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(54) MICROFIBER REINFORCEMENT FOR ABRASIVE TOOLS

MIKROFASERVERSTÄRKUNG FÜR SCHLEIFWERKZEUGE

RENFORCEMENT À MICROFIBRES POUR OUTILS ABRASIFS

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Description

TECHNICAL FIELD

[0001] Chopped strand fibers are used to reinforce resin-based grinding wheels. The chopped strand fibers typically 3-4 mm in length, are a plurality of filaments. The number of filaments can vary depending on the manufacturing process but typically consists of 400 to 6000 filaments per bundle. The filaments are held together by an adhesive known as a sizing, binder, or coating that should ultimately be compatible with the resin matrix. One example of a chopped strand fiber is referred to as 183 Cratec®, available from Owens Corning.

[0002] Incorporation of chopped strand fibers into a dry grinding wheel mix is generally accomplished by blending the chopped strand fibers, resin, fillers, and abrasive grain for a specified time and then molding, curing, or otherwise processing the mix into a finished grinding wheel.

[0003] In any such cases, chopped strand fiber reinforced wheels typically suffer from a number of problems, including lower strength, poor grinding performance as well as inadequate wheel life, presumably due to incomplete dispersal of the filaments within the chopped strand fiber bundle.

[0004] There is a need, therefore, for improved reinforcement techniques for abrasive processing tools without compromising grinding performance.

[0005] US 2008/0072500 A1 proposes an abrasive article comprising an organic bond material, an abrasive material dispersed in the organic bond material, a plurality of microfibers uniformly dispersed in the organic bond material wherein the microfibers are individual filaments and one or more fillers including a manganese compound.

SUMMARY OF INVENTION

[0006] The present invention provides an abrasive article according to claim 1 and a method of abrasive processing a workpiece according to claim 9. The dependent claims describe further embodiments of the invention.

[0007] One embodiment of the present invention provides a composition, comprising an organic bond material (e.g., thermosetting resin, thermoplastic resin, or rubber), an abrasive material dispersed in the organic bond material, and microfibers uniformly dispersed in the organic bond material. The microfibers are individual filaments and may include, for example, mineral wool fibers, slag wool fibers, rock wool fibers, stone wool fibers, glass fibers, and in particular milled glass fibers, ceramic fibers, milled basalt fibers, carbon fibers, aramid fibers, and polyamide fibers, and combinations thereof. The microfibers can have an average length, for example, of less than about 1000 μm. In one particular case, the microfibers have an average length in the range of about 100 to 500 μm and a diameter less than about 10 microns. In some embodiments, chopped strand fibers, e.g., fiberglass chopped strand fibers, are also present. In many instances the composition further includes one or more fillers with at least one being an active filler, capable of chemically reacting with the microfibers at the temperatures that occur during grinding. These chemical reactions of the active filler and microfibers provide various abrasive process benefits (e.g., improved wheel life, higher G-ratio, and/or anti-loading of abrasive tool face). Examples of suitable active fillers include manganese compounds, silver compounds, boron compounds, phosphorous compounds, and combinations thereof. In one specific such case, the one or more active fillers include manganese dichloride. Other fillers that do not chemically react with the microfibers may also be incorporated.

[0008] The composition may include, for example, from 10 % by volume to 50 % by volume of the organic bond material, from 30 % by volume to 65 % by volume of the abrasive material, and from 1 % by volume to 20 % by volume of the microfibers. In another particular case, the composition includes from 25 % by volume to 40 % by volume of the organic bond material, from 50 % by volume to 60 % by volume of the abrasive material, and from 2 % by volume to 10 % by volume of the microfibers. In another particular case, the composition includes from 30 % by volume to 40 % by volume of the organic bond material, from 50 % by volume to 60 % by volume of the abrasive material, and from 3 % by volume to 8 % by volume of the microfibers. In some instances, the composition also contains chopped strand fibers, e.g., in an amount within the range of from about 0.1 to about 10 % by volume, for example, from about 2 to about 8 % by volume.

[0009] In another embodiment, the composition is in the form of an abrasive article used in abrasive processing of a workpiece. In one such case, the abrasive article is a wheel or other suitable form for abrasive processing. Typically, the composition is a bonded abrasive article e.g., a wheel or another type of tool, in which abrasive grains are held in a three dimensional organic bond matrix.

[0010] In one aspect, an abrasive article includes an organic bond material; an abrasive material, dispersed in the organic bond material; chopped strand fibers dispersed in the organic bond material; mineral wool microfibers that are uniformly dispersed in the organic bond material, wherein said microfibers are individual filaments; and one or more fillers. In specific implementations, the one or more fillers include a manganese compound. In some cases, an abrasive article contains chopped strand fibers, mineral wool microfibers, a manganese compound and, optionally, other fillers such as, for example, lime, pyrites and others, yet it does not include potassium salts (e.g., potassium sulfate and/or potassium chloride).

