(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 December 2014 (24.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/203142 A1

(51) International Patent Classification:
F16D 69/02 (2006.01) *C04B 111/00* (2006.01)
C04B 28/04 (2006.01)

(21) International Application Number:
PCT/IB2014/062258

(22) International Filing Date:
16 June 2014 (16.06.2014)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
MI2013A000998 17 June 2013 (17.06.2013) IT

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

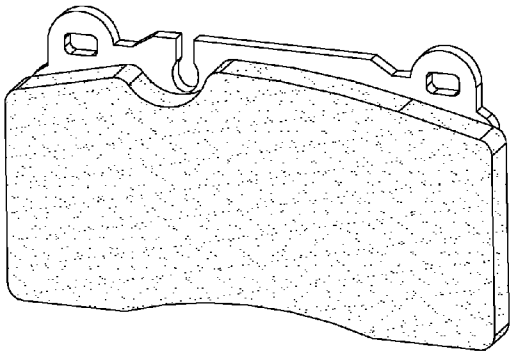
Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: FRICTION MATERIAL FOR BRAKE PADS AND RELATED BRAKE PADS

FIG.1



(57) Abstract: A friction material is disclosed comprising a binding composition based on a hydraulic binder and its use in brake pads and industrial applications.

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"Friction material for brake pads and related brake pads."

The present invention relates to a friction material for brake pads and related brake pads.

The present invention is comprised in the field of friction materials for brake pads, which, as well known, shall have a composition such as to ensure consistent and reliable performances in a wide range of operative conditions.

In particular, as the disc brake pads for vehicles operate under extreme and hard working conditions, having to satisfy at the same time reliability and a long life, the manufacturers have constantly tried to improve the features and performances of friction materials.

The brake pad is indeed formed of a support base, usually metallic, and of a friction layer composed of various materials. According to the properties and the composition of the friction material, it is possible to promote efficiency (namely the braking force) or the pad life.

In the state of the art the first friction materials for brake pads had a composition containing asbestos. However, also in this field, as soon as the dangerousness of asbestos made its use, at first discouraged, then forbidden, substitutive compounds have been sought.

Replacement materials have been therefore searched which could allow to achieve a product characterized by equal or improved performances with respect to those obtained through the friction material containing

asbestos and have been thus developed, for example, friction materials containing steel and various types of metals in variable amounts (such as for example copper, aluminium, zinc, etc.) and comprising, as binding element, thermosetting resins such as phenolic resins as such, and or modified phenolic resins among which the silicon and epoxy acrylic resins.

These thermosetting resins are currently present in the friction materials for brake pads in a percentage of 8-20% by weight with respect to the total weight of the composition of the friction material and are necessary for allowing hot moulding of the braking mixture, ensuring excellent final performances of the brake pad, such as braking capability, resistance to wear and to abrasion, etc.

The use of thermosetting phenolic resins presents however some drawbacks, first of all a problem of environmental sustainability and potential toxicity. It deals, indeed, with resins which may release phenol, formaldehyde and derivatives from the thermo-oxidative degradation, both during processing, and during the use of the end-product. Pursuant to regulation EC 1272/2008, phenol is classified as toxic substance, harmful in case of protracted contact with the skin and mutagenic of class 3. Consequently the search for alternatives for reducing the emission of phenols in the environment is active in all fields.

As a consequence, such a problem occurred also in the field of friction materials: indeed, although each piece of friction materials releases only low quantities of phenols and formaldehyde, overall the quantity of phenols released can become significant,

both due to the great number of vehicles on the roads and for the great number of industrial applications using said materials.

A purpose of the present invention is therefore that of identifying a friction material having a composition allowing to satisfy at the same time the required technical specifications, such as the thermo-mechanical ones, ensuring however a high environmental sustainability, overcoming thus the drawbacks of the friction materials containing phenolic resins according to the prior art.

A further purpose of the present invention is the use of such a friction material in brake pads and in further industrial applications.

Subject-matter of the present invention is therefore a friction material for brake pads comprising a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine.

A further subject-matter of the present invention are also brake pads composed of a friction material comprising a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine and a base of metallic support.

A subject-matter of the present invention are also the

use of a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine for achieving friction materials and the use of said friction materials in brake pads and in further industrial applications.

The present invention therefore relates to friction materials which comprise a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine.

The binding composition based on a hydraulic binder present in the friction material according to the present invention replaces in full the thermosetting resin (currently present in a percentage of 8-20% by weight with respect to the total weight of the composition of the friction material for allowing hot moulding of the braking mixture), ensuring overall improved performances of the brake pad.

Indeed, braking capability, resistance to wear, to abrasion, etc. can be compared with the brake pads according to the state of the art, achieved through thermosetting resin binders.

The friction materials according to the present invention are therefore characterized by fully unexpected advantages, in that, although any type of

thermosetting resin is used as binder, they provide equal performances in terms of friction, resistance to wear, life-lasting and other features with respect to a conventional product using materials based on thermosetting resins.

Therefore, a first advantage of friction materials according to the present invention can be identified in the absence of release of phenols in the environment; hence, they stand for materials of particular interest which, also with equal other thermo-mechanical features, overcome such a problem, with an environmental sustainability definitely improved.

Moreover, as the phenolic resins are for their very nature thermosetting, the presence of phenolic resins as binders requires process temperatures (moulding) not lower than 130°C to obtain the brake pad.

