about 1% to about 12% based on the weight of the composition. Preferably, the amount is between about 2% and 10%.

The glass fibers useful in the practice of the invention are those typically utilized for reinforcing cured resinous materials. The glass fiber surface is treated with a sizing composition to permit bonding of the glass surface to the matrix of the friction element.

The sizing composition and its application to the individual glass filaments is described in U.S. 4,130,537 (Bohrer), incorporated herein by reference. The sized fibers may be coated with a resinous material to give a so-called "RFL-coated" glass fiber. These also are described in the Bohrer patent, and the preferred glass fibers herein are RFL-coated glass fibers.

The physical form of the glass fiber is an important and critical element of the invention. It must be in the form of chopped strands, preferably 0.1-1.0 inch in length.

The amount of glass fibers in the friction compositions herein should be from about 5% to about 30%, preferably from about 10% to about 25%, based on the weight of the composition.

The binder composition contains a curable resin which invariably is a phenolic resin, i.e., a thermosetting resin resulting from the reaction of a phenol and an aldehyde. The phenols contemplated herein for such purpose include, e.g., phenol, resorcinol, catechol, p-aminophenol and the like, that is, those capable of electrophilic aromatic substitution. Aldehydes contemplated include formaldehyde, acetaldehyde, acrolein and the like, i.e., aliphatic aldehydes having 1-4 carbon atoms. Both resole and novalac type phenolic resins are contemplated, although the novalac resins are preferred.

The binder composition also usually contains an elastomer, i.e., a natural or synthetic rubber. Especially preferred are the nitrile rubbers including copolymers of butadiene and acrylonitrile. Also included, though, are copolymers of 1,3-alkadienes, e.g., butadiene, isoprene, etc., with such monoolefines as styrene, alpha-methyl styrene, etc.

The proportion of binder composition in the friction material of the invention should be within the range of from about 10 to about 40%, based on the weight of the friction material. The ratio of curable resin to elastomer within such composition generally is about 3.5:1 although it may range from about 1:1 to about 10:1.

Fillers may be added to the binder to modify the physical properties of the final product and reduce the expense of the friction material. Such fillers include carbon black, clay, graphite, lead sulfate, rottenstone, mica, lime, wollastonite, cashew resin, copper oxide, sulfur and the like.

Friction elements embodying the present invention may be prepared in accordance with any of several well-known processes. In general, the glass fibers and aramid pulp are saturated with the binder composition and the saturated material then dried by evaporating the solvent to form an intermediate product. This intermediate product is molded under heat and pressure to cure the binder material.

In general, the friction element, especially if it is a clutch facing, is formed by the following method. A so-called "preform" is prepared as a loosely-structured article (the intermediate product referred to above) containing reinforcing constituents saturated with a curable binder, which roughly resembles the configuration of the final friction element. This preform is molded under heat and pressure to give it a final shape and to cure the binder.

Preferably, such method for preparing the preform involves mixing the binder composition, glass fibers and aramid fibers with a solvent which is effective to dissolve at least a portion of the binder materials to form a relatively homogeneous mass which then is pressed into a flat pancake-like sheet of at least about 12 inches in diameter and 0.3 inch thick. This sheet is cut to the desired shape of the preform, e.g., 11 inches in diameter with an inside diameter of 6.25 inches. This preform is dried overnight for about 16 hours at 175°F in a circulating air oven.

The dry preform is molded in a positive pressure mold for five minutes at 300-400°F and about 50-100 tons pressure, then post-cured for five hours at from about 400°F to about 500°F.

The following specific embodiment of the invention illustrates the preparation of a homogeneous preform, with subsequent preparation of a finished clutch facing.

The solid ingredients shown below are mixed in a Sigma mixer to form a relatively homogeneous dry mixture;

Parts	
154.7	Nitrile Rubber (Hycar 1411)
80.1	Thermosetting Phenolic Resin (Durey 14000)
39.3	Graphite
93.5	Cupric Oxide
37.3	Antimony Trisulfide
84.4	Friction Dust (Cardolite)
106.3	Sulfur
156.8	Wollastonite

200.0 parts of methylisobutylketone is added and mixing is continued for an additional 25 minutes. 193.1 parts of chopped (¼") fiber glass is added with mixing, then 54.5 parts of aromatic polyamide fiber pulp (Kevlar) is added portionwise with mixing. The moist, plastic mass is pressed flat to a thickness of about 0.5 inch, then folded back on itself several times and pressed again to the same thickness.

The pressed sheet is placed on a ⅛" thick plastic cutting surface and a cutting die impressed on the surface to form a preform having a planar, cylindrical shape, about 11 inches in diameter. The preform is dried for 16 hours in a circulating air oven at 17°F, then placed in a suitable, pre-heated mold for five minutes at 325°F and 60 tons pressure. The molded product then is heated, under constraint to prevent deformation, at 400-500°F for five hours.

The cured product is allowed to cool and then is finished by trimming off any excess material to the exact shape desired by sanding and/or other techniques known in the art.

The efficacy of the above product is reflected by the following test results:

Burst Strength, RPM	8400-9600
Dyamometer Fade, °F	450-500
Truck Capacity Test	39 Starts
Drivability	Slight Initial Chatter

Further, the green strength of the preform is unexpectedly superior to a similar preform prepared without the aromatic polyamide pulp. It is homogeneous and structurally quite stable. This is an important feature of the invention because it greatly facilitates conversion (as by extrusion) of the moist mixture of ingredients into the desired preform and subsequent handling of this preform.

All parts and percentages herein, unless otherwise expressly stated, are by weight.

CLAIMS

1. A composition for use in the preparation of an asbestos-free friction material comprising (1) a binder composition, (2) an aromatic polyamide fiber in pulp form, and (3) chopped fiber glass.

2. A composition according to claim 1 wherein the aromatic polyamide is a polymer of terephthalic acid and p-phenylenediamine.

3. A composition according to claim 1 or 2 wherein the fiber glass is "RFL-coated" glass fiber.

4. A composition according to claim 1, 2 or 3 wherein the fiber glass comprises chopped strands which are from 0.1 to 1.0 inch (0.25 to 2.5 cm) in length.

5. A composition according to claim 4 wherein the fiber glass comprises chopped strands which are about 0.25 inch (0.6 cm) in length.

6. A composition according to claim 1 substantially as described by reference to the specific embodiment.

7. A process for the preparation of a friction material comprising (1) mixing a binder composition, an aromatic polyamide fiber in pulp form, chopped fiber glass, and solvent for said binder composition, to form a relatively homogeneous mass, (2) converting said mass into a flat preform product, (3) drying said preform product, and (4) molding it at an elevated temperature into a desired structure.

8. A process according to claim 7 wherein, in step (1), the aromatic polyamide fiber in pulp is added to a mixture of the binder composition, chopped fiber glass and solvent.

9. A process according to claim 7 or 8 wherein the solvent is methyl isoburyl ketone.

10. A friction material derived from a composition as claimed in any one of claims 1 to 6.

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