[0011] Another embodiment of the present invention provides a method of abrasive processing a workpiece. The method includes mounting the workpiece onto a machine capable of facilitating abrasive processing, and operatively coupling an abrasive article to the machine. The abrasive article includes an organic bond material, an abrasive material dispersed in the organic bond material, and microfibers uniformly dispersed in the organic bond material, wherein the microfibers are individual filaments, e.g., having an average length of, for example, less than about 1000 μm. The abrasive article may further include chopped strand fibers, dispersed in the organic bond material. In specific implementations, the abrasive article contains one or more fillers, e.g., including a manganese compound. In some cases, the abrasive article excludes potassium salts. The method continues with contacting the abrasive article to a surface of the workpiece.

[0012] The abrasive article can be reinforced, e.g., internally reinforced, containing, for example, one or more fiberglass reinforcements. For instance, an abrasive article comprises an organic bond material; an abrasive material, dispersed in the organic bond material; mineral wool microfibers that are uniformly dispersed in the organic bond material, wherein said microfibers are individual filaments; one or more fillers, the one or more fillers including a manganese compound; and at least one glass web reinforcement.

[0013] Aspects of the invention provide compositions in the form of abrasive articles such as, for example, grinding wheels or other bonded abrasive tools that exhibit improved strength (as reflected, e.g., by the burst speed characterizing the tool) and impact resistance, with tools according to embodiments of the invention being robust and less prone to breakage. Abrasive articles according to embodiments of the invention also display improved wheel wear rate, G-ratio and a longer tool life. Examples of the bonded articles disclosed herein can exhibit good thermal shock resistance with little or no thermal cracking being observed. Abrasive articles that contain glass web reinforcements, and, optionally, chopped strand fibers, typically display improved impact properties.

[0014] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

Figure 1 is a plot representing the strength analysis of compositions configured in accordance with various embodiments of the present invention.

Figure 2 is a plot representing the grinding performance of a tool according to embodiments described herein.

DESCRIPTION OF EMBODIMENTS

[0016] As previously mentioned, chopped strand fibers can be used in dense resin-based grinding wheels to increase strength and impact resistance, where the incorporation of chopped strand fibers into a dry grinding wheel mix is generally accomplished by blending the chopped strand fibers, resin, fillers, and abrasive grain for a specified time. However, the blending or mixing time plays a significant role in achieving a useable mix quality. Inadequate mixing results in non-uniform mixes making mold filling and spreading difficult and leads to non-homogeneous composites with lower properties and high variability. On the other hand, excessive mixing leads to formation of "fuzz balls" (clusters of multiple chopped strand fibers) that cannot be re-dispersed into the mix. Moreover, the chopped strand itself is effectively a bundle of filaments bonded together. In either case, such clusters or bundles effectively decrease the homogeneity of the grinding mix and make it more difficult to transfer and spread into a mold. Furthermore, the presence of such clusters or bundles within the composite decreases composite properties such as strength and modulus and increases property variability. Additionally, high concentrations of glass such as chopped strand or clusters thereof have a deleterious affect on grinding wheel life. Increasing the level of chopped strand fibers in the wheel can also lower the grinding performance (e.g., as measured by G-Ratio and/or WWR).

[0017] In one particular embodiment of the present invention, producing microfiber-reinforced composites involves complete dispersal of individual filaments within a dry blend of suitable bond material (e.g., organic resins) and fillers. Complete dispersal can be defined, for example, by the maximum composite properties (such as strength) after molding and curing of an adequately blended/mixed combination of microfibers, bond material, and fillers. For instance, poor mixing results in low strengths but good mixing results in high strengths. Another way to assess the dispersion is by isolating and weighing the undispersed (e.g., material that resembles the original microfiber before mixing) using sieving techniques. In practice, dispersion of the microfiber reinforcements can be assessed via visual inspection (e.g., with or without microscope) of the mix before molding and curing. As will be apparent in light of this disclosure, incomplete or otherwise inadequate microfiber dispersion generally results in lower composite properties and grinding performance.

[0018] In accordance with various embodiments of the present invention, microfibers are small and short individual filaments having high tensile modulus and can be either inorganic or organic. In one example, the microfibers are mineral wool microfibers, also known as slag or rock wool microfibers. Examples of other microfibers that can be utilized include but are not limited to milled glass fibers, milled basalt fibers, ceramic fibers, carbon fibers, aramid or pulped aramid fibers, polyamide or aromatic polyamide fibers.