For such resins indeed the binding action occurs only through hardening which is actually induced by temperature conditions not lower than 130°C. In some cases it is necessary to carry out also a subsequent cross-linking treatment at temperatures not lower than 130°C.

In case of use of a binding composition based on a hydraulic binder, subject-matter of the present invention, the hardening process of the binding part is induced by the presence of water, according to the definition of hydraulic binder, below reported.

Therefore, during the process of production of the brake pad, significantly lower temperatures are used, lower than about 90°C, univocally for accelerating the hardening process of the hydraulic binder to short aging, according to what is known from the prior art on

cement-based articles, and making the hardening process compatible with the moulding times of the brake pad production process.

The use of a phenolic resin under moulding conditions with a temperature lower than 90°C would not lead to the binding action necessary for the formation of the brake pad provided with the desired features.

As known from the prior art, cement-based materials such as mortars/cement pastes, when subjected to thermic treatments higher than 300°C, undergo a progressive loss of the final physical mechanical properties of the product. Indeed, regardless of the type of aging, the performance decrease of the elastic module of a specimen of mortar thermally treated at 300°C, compared with an identical specimen not thermally treated, ranges around 30% with respect to the initial value.

It is apparent that from these assumptions it is fully unexpected and surprising that a binding composition based on a hydraulic binder can be used as binder in friction materials in replacement of thermosetting resins, and mostly that the friction material thus obtained meets the necessary specifications, considering that the braking systems are subjected to high local temperatures (eve >600°C) under mechanical "shear" (shear stress) conditions.

The friction material for brake pads according to the present invention comprises a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and

still more preferably with a fineness equal to 6500 blaine.

The wording "binding composition based on a hydraulic binder", according to the present invention, means a powder material comprising a hydraulic binder as above indicated and possibly additives and additions of the inorganic type. The wording "hydraulic binder" means a powder material which, mixed with water, hardens by hydration irrespective of the temperature conditions, provided that they are higher than 4°C (temperature at which water is no longer present in the liquid form, but solid) and that, after hardening, keeps its resistance and stability.

A clinker which can be used for the preparation of a hydraulic binder according to the present invention is a Portland cement clinker, as defined according to the UNI EN 197.1 standard, that is, a hydraulic material composed of at least two-thirds by mass of calcium silicates ($3CaO \cdot SiO_2$) and ($2CaO \cdot SiO_2$), the remaining part being Al_2O_3, Fe_2O_3 and other oxides.

Still more preferably, the "hydraulic binder" is based on Portland cement of the I 52.5R type and it is provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine.

The Blaine fineness of cement is measured according to Blaine Method described in standard UNI EN 196-6 part 4; in particular the fineness of the cement is measured as a specific surface by observing the time taken for a fixed quantity of air to flow through a compacted cement bed of specified dimensions and porosity.

Under standardized conditions the specific surface of cement is proportional to $\sqrt{t}$ where t is the time for a given quantity of air to flow through the compacted cement bed.

The method is comparative rather than absolute and therefore a reference sample of known specific surface (NIST Portland cement fineness standard 3774 cm^2/g) is required for calibration of the apparatus.

The selection of these particular types of cement allows, indeed, to further increase the thermal stability and mechanical resistance, resulting at the maximum in the case of Portland cement of the I 52.5R type, further grinded up to obtain a fineness of about 6500 blaine.

The binding composition based on a hydraulic binder can also comprise aggregates.

The aggregates, or inerts, also defined as inert aggregates, according to the present invention can comprise:

- fine aggregates such as powders and sands, defined in the UNI EN 206 standard, having, according to the present invention, a maximum diameter, d_{max}, equal to 40 micron;
- not fine aggregates with a d_{max} greater than 40 micron.

The aggregates can be suitably selected from limestone aggregates, quartz or silico-limestone aggregates, with whichever form, or grinded, or spherical, for example marble powders, ceramized and also of the lightened type.

As above indicated, the wording "binding composition based on a hydraulic binder", according to the present

invention, means a powder material comprising a hydraulic binder and possibly additives and additions of the inorganic type: the composition may thus also comprise one or more auxiliary substances selected among feeds of mining or pozzolana origin, pigments of organic and/or inorganic nature or other. For mining or pozzolana feeds it means microsilica, silica fume, slag, fly ash, metakaolin, natural pozzolans, limestone and natural calcium carbonate. For the purposes of the present invention the binding composition based on a hydraulic binder may contain an agent or a waterproofing or hydrophobic additive. Such agents include a wide range of compounds of organic or organo-siliceous nature, such as for example a mixture of polyvinylalcohol and silane, namely alkyloxysilanes. In addition to the above mentioned components, the binding composition based on a hydraulic binder present in the friction material subject-matter of the present invention, may comprise various other additives to adapt the characteristics of the mixture to specific requirements. Examples of such additives can be super-fluidifiers, preferably of the polycarboxylic type, anti-shrinkage agents, hardening and/or seizing accelerators, rheology or physic-mechanical properties modifiers, such as for example celluloses or lattices, expansive, aerating, deaerating or adhesion agents. Such additives are optional for the purposes of the invention.

The binding composition based on a hydraulic binder may also comprise the addition of fibres of a different nature, such as inorganic fibres as metallic fibres or glass fibres and wollastonite, and organic fibres based

on polyvinylalcohol or polypropylene or aramid fibres, selected according to the final application.