[0019] One particular embodiment of the present invention uses a microfiber that is an inorganic individual filament with an average length that is less than or equal to about 4,000 microns and filament diameter less than or equal to 40 microns and a reinforcing aspect ratio (length to diameter or L/d) of at least 10. For instance, an average length of about 100 microns and filament diameter of about 10 microns result in a reinforcing aspect ratio of 10. A filament length of about 50 microns with a filament diameter of about 5 microns has a reinforcing aspect ratio of 10. Similarly, a filament length of about 20 with a filament diameter of about 2 microns has a reinforcing aspect ratio of 10.

[0020] In addition, this example microfiber has a high melting or decomposition temperature (e.g., over 800 °C), a tensile modulus greater than about 50 GPa, and has no or very little adhesive coating. Preferably, the microfibers are highly dispersible as discrete filaments, and resistant to fiber bundle formation. Typically, the microfibers will chemically bond to the bond material being used (e.g., organic resin).

[0021] In contrast, a chopped strand fiber and its variations include a plurality of filaments held together by adhesive and have aspect ratios less than 10. However, some chopped strand fibers can be milled or otherwise broken-down into discrete filaments, and such filaments can be used as microfiber in accordance with an embodiment of the present invention. In some such cases, the resulting filaments may be significantly weakened by the milling/break-down process (e.g., due to heating processes required to remove the adhesive or bond holding the filaments together in the chopped strand or bundle). Thus, the type of microfiber used in the bond composition will depend on the application at hand and desired strength qualities.

[0022] Mineral wool microfibers, in the form of individual filaments, can be present in the compositions and/or tools described herein in an amount within the range of from about 0.4 to several volume percents, for example, within the range of from about 0.4 to about 12 vol. %. Some abrasive articles according to aspects of the invention contain mineral wool microfibers in an amount of from about 0.5 to about 10 vol %. In specific implementations, the abrasive article contains mineral wool microfibers in an amount within the range of from about 0.8 to about 8 volume percent, e.g., within the range of from about 0.8 to about 4 volume %.

[0023] In one such embodiment, microfibers suitable for use in the present invention are mineral wool fibers such as those available from Sloss Industries Corporation, AL, and sold under the name of PMF®. Similar mineral wool fibers are available from Fibertech Inc, MA, under the product designation of Mineral wool FLM. Fibertech also sells glass fibers (e.g., Microglass 9110 and Microglass 9132). These glass fibers, as well as other naturally occurring or synthetic mineral fibers or vitreous individual filament fibers, such as stone wool, glass, and ceramic fibers having similar attributes can be used as well. Mineral wool generally includes fibers made from minerals or metal oxides. An example composition and set of properties for a microfiber that can be used in the bond of a reinforced grinding tool, in accordance with one embodiment of the present invention, are summarized in Tables 1 and 2, respectively. Numerous other microfiber compositions and properties sets will be apparent in light of this disclosure, and the present invention is not intended to be limited to any particular one or subset.

Table 1: Composition of Sloss PMF® Fibers

Oxides	Weight %
SiO2	34-52
Al2O3	5-15
CaO	20-23
MgO	4-14
Na2O	0-1
K2O	0-2
TiO2	0-1
Fe2O3	0-2
Other	0-7

Table 2: Physical properties of Sloss PMF® Fibers

Hardness	7.0 mohs
Fiber Diameters	4 - 6 microns average
Fiber Length	0.1 - 4.0 mm average
Fiber Tensile Strength	3489 MPa (506,000 psi)
Specific Gravity	2.6
Melting Point	1260 °C
Devitrification Temp	815.5 °C
Expansion Coefficient	54.7 E-7 °C
Anneal Point	638 °C
Strain Point	612

[0024] The composition can further include chopped strand fibers, for instance fiberglass chopped strand fibers, such as those described above. Chopped strand fibers can have a length of, for example, 3-4 mm, each strand being formed from a plurality of filaments held together by an adhesive known as a sizing, binder, or coating. The number of filaments and filament diameters can vary depending on the manufacturing process but typically consists of 400 to 6000 filaments per bundle with filament diameters being 10 microns or greater. The average reinforcing aspect ratio is less than 3. One example of a chopped strand fiber material that can be utilized is referred to as 183 Cratec®, available from Owens Corning.

[0025] Based on the total volume of the composition or abrasive article, chopped strand fibers may be added at levels that represent a few volume percents. Higher or lower levels can be selected based, for example, on desired properties, e.g., impact resistance, in the finished abrasive article. In some embodiments, the abrasive article contains the minimum level of chopped strand fibers determined to provide one or more such desired property. In specific implementations, chopped strand fibers are present in an amount of from about 0.1 to about 10 vol.%, for instance from about 2 to about 8 vol. %, such as from about 3 to about 6 vol. %.

[0026] Bond materials that can be used in the bond of grinding tools configured in accordance with an embodiment of the present invention include organic resins such as epoxy, polyester, phenolic, and cyanate ester resins, and other suitable thermosetting or thermoplastic resins. In one particular embodiment, polyphenolic resins are used (e.g., such as Novolac resins). Specific examples of resins that can be used include the following: the resins sold by Durez Corporation, TX, under the following catalog/product numbers: 29722, 29344, and 29717; the resins sold by Dynea Oy, Finland, under the trade name Peracit® and available under the catalog/product numbers 8522G, 8723G, and 8680G; and the resins sold by Hexion Specialty Chemicals, OH, under the trade name Rutaphen® and available under the catalog/product numbers 9507P, 8686SP, and 8431SP. Numerous other suitable bond materials will be apparent in light of this disclosure (e.g., rubber), and the present invention is not intended to be limited to any particular one or subset.

[0027] Abrasive materials that can be used to produce grinding tools configured in accordance with embodiments of the present invention include commercially available materials, such as alumina (e.g., extruded bauxite, sintered and sol gel sintered alumina, fused alumina), silicon carbide, and alumina-zirconia grains. Superabrasive grains such as diamond and cubic boron nitride (cBN) may also be used depending on the given application. In one particular embodiment, the abrasive particles have a Knoop hardness of between 1600 and 2500 kg/mm2 and have a size between about 10 millimeters and 3000 microns, or even more specifically, between about 5 millimeters to about 2000 microns. Combinations of two or more types of abrasive grains also can be utilized. In one case, the composition from which grinding tools are made comprises greater than or equal to about 50% by weight of abrasive material.

[0028] In specific embodiments, the composition further includes one or more active fillers with at least one filler being capable of chemically reacting with the microfibers at the temperatures that occur during grinding. In one such case, the microfiber-reactive active filler is selected from: manganese compounds, silver compounds, boron compounds, phosphorous compounds, and any combinations thereof. In specific implementations, the active filler utilized is a manganese compound, e.g., a manganese halogenide, such as, for instance, manganese dichloride, metallic compound complex salts containing manganese, combinations containing one or more manganese compounds and so forth. Amounts of manganese compound active filler present in the composition and/or abrasive article can be within the range of from about 1 to about 10 vol. %, e.g., within the range of from about 2 to about 4 vol. %. Other amounts can be utilized.

[0029] Thus, an abrasive article composition that includes a mixture of microfibers, e.g., mineral wool microfibers, and active fillers is provided. Benefits of the composition include, for example, improvements in both strength and grinding performance.

[0030] Other fillers that do not chemically react with the microfibers may also be incorporated. These additional fillers may be added to facilitate dispersion of the microfibers or enhance grinding performance through conventional mechanisms known to those skilled in the art such as resin degradation, work-piece degradation, abrasive degradation, antiloading qualities, and lubrication. Suitable examples include pyrite, zinc sulfide, cryolite, calcium fluoride, potassium aluminum fluoride, potassium floroborate, potassium sulfate, potassium chloride, and combinations thereof.

[0031] During the manufacture of abrasive articles, fillers often are provided as a filler "package", also referred to herein as a filler "component", containing a combination of compounds that act as processing aids, to disperse the microfibers, provide lubricantion during the pressing cycle, absorb moisture or volatiles during curing and so forth. Such fillers can, for example, decrease the friction between a finished abrasive article and a workpiece, protect the abrasive grains used, and/or provide other benefits, as known in the art. Filler components that can be employed in the compositions and/or articles described herein include, for example, lime, pyrites, potassium sulfate (K2SO4), potassium chloride (KCl), zinc sulfide, cryolite, calcium fluoride, potassium aluminum fluoride, potassium floroborate, combinations thereof, as well as active fillers such as the manganese compounds discussed above, and so forth. In some aspects described herein, the filler package excludes potassium salts.

[0032] In one implementation, the composition and/or abrasive article includes, abrasive grains, an organic bond, mineral wool microfibers that are uniformly dispersed in the organic bond, the mineral wool microfibers being individual filaments, chopped strand fibers, a manganese compound and, optionally, other fillers. The composition and/or abrasive article, however, excludes potassium salts such as, for example, potassium sulfate and/or potassium chloride. It has been discovered that omitting potassium salts from some of the compositions and/or abrasive articles described herein can result in enhanced grinding performance of the tool, relative to a comparative tool that contains potassium sulfate and/or other potassium salts. As used herein, the term "comparative" refers to articles or compositions that are similar to the experimental article or composition in all aspects except for the amount, property, and/or compound or component being investigated.