The binding composition based on a hydraulic binder is present in a percentage ranging from 5 to 30% by weight with respect to the total weight of the mixture composing the friction material, preferably is present in a percentage varying from 10 to 15% and still more preferably is equal to about 12% by weight with respect to the total weight of the mixture composing the friction material.

The preferred percentage of about 12% by weight with respect to the total weight of the mixture composing the friction material allows to obtain an optimal friction material with respect to the characteristics of mechanical seal in the "shear" process under thermo-oxidative conditions.

For the purposes of the present invention the added water necessary for the hardening process of the hydraulic binder is comprised in a percentage varying from 5 to 20% by weight with respect to the total weight of the mixture composing the friction material, preferably varying from 8 to 15% by weight, more preferably from 10 to 12% by weight.

The friction material according to the present invention is a material which, additional to the binding composition, may comprise fibres, lubricants, abrasives, friction modifiers and/or other additional materials, defined in the present invention through the term "Multi-component mixture".

A friction material according to the present invention, additional to the binding composition based on a hydraulic binder in a percentage varying from 5 to 20%

by weight, is provided with a multi-component mixture comprising a lubricant in a percentage varying from 5 to 15% by weight, at least an abrasive in a percentage varying from 8 to 25% by weight, at least a component containing carbon in a percentage varying from 8 to 25% by weight, at least a modifier in a percentage varying from 15 to 30% by weight, all the percentages being computed with respect to the total weight of the composition composing the friction material.

Optionally, the friction material according to the present invention may comprise one or more fibres in a percentage varying from 7 to 30% by weight with respect to the total weight of the composition composing the friction material.

As possible examples of fibres, among which is selected the fibre used in the friction material according to the present invention, it can be indicated fibres based on polyacrylonitrile, PAN, polyaramid, cellulose fibres, metallic fibres.

The fibres in the friction material according to the present invention are preferably steel fibres and aramid fibres.

As possible examples of lubricants, among which is selected the lubricant used in the friction material according to the present invention, it may be indicated organic lubricants and metallic lubricants, metallic sulphides mixtures, as tin sulphides, zinc sulphides, iron sulphides and molybdenum sulphide, boron nitride, tin powder and zinc powder.

The lubricant in the friction material according to the present invention is preferably selected from metallic sulphides.

As possible examples of abrasives, generally classified on the basis of their Mohs hardness, from which is selected the abrasive used in the friction material according to the present invention, it can be indicated mineral fibres, zirconium oxide, zirconia, zirconium silicate, mica, alumina, ceramic fibres; calcium silicates, magnesium, zirconium and/or aluminium; synthetic mineral fibres as hardwool, slagwool and rock wool, silica, silicon dioxide, sand, silicon carbide, iron oxide, chromite iron and magnesium oxide, potassium titanate.

The abrasive in the friction material according to the present invention is preferably selected from metal oxides and other abrasives with a hardness according to the mohs scale greater than 6.

As possible examples of component containing carbon, from which is selected the component used in the friction material according to the present invention, it can be indicated natural graphite, synthetic graphite, petroleum coke, desulfurized petroleum coke and carbon black.

The above mentioned component containing carbon in the friction material according to the present is preferably selected from graphite and coke.

As possible examples of modifiers, from which are selected the modifiers used in the friction material according to the present invention, are mentioned lime, calcium oxide, calcium hydroxide, talc, calcium carbonate, calcium silicate, barite, fluorinated compounds, metallic powders, rubber in form of rubber powder or recycled rubber in pieces and various types of friction powders.

The modifier in the friction material according to the present invention is preferably selected from barite, rubber and metallic powders.

A preferred friction material according to the present invention consists of a binding composition based on the Portland cement type I 52.5R with fineness 6500 Blaine and water and from a multi-component mixture comprising components preferably selected from metallic oxides, steel fibres, aramid fibres, chromite, metallic sulphides, graphite, coke, metallic powders, barite and rubber.

Figure 1 is a perspective view of an illustrative brake pad, incorporating a friction material according to an embodiment of the present invention.

The several components as above listed form the friction material and, when mixed in the way and in the proportions suggested, provide a family of friction materials presenting performances equal or higher than those of a material containing phenolic resins, in full absence of any type of phenolic resin as binder.

For their complete homogenization, cement, water and the other components constituting the friction material are mixed, in proper proportions, up to obtain a homogeneous mixture free of lumps and with a suitable consistence, which is thus subjected to the moulding process for obtaining brake pads.

The braking mixture thus achieved is, indeed, subjected to a compression moulding process at a temperature ranging from 4 to 90°C preferably from 40 to 80°C and at a pressure ranging from 2 to 6 KN/cm^2, preferably from 4 to 5 KN/cm^2, being these temperature and pressure conditions optimal for moulding of brake pads

starting from the friction materials according to the present invention.

After a week of aging in air, the pads are rectified and painted. After about 28 days of aging from moulding, the pads are characterized and tested as indicated below.

The characterization of the pads achieved through the moulding process with the selected formulations is based on the assessment of the following aspects:

A) uniformity and regularity of the outline of the edges and absence of form flaws;

B) compressibility and surface hardness;

C) tribological characteristics of the friction material, determined through the test called "*AK Master" and "AMS".*

The characterizations A) and B) are achieved through the following test:

A) uniformity and regularity of the outline of the edges and absence of form flaws: it basically deals with an evaluation of the moulding test consisting in the observation of the following parameters: A1) homogeneous filling of the mould with the material, with the consequent achievement of a product free of flaws; A2) observations of possible surface oxidations or anomalous bulges. Such observations are carried out through visual ascertainment and through planarity and parallelism measurement of the product.