[0033] In specific implementations, the composition or abrasive article includes (based on the total volume of the composition or abrasive article) from about 10 to about 50 vol %, e.g., from about 38 to about 41 vol% organic bond; from about 30 to about 65 vol %, e.g., from about 49 to about 59 vol. % abrasive grain; from about 0.4 to about 12 vol %, e.g., from 0.8 to about 8 vol % of mineral wool microfibers; from about 0 to about 10 vol %, for example from about 0.1 to about 10 volume %, e.g., from about 2 to about 8 or from about 3 to about 6 volume % of chopped strand fibers; and from about 1 to about 10, e.g., from about 2 to about 4 vol. % manganese compound active filler.

[0034] Optionally, one or more other fillers such as described above, e.g., lime, iron pyrite, potassium sulfate, potassium chloride and so forth, also are present. Suitable amounts used can be selected as known in the art. In some cases, the volume % of potassium salts is 0.

[0035] Also optionally, the composition or abrasive article can further include secondary abrasive grains capable of acting as fillers. Examples include silicon carbide, brown fused alumina, and others, as known in the art.

[0036] Some of the abrasive articles described herein can contain abrasive grains, a bond, microfibers that are individual filaments, e.g., mineral wool microfibers, an active filler, for example a manganese compound, one or more reinforcements and, optionally, chopped strand fibers. As used herein, terms such as "reinforced" or "reinforcement" refer to discrete layers or inserts or other such components of a reinforcing material that is different from the bond and abrasive materials employed to make the bonded abrasive tool. Terms such as "internal reinforcement" or "internally reinforced" indicate that these components are within or embedded in the body of the tool. Background details related to reinforcement techniques and materials are described, for example, in U.S. Patent No. 3,838,543, issued on October 1, 1974 to Lakhani. Reinforced wheels also are described in U.S. Patent Nos. 6,749,496 issued to Mota, et al. on June 15, 2004 and 6,942,561 issued to Mota, et al. on September 13, 2005.

[0037] In many cases, internally reinforced abrasive wheels include discs cut from nylon, carbon, glass or cotton cloth. In specific implementations, the abrasive article includes a fiberglass reinforcement that is in the form of a web, e.g., a material woven from very fine fibers of glass, also referred to herein as glass cloth. One, two or more than two such fiberglass webs can be used and they can be arranged in the bonded abrasive tool in any suitable manner.

[0038] The fiberglass utilized can be E-glass (alumino-borosilicate glass with less than 1 wt% alkali oxides. Other types of fiberglass, e.g., A-glass (alkali-lime glass with little or no boron oxide), E-CR-glass (alumino-lime silicate with less than 1 wt% alkali oxides, with high acid resistance), C-glass (alkali-lime glass with high boron oxide content, used for example for glass staple fibers), D-glass (borosilicate glass with high dielectric constant), R-glass (alumino silicate glass without MgO and CaO with high mechanical requirements), and S-glass (alumino silicate glass without CaO but with high MgO content with high tensile strength), glass fiber webs and so forth can be used.

[0039] Compositions in the form of abrasive articles can include porosity, e.g., at levels suitable for a given application. In specific examples, the porosity is less than 30 volume %, for instance within the range of from about 2 % to about 8 % by volume.

[0040] Without wishing to be held to any particular interpretation, it is believed that manganese compounds chemically interact with mineral wool microfibers providing multiple abrasive process benefits, such as, for instance, increased tool strength and grinding performance and/or wheel life benefits. In contrast to chopped strand fibers, the high aspect ratio of microfibers (e.g., mineral wool, milled glass or milled basalt fibers) offers an increased surface area, resulting in synergistic reactions with the active filler or fillers employed. The presence of discrete filaments with very low coating levels, in conjunction with one or more manganese compounds, provides optimal composite and grinding benefits as opposed to fiber bundles with high coating levels. Furthermore, it has been observed that the presence of potassium salts such as potassium chloride or potassium sulfate interferes with this "synergistic" interaction of the maganaese salts and discrete filaments. Abrasive articles that contain glass web reinforcements, and/or chopped strand fibers, typically display improved impact properties. The combination of mineral wool microfibers that are individual filaments (as opposed to fiber bundles), preferably in the presence of an active filler, e.g., a manganese compound, with (bundled) chopped strand fibers and/or fiber web products (reinforcements) provides increased tool strength, increased grinding performance and/or improved tool life, as well as enhanced impact resistance, diminishing tendencies of the abrasive article to break.

[0041] A number of examples of microfiber reinforced abrasive composites are now provided to further demonstrate features and benefits of an abrasive tool composite configured in accordance with embodiments of the present invention. In particular, Example 1 demonstrates composite properties bond bars and mix bars with and without mineral wool; Example 2 demonstrates composite properties as a function of mix quality; Example 3 demonstrates grinding performance data as a function of mix quality; and Example 4 demonstrates grinding performance as a function of active fillers with and without mineral wool. Example 5 compares the synergistic effects on grinding performance obtained by adding a manganese compound active filler to mineral wool microfibers relative to adding the manganese compound active filler to chopped strand fibers. Example 6 demonstrates grinding performance as a function of active fillers with mineral wool microfibers used in combination with glass chopped strand fibers.

Example 1

[0042] Example 1, which includes Tables 3, 4, and 5, demonstrates properties of bond bars and composite bars with and without mineral wool fibers. Note that the bond bars contain no grinding agent, whereas the composite bars include a grinding agent and reflect a grinding wheel composition. As can be seen in Table 3, components of eight sample bond compositions are provided (in volume percent, or vol%). Some of the bond samples include no reinforcement (sample #s 1 and 5), some include milled glass fibers or chopped strand fibers (sample #s 3, 4, 7, and 8), and some include Sloss PMF® mineral wool (sample #s 2 and 6) in accordance with one embodiment of the present invention. Other types of individual filament fibers (e.g., ceramic or glass fiber) may be used as well, as will be apparent in light of this disclosure. Note that the brown fused alumina (220 grit) in the bond is used as a filler in these bond samples, but may also operate as a secondary abrasive (primary abrasive may be, for example, extruded bauxite, 16 grit). Further note that SaranTM 506 is a polyvinylidene chloride bonding agent produced by Dow Chemical Company, the brown fused alumina was obtained from Washington Mills.

Table 3: Example Bonds with and without Mineral Wool

Samples → Components ↓	#1	#2	#3	#4	#5	#6	#7	#8
Durez 29722	48.11	48.11	48.11	48.11	42.09	42.09	42.09	42.09
Saran 506	2.53	2.53	2.53	2.53	2.22	2.22	2.22	2.22
Brown Fused Alumina - 220 Grit	12.66	6.33	6.33	6.33	18.99	9.50	9.50	9.50
Sloss PMF®		6.33				9.50		
Milled Glass Fiber			6.33				9.50	
Chopped Strand				6.33				9.50
Iron Pyrite	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
Potassium Chloride/Sulfate (60:40 blend)	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Lime	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5

[0043] For the set of sample bonds 1 through 4 of Table 3, the compositions are equivalent except for the type of reinforcement used. In samples 1 and 5 where there is no reinforcement, the vol% of filler (in this case, brown fused alumina) was increased accordingly. Likewise, for the set of samples 5 through 8 of Table 3, the compositions are equivalent except for the type of reinforcement used.

[0044] Table 4 demonstrates properties of the bond bar (no abrasive agent), including stress and elastic modulus (E-Mod) for each of the eight samples of Table 3.

Table 4: Bond Bar Properties (3-point bend)

Samples →	#1	#2	#3	#4	#5	#6	#7	#8
Stress (MPa)	90.1	115.3	89.4	74.8	103.8	118.4	97	80.7
Std Dev (MPa)	8.4	8.3	8.6	17	8	6.5	8.6	10.8
E-Mod (MPa)	17831	17784	17197	16686	21549	19574	19191	19131
Std Dev (MPa)	1032	594	1104	1360	2113	1301	851	1242

[0045] Table 5 demonstrates properties of the composite bar (which includes the bonds of Table 3 plus an abrasive, such as extruded bauxite), including stress and elastic modulus (E-Mod) for each of the eight samples of Table 3. As can be seen in each of Tables 4 and 5, the bond/composite reinforced with mineral wool (samples 2 and 6) has greater strength relative to the other samples shown.

Table 5: Composite Bar Properties (3-point bend)

Samples →	#1	#2	#3	#4	#5	#6	#7	#8
Stress (MPa)	59.7	66.4	61.1	63.7	50.1	58.2	34	34
Std Dev (MPa)	8.1	10.2	8.5	7.2	9.8	4.6	4.4	4.1
E-Mod (MPa)	6100	6236	6145	6199	5474	5544	4718	4427
Std Dev (MPa)	480	424	429	349	560	183	325	348

[0046] In each of the abrasive composite samples 1 through 8, about 44 vol% is bond (including the bond components noted, less the abrasive), and about 56 vol% is abrasive (e.g., extruded bauxite, or other suitable abrasive grain). In addition, a small but sufficient amount of furfural (about 1 vol% or less of total abrasive) was used to wet the abrasive particles. The sample compositions 1 through 8 were blended with furfural-wetted abrasive grains aged for 2 hours before molding. Each mixture was pre-weighed then transferred into a 3-cavity mold (26 mm x 102.5 mm) (1.5 mm x 114.5 mm) and hot-pressed at 160 °C for 45 minutes under 140 kg/cm2, then followed by 18 hours of curing in a convection oven at 200 °C. The resulting composite bars were tested in three point flexural (5:1 span to depth ratio) using ASTM procedure D790-03.