B) "compressibility" according to ISO-6310 and "surface hardness" according to JIS D4421; compressibility and surface hardness provide an indication on the homogeneousness of the mechanical properties between edge and internal part of the pad.

C) Tribological characteristics.

The tribological characteristics of the friction material are determined through the test called "*SAE J2522" (called "AK Master") and "AMS".*

The test named "AK Master" is a test on performance, during which a pair of pads is tested in various braking situations, among which, after a break-in phase, a plurality of braking operations are simulated at different pressures and at low, medium and high speeds, and specific braking, such as cold braking and highway braking.

The test named "AMS" is the test on the behaviour of the braking system at high and repeating stress and simulates extreme situations which the braking systems could undergo. It deals with 10 consecutive braking operations at high pressure from 100 Km/h to 0. With respect to the AK-Master test the same temperatures are reached, but with higher pressures. Through this test the friction and the fluid consumption are measured.

The main advantage of the friction material according to the present invention is that it allows to achieve brake pads, as well as other industrial applications based on said material, which are environment-friendly, not presenting any release of phenols in the environment.

Moreover, the particular features of the binding composition allow to achieve friction materials which ensure performances equal to or higher than those of a material containing phenolic resins, in complete absence of any type of phenolic resin as binder.

Other features and advantages of the invention will appear from the following examples reported with an

illustrative and not limitative purpose.

Example 1

It has been prepared a friction material (FB41) through the composition reported in the following table 1.

Table 1

FB41	
Binding composition based on Portland Cement type I 52,5 R Calusco (6500 blaine)	11.79%
Multi-component Mixture	78.05%
Water	10.16%

Specifically the friction material has been prepared using a binding composition containing a Portland cement type I 52.5R of the cement plant of Calusco, over-grinded up to obtain a fineness of about 6500 blaine. Such a binding composition has been added in a percentage equal to 11.79% by weight with respect to the total weight of the composition constituting the friction material and contains, additional to the cement binder Portland type I 52.5R of the cement plant of Calusco, the waterproofing additive Seal 200 (a mixture of polyvinylalcohol and silane, namely an alkyloxysilane) in a percentage equal to 1.15% by weight, with respect to the total weight of the binding composition.

The multi-component mixture used in the present example consists of:

Aluminium and magnesium oxides	12

Steel Fibres	27.2
Aramid Fibres	2.2
Chromite	4.3
tin and molybdenum sulphides	7.6
Graphite	6.5
Coke	12
Metallic Powders	17.4
Barite	8.7
Rubber	2.2

The % of the multi-component mixture are percentages by weight with respect to the total weight of the only multi-component mixture.

The friction material thus achieved has been moulded by compression under temperature and pressure conditions equal to 80°C and 4.5 KN/cm^2, using moulds which led to the achievement of a pad with a surface of 77 cm^2, with a thickness equal to 1 cm.

More precisely, the moulds used in the test reported in the present example are moulds providing the achievement of a pad with a surface of 77 cm^2, with a thickness equal to 1 cm, which represents the Ferrari F152 back size and Alfa 939 front size.

After a week of aging in the air, the pads have been rectified and painted. Then, after about 28 days of aging from the moulding, the pads have been characterized and tested as indicated below.

The pads obtained from the formulation reported in table 1 have been visually observed and do not present neither surface oxidations, nor anomalous bulges.

It has been next made measurements of the HRR surface hardness of the product thus obtained according to the JIS D4421 standard, obtaining an average value of 91 and also observing a good homogeneousness of the mechanical properties between edge and central part of the pad.

Said aspect is of crucial importance to achieve a friction material which does not present potential detachment points and therefore characterized by a high resistance to wear.

A uniformity and regularity of the outline of the edges and the homogeneousness of the central part of the pad with respect to the edges are therefore key elements for having wear of the pad analogous or improved with respect to the common values of pads using phenolic resins as binders.

The test of "Compressibility" according to ISO-6310 highlighted an average value equal to 40.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.33-0.33 mm (this value refers to the measurement made on the pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.42.

It deals with values of friction coefficient absolutely in line with the required specifications.

Said value is in line with what has been obtained for pads achieved with thermosetting resins.

The pads already tested through the test AK-MASTER have been thus subjected to the test AMS.

With respect to the test AK-Master, the test AMS operates under the same temperatures but with higher

pressures, measuring the friction and consumption of the braking fluid.

Also the test according to the test AMS had a positive outcome: the performances obtained in terms of friction coefficient are good also at a high temperature.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of pads equal to 0.11-0.10 mm (this value refers always to the measurement carried out on the pair of pads).

Also this value is in line with what has been obtained for pads achieved with thermosetting resins.

Wears are quite low and confirm the solidity of the braking pad according to the present invention.

The aspect of the discs and pads is such that it has not been observed any detachment/crack, but only some small inclusions on the face of the disc.

Example 2

It has been prepared a friction material (FB42) through the composition reported in the following table 2.