Example 2

[0047] Example 2, which includes Tables 6, 7, and 8, demonstrates composite properties as a function of mix quality. As can be seen in Table 6, components of eight sample compositions are provided (in vol%). Sample A includes no reinforcement, and samples B through H include Sloss PMF® mineral wool in accordance with one embodiment of the present invention. Other types of single filament microfiber (e.g., ceramic or glass fiber) may be used as well, as previously described. The bond material of sample A includes silicon carbide (220 grit) as a filler, and the bonds of samples B through H use brown fused alumina (220 grit) as a filler. As previously noted, such fillers assist with dispersal and may also operate as secondary abrasives. In each of samples A through H, the primary abrasive used is a combination of brown fused alumina 60 grit and 80 grit. Note that a single primary abrasive grit can be mixed with the bond as well, and may vary in grit size (e.g., 6 grit to 220 grit), depending on factors such as the desired removal rates and surface finish.

Table 6: Example Composites with and without Mineral Wool

Samples →	A	B	C	D	E	F	G	H
Components ↓								
Durez 29722	17.77	16.88	16.88	16.88	16.88	16.88	16.88	16.88
Saran 506	1.69	1.57	1.57	1.57	1.57	1.57	1.57	1.57
Silicon Carbide -220 Grit	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(continued)

Samples →	A	B	C	D	E	F	G	H
Components ↓								
Brown Fused Alumina - 220 Grit	0.00	3.98	3.98	3.98	3.98	3.98	3.98	3.98
Sloss PMF®	0.00	3.81	3.81	3.81	3.81	3.81	3.81	3.81
Iron Pyrite	10.15	9.64	9.64	9.64	9.64	9.64	9.64	9.64
Potassium Sulfate	4.23	4.02	4.02	4.02	4.02	4.02	4.02	4.02
Lime	2.54	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Brown Fused Alumina - 60 Grit	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
Brown Fused Alumina - 80 Grit	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
Furfural	~ 1 wt% or less of total abrasive							

[0048] As can be seen, samples B through H are equivalent in composition. In sample A where there is no reinforcement, the vol% of other bond components is increased accordingly as shown.

Table 7: Composite Properties as a Function of Mixing Procedures

Samples→	A	B	C	D	E	F	G	H
Mixing Method	Hobart Paddle	with	Hobart with Wisk	Hobart w/ Paddle & Interlator @6500rpm	Eirich	Interlator @3500 rpm	Interlator @6500 rpm	Eirich & Interlator@ 3500rpm
Mix Time	30 minutes				15 minutes	N/A		15 minutes
Undispersed mineral wool	N/A	0.9 g	0.6 g	0	0.5		0	

[0049] Table 7 indicates mixing procedures used for each of the samples. Samples A and B were each mixed for 30 minutes with a Hobart-type mixer using paddles. Sample C was mixed for 30 minutes with a Hobart-type mixer using a wisk. Sample D was mixed for 30 minutes with a Hobart-type mixer using a paddle, and then processed through an Interlator (or other suitable hammermill apparatus) at 6500 rpm. Sample E was mixed for 15 minutes with an Eirich-type mixer. Sample F was processed through an Interlator at 3500 rpm. Sample G was processed through an Interlator at 6500 rpm. Sample H was mixed for 15 minutes with an Eirich-type mixer, and then processed through an Interlator at 3500 rpm. A dispersion test was used to gauge the amount of undispersed mineral wool for each of samples B through H. The dispersion test was as follows: amount of residue resulting after 100 grams of mix was shaken for one minute using the Rototap method followed by screening through a #20 sieve. As can be seen, sample B was observed to have a 0.9 gram residue of mineral wool left on the screen of the sieve, sample C a 0.6 gram residue, and sample E a 0.5 gram residue. Each of samples D, F, G, and H had no significant residual fiber left on the sieve screen. Thus, depending on the desired dispersion of mineral wool, various mixing techniques can be utilized.

[0050] The sample compositions A through H were blended with furfural-wetted abrasive grains aged for 2 hours before molding. Each mixture was pre-weighed then transferred into a 3-cavity mold (26 mm x 102.5 mm) (1.5 mm x 114.5 mm) and hot pressed at 160 °C for 45 minutes under 140 kg/cm2, then followed by 18 hours of curing in a convection oven at 200 °C. The resulting composite bars were tested in three point flexural (5:1 span to depth ratio) using ASTM procedure D790-03.