Table 2

FB42	
Binding composition based on Cement type IV/B(P) 32,5R (6000 blaine)	11.80%
Multi-component mixture	78.05%

Water	10.15%

The friction material has been prepared using a binding composition containing cement type IV/B(P) 32.5R (6000 blaine). Such a binding composition has been added in a percentage equal to 11.80% by weight with respect to the total weight of the composition constituting the friction material and contains, additional to the cement binder type IV/B(P) 32.5R (6000 blaine), the waterproofing additive Seal 200 (a mixture of polyvinylalcohol and silane, namely an alkyloxysilane) in a percentage equal to 1.15% by weight, with respect to the total weight of the binding composition.

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1, braking pads starting from the formulation reported in table 2 have been achieved.

Measurements of surface hardness HRR of the product thus obtained were carried out according to the JIS D4421 standard, obtaining an average value of 90 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad.

The test of "Compressibility" according to ISO-6310 highlighted an average value equal to 40.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of pads equal to 0.29-0.40 mm (this value refers to the measurement carried out on the pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.41.

The pads, tested according to the test "AMS" have shown

values in terms of wear and aspect of the discs and of pads equal to 0.10-0.08 mm (this value refers to the measurement carried out on the pair of pads).

Example 3

It has been prepared a friction material (FB45) through the composition reported in the following table 3.

Table 3

FB45	
Binding composition based Portland slag cement II B-S 42,5N (4200 Blaine)	11.80%
Multi-component mixture	78.05%
Water	10.15%

The friction material has been prepared using a binding composition containing Portland slag cement II B-S 42.5N (4200 Blaine). Such a binding composition has been added in a percentage equal to 11.80% by weight with respect to the total weight of the composition constituting the friction material and contains, additional to the cement binder type IV/B(P) 32,5R (4200 blaine), the waterproofing additive Seal 200 (a mixture of polyvinylalcohol and silane, namely an alckyloxysilane) in a percentage equal to 1.15% by weight, with respect to the total weight of the binding composition.

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1 it has been thus achieved brake pads starting from the

formulation reported in table 3.

Measurements of surface hardness HRR of the product thus obtained according to the JIS D4421 standard have been carried out, obtaining an average value equal to 91 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad. The test of "Compressibility" according to ISO-6310 have shown an average value equal to 38.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.34-0.30 mm (this value refers to the measurement carried out on a pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.40.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of the pads equal to 0.08-0.08 mm (this value refers to the measurement carried out on the pair of pads).

Into figures 2 and 3 are illustrated brake pads after being subjected to test AK Master and AMS: more precisely, it has been photographed a referenced pad with resin without cement (figure 2) and the pad FB45 (figure 3).

Example 4 (calcareous cement)

It has been prepared a friction material through the composition reported in the following table 4.

Table 4

Binding composition	12%

based on cement CEM II/A-LL 42.5 R Calusco (3800 Blaine)	
Multi-component mixture	82%
Water	6%

The friction material has been prepared using a binding composition containing cement CEM II/A-LL 42.5 R Calusco (3800 Blaine). Such a binding composition has been added in a percentage equal to 12% by weight with respect to the total weight of the composition constituting the friction material.

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1 it has been thus achieved brake pads starting from the formulation reported in table 4.

Measurements of surface hardness HRR of the product thus obtained according to the JIS D4421 standard have been carried out, obtaining an average value equal to 90 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad. The test of "Compressibility" according to ISO-6310 have shown an average value equal to 40.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.33-0.35 mm (this value refers to the measurement carried out on a pair of pads), therefore fully surprising, and an average friction coefficient equal

to 0.40.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of the pads equal to 0.07-0.09 mm (this value refers to the measurement carried out on the pair of pads).

Example 5 (Cement type I and slag)

It has been prepared a friction material through the composition reported in the following table 5.

Table 5

Binding composition based on Portland cement type I 52.5 R Calusco (6500 Blaine) (6.11%) + slag (4000 blaine) (6.11%) and waterproofing additive Seal 200 (0.28%)	12.5 %
Multi-component mixture	82%
Water	5.5%

The friction material has been prepared using a binding composition containing Portland cement type I 52.5 R Calusco (6500 Blaine), blast furnace slag (4000 Blaine) and waterproofing additive Seal 200, in a percentage equal to 12.5% by weight with respect to the total weight of the composition constituting the friction material

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1 it has been thus achieved brake pads starting from the formulation reported in table 5.

Measurements of surface hardness HRR of the product thus obtained according to the JIS D4421 standard have been carried out, obtaining an average value equal to 90 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad. The test of "Compressibility" according to ISO-6310 have shown an average value equal to 41.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.30-0.32 mm (this value refers to the measurement carried out on a pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.39.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of the pads equal to 0.08-0.09 mm (this value refers to the measurement carried out on the pair of pads).

Example 6 (Cement type I and metakaolin)

It has been prepared a friction material through the composition reported in the following table 6.

Table 6

Binding composition based on Portland	12.5 %

cement type I 52.5 R Calusco (6500 Blaine) (7.32%) + metakaolin (4.90%) and waterproofing additive Seal 200 (0.28%)	
Multi-component mixture	82 %
Water	5.5%

The friction material has been prepared using a binding composition containing Portland cement type I 52.5 R Calusco (6500 Blaine), metakaolin (Metastar 501- Imerys) and waterproofing additive Seal 200, in a percentage equal to 12.5% by weight with respect to the total weight of the composition constituting the friction material.

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1 it has been thus achieved brake pads starting from the formulation reported in table 6.

Measurements of surface hardness HRR of the product thus obtained according to the JIS D4421 standard have been carried out, obtaining an average value equal to 90 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad.

The test of "Compressibility" according to ISO-6310 have shown an average value equal to 40.

The pads, tested according to the test "AK Master"

previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.35-0.34 mm (this value refers to the measurement carried out on a pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.38.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of the pads equal to 0.10-0.11 mm (this value refers to the measurement carried out on the pair of pads).

Example 7 (Cement type I and flying ashes)

It has been prepared a friction material through the composition reported in the following table 7.

Table 7

Binding composition based on Portland cement type I 52.5 R Calusco (6500 Blaine) (7.32%) + Flying ashes (4.9%) and waterproofing additive Seal 200 (0.28%)	12.5 %
Multi-component mixture	82%
Water	5.5%

The friction material has been prepared using a binding composition containing Portland cement type I 52.5 R Calusco (6500 Blaine), flying ashes and waterproofing

additive Seal 200, in a percentage equal to 12.5% by weight with respect to the total weight of the composition constituting the friction material

The multi-component mixture used in the present example is the same mixture used into example 1.

Through the same process described for example 1 it has been thus achieved brake pads starting from the formulation reported in table 7.

Measurements of surface hardness HRR of the product thus obtained according to the JIS D4421 standard have been carried out, obtaining an average value equal to 90 and observing also a good homogeneousness of the mechanical properties between edge and central part of the pad. The test of "Compressibility" according to ISO-6310 have shown an average value equal to 42.

The pads, tested according to the test "AK Master" previously described, have shown values in terms of wear and aspect of the discs and of the pads equal to 0.32-0.34 mm (this value refers to the measurement carried out on a pair of pads), therefore fully surprising, and an average friction coefficient equal to 0.36.

The pads, tested according to the test "AMS" have shown values in terms of wear and aspect of the discs and of the pads equal to 0.09-0.11 mm (this value refers to the measurement carried out on the pair of pads).

CLAIMS

1) Friction material for brake pads comprising a binding composition based on a hydraulic binder, selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine.

2) Friction material according to claim 1, wherein the hydraulic binder is based on Portland cement.

3) Friction material according to any of the preceding claims, wherein the hydraulic binder is based on Portland cement type I 52.5R, preferably with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine.

4) Friction material according to any of the preceding claims, wherein the binding composition is present in a percentage ranging from 5 to 30% by weight with respect to the total weight of the mixture constituting the friction material, preferably from 10 to 15% and still more preferably is equal to about 12% by weight with respect to the total weight of the mixture.

5) Friction material according to any of the preceding claims, comprising the binding composition in a percentage ranging from 5 to 30% by weight, water in a percentage ranging from 5 to 20 % by weight, a multi-component mixture providing at least a lubricant, preferably in a percentage ranging from 5 to 15% by weight, at least an abrasive, preferably in a percentage ranging from 8 to 25% by weight, at least a

component containing carbon, preferably in a percentage ranging from 8 to 25% by weight, at least a modifier, preferably in a percentage ranging from 15 to 30 % by weight, all the percentages being computed with respect to the total weight of the composition constituting the friction material.

6) Friction material according to any of the preceding claims, wherein the multi-component mixture comprises also one or more fibres in a percentage ranging from 7 to 30% by weight with respect to the total weight of the composition constituting the friction material.

7) Friction material according to any of the preceding claims, wherein the friction material is composed of a binding composition based on Portland cement type I 52.5R with a fineness 6500 Blaine and water and of a multi-component mixture comprising components preferably selected from metallic oxides, steel fibres, aramid fibres, chromite, metallic sulphides, graphite, coke, metallic powders, barite and rubber.

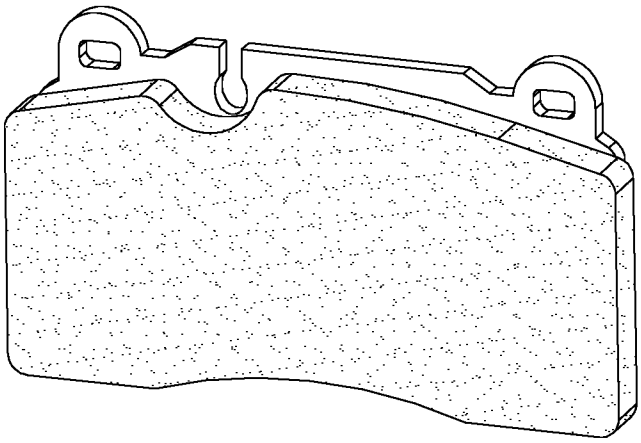
8) Brake pads composed of a friction material according to any of the claims from 1 to 7 and a base of metallic support.

9) Use of a binding composition based on a hydraulic binder selected among Portland cement, pozzolana cement or slag cement, said binder being provided with a blaine fineness comprised between 3500 and 9000, more preferably between 4000 and 7000 and still more preferably with a fineness equal to 6500 blaine for the achievement of friction materials for brake pads.

10) Use of a friction material comprising a binding

composition based on a hydraulic binder, according to any of the claims from 1 to 7 in brake pads and industrial applications, preferably in brake pads.

FIG.1



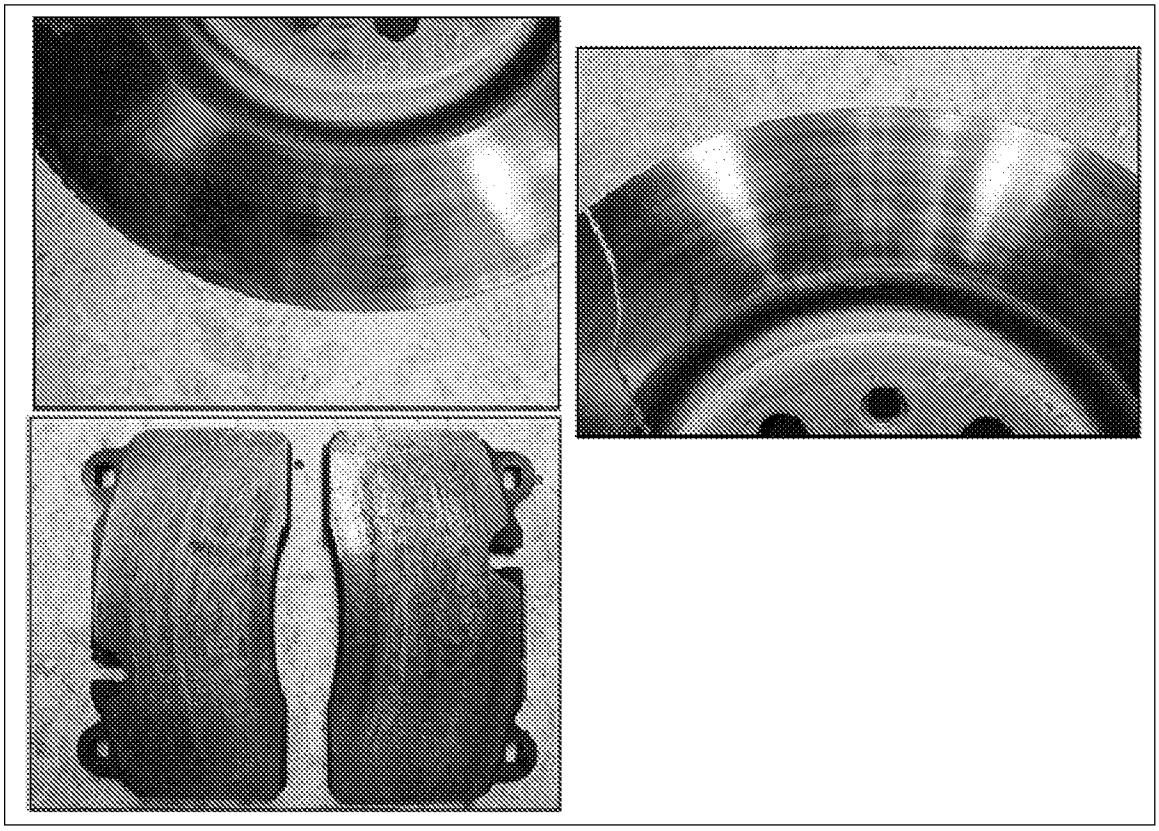


FIG.2

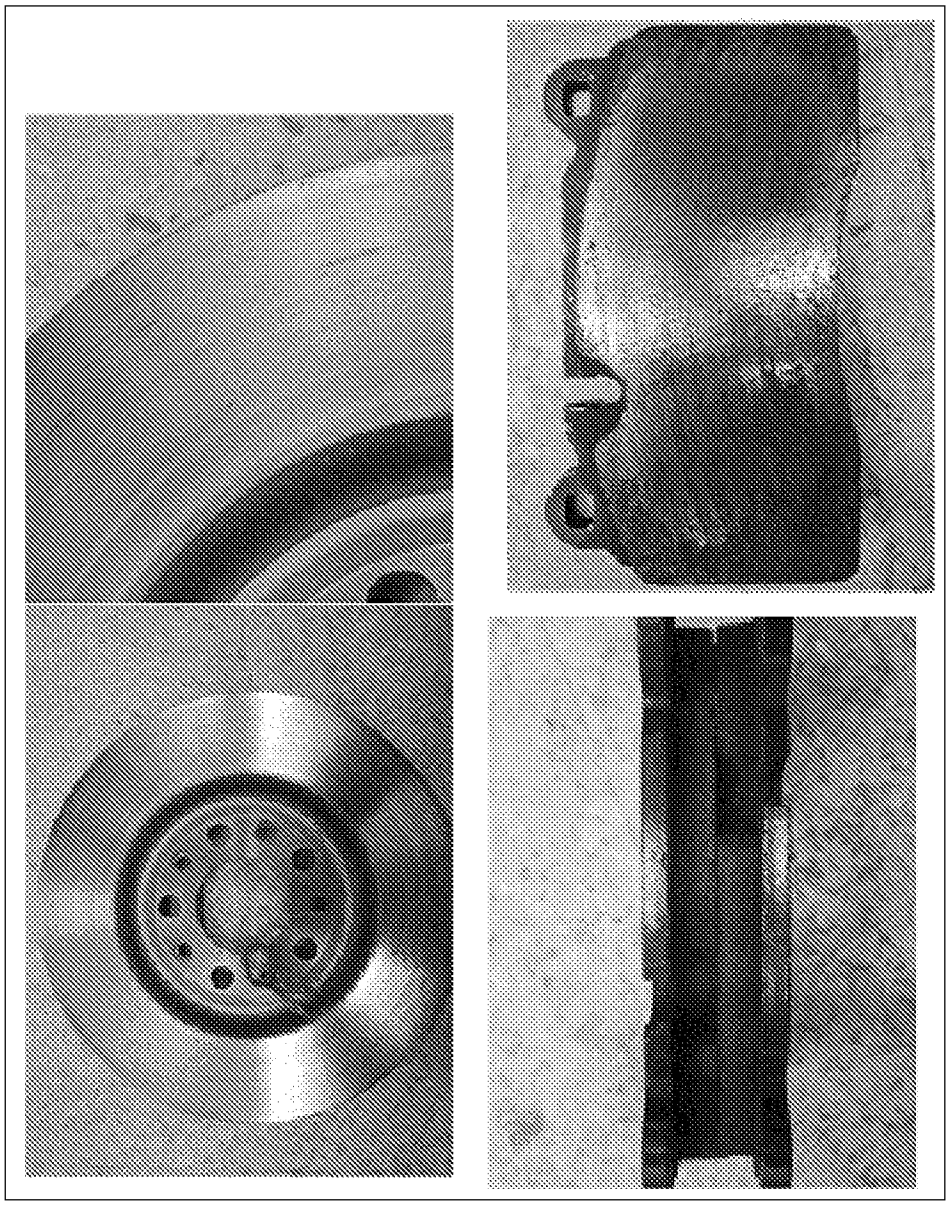


FIG.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/062258

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D69/02 C04B28/04 C04B111/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16D C04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 035 591 A (HICKS JAMES K [US] ET AL) 14 March 2000 (2000-03-14)	1-7,9,10
A	column 2, line 23 - line 25 column 6, line 5 - line 9 column 8, line 25 - line 35	8

X	US 5 433 774 A (KAPL GERHARD [AT] ET AL) 18 July 1995 (1995-07-18) claims 1-5,9,22-26 column 5, line 29 - line 37 page 6, line 11 - line 58	1-10

X	US 4 780 141 A (DOUBLE DAVID D [US] ET AL) 25 October 1988 (1988-10-25)	1-4,6,7, 9,10
A	claims 1,3,11,22,33	8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 October 2014	16/10/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Domínguez Gutiérrez

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/062258

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1 967 224 A (SIMON COLLIER ET AL) 24 July 1934 (1934-07-24) claims 1,14 page 1, column 2, line 66 - line 73	1-10
A	"NAtioNAl CooperAtive HigHwAy reseArCH prograAm Appendix A-Standard Method of Test for Particle Size Analysis of Hydraulic Cement and Related Materials by Light Scattering, A-1 MEASuRINg CEMENT PARTICLE SIzE AND SuRfACE AREA by LASER DIffRACTION INTRODuCTION", , 30 April 2013 (2013-04-30), XP055145401, Retrieved from the Internet: URL:http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_382.pdf [retrieved on 2014-10-09] the whole document	1-10
A	Pca: "Fly Ash, Slag, Silica Fume, and Natural Pozzolans", , 2 December 2002 (2002-12-02), XP055145409, Retrieved from the Internet: URL:http://www.ce.memphis.edu/1101/notes/concrete/PCA_manual/Chap03.pdf [retrieved on 2014-10-09] table 3.2 Slag Silica fume	1-10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2014/062258

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1-10(partially)
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 1-10(partially)

Claim 1 demands a component which is defined as having a "blaine fineness comprised between [...] blaine". Contrary to Art 6 and Rule 10.1(a) and (b) PCT, the unit "blaine" does not have a recognised meaning. In the description, reference is made solely to the "blaine" when mentioning the material's Blaine fineness. Specific surface areas are measured in <surface area>.<mass> -1. The use of this unusual unit in combination with unclear units in the present context is considered to lead to a lack of clarity because the claim does not clearly identify the products encompassed by it, as the parameter cannot be clearly and reliably determined by indications in the description or by objective procedures which are usual in the art. This makes it impossible to compare the claims to the prior art. As a result, the application does not comply with the requirement of clarity under Article 6 PCT. Given the fact that independent claim 1 attempts to define a friction material only by the type of binder used, and this binder is characterized by an unclear parameter, it is impossible to ascertain the material's properties.

The lack of clarity is to such an extent, that the search was performed taking into consideration the non-compliance in determining the extent of the search of claims 1-10. The search of claims 1-10 was restricted to the clear part of claims 1 and 9, namely: "binding composition based on a hydraulic binder, selected among Portland cement, pozzolana cement or slag cement ". Consequently, the scope of claim 1 has been restricted to the following form: friction material for brake pads comprising a binding composition based on a hydraulic binder, selected among Portland cement, pozzolana cement or slag cement.

The same argument applies mutatis mutandis to the subject-matter of claim 9. Therefore , the scope of claim 9 has been restricted to the form: use of a binding composition based on a hydraulic binder, selected among Portland cement, pozzolana cement or slag cement for the achievement of friction materials for brake pads.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2),

should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/062258

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6035591 A	14-03-2000	CA 2297720 A1	25-02-1999
		US 5918429 A	06-07-1999
		US 6035591 A	14-03-2000
		WO 9908976 A1	25-02-1999
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		EP 0273181 A2	06-07-1988
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		US 4780141 A	25-10-1988
US 1967224 A	24-07-1934	NONE	