Table 8: Means and Std Deviations

Sample	# of Tests	Mean	Std. Dev.	Std. Err. Mean	Lower 95%	Upper 95%
A	18	77.439	9.1975	2.1679	73.16	81.72
B	18	86.483	9.2859	2.1887	82.16	90.81

(continued)

Sample	# of Tests	Mean	Std. Dev.	Std. Err. Mean	Lower 95%	Upper 95%
C	18	104.133	10.2794	2.4229	99.35	108.92
D	18	126.806	5.9801	1.4095	124.02	129.59
E	18	126.700	5.5138	1.2996	124.13	129.27
F	18	127.678	4.2142	0.9933	125.72	129.64
G	18	122.983	4.8834	1.1510	120.71	125.26
H	33	123.100	6.4206	1.1177	120.89	125.31

[0051] Figure 1 is a one-way ANOVA analysis of composite strength for each of the samples A through H. Table 8 demonstrates the means and standard deviations. The standard error uses a pooled estimate of error variance. As can be seen, the composite strength for each of samples B through H (each reinforced with mineral wool, in accordance with an embodiment of the present invention) is significantly better than that of the non-reinforced sample A.

Example 3

[0052] Example 3, which includes Tables 9 and 10, demonstrates grinding performance as a function of mix quality. As can be seen in Table 9, components of two sample formulations are provided (in vol%). The formulations are identical, except that Formulation 1 was mixed for 45 minutes and Formulation 2 was mixed for 15 minutes (the mixing method used was identical as well, except for the mixing time as noted). Each formulation includes Sloss PMF® mineral wool, in accordance with one embodiment of the present invention. Other types of single filament microfiber (e.g., glass or ceramic fiber) may be used as well, as previously described.

Table 9: Grinding Performance as a Function of Mix Quality

Sequence	Component	Formulation 1 (vol %)	Formulation 2 (vol %)
Step 1: Bond Preparation	Durez 29722	22.38	22.38
	Brown Fused Alumina-220 grit	3.22	3.22
	Sloss PMF®	3.22	3.22
	Iron Pyrite	5.06	5.06
	Zinc Sulfide	1.19	1.19
	Cryolite	3.28	3.28
	Lime	1.19	1.19
	Tridecyl alcohol	1.11	1.11
Step 2:Mixing		45 minutes	15 minutes
Bond Quality Assessment	Wt % of un-dispersed mineral wool from Rototap method	1.52	2.36
Step 3: Composite Preparation	Abrasive	48	48
	Varcum 94-906	4.37	4.37
	Furfural	1 wt% of total abrasive	
Step 4: Mold Filing & Cold Pressing	Porosity target	8%	8%
Step 5: Curing		30hr ramp to 175°C followed by 17Hr soak at 175°C	

[0053] As can also be seen from Table 9, the manufacturing sequence of a microfiber reinforced abrasive composite configured in accordance with one embodiment of the presents invention includes five steps: bond preparation; mixing, composite preparation; mold filling and cold pressing; and curing. A bond quality assessment was made after the bond preparation and mixing steps. As previously discussed, one way to assess the bond quality is to perform a dispersion test to determine the weight percent of un-dispersed mineral wool from the Rototap method. In this particular case, the Rototap method included adding 50g-100g of bond sample to a 40 mesh screen and then measuring the amount of residue on the 40 mesh screen after 5 minutes of Rototap agitation. The abrasive used in both formulations at Step 3 was extruded bauxite (16 grit). The brown fused alumina (220 grit) is used as a filler in the bond preparation of Step 1, but may operate as a secondary abrasive as previously explained. Note that the Varcum 94-906 is a Furfurol-based resole available from Durez Corporation.

[0054] Table 10 demonstrates the grinding performance of reinforced grinding wheels made from both Formulation 1 and Formulation 2, at various cutting-rates, including 0.75, 1.0, and 1.2 sec/cut.

Table 10: Demonstrates the Grinding Performance

Formulation	Cut Rate (sec/cut)	MRR (in3/min)	WWR (in3/min)	G-Ratio
Formulation 1	0.75	31.53	4.35	6.37
Formulation 1	1.0	23.54	3.29	7.15
Formulation 1	1.2	19.97	2.62	7.63
Formulation 2	0.75	31.67	7.42	4.27
Formulation 2	1.0	23.75	4.96	4.79
Formulation 2	1.2	19.88	3.64	5.47

[0055] As can be seen, the material removal rate (MRR), which is measured in cubic inches per minute, of Formulation 1 was relatively similar to that of Formulation 2. However, the wheel wear rate (WWR), which is measured in cubic inches per minute, of Formulation 1 is consistently lower than that of Formulation 2. Further note that the G-ratio, which is computed by dividing MRR by WWR, of Formulation 1 is consistently higher than that of Formulation 2. Recall from Table 9 that the example bond of Formulation 1 was mixed for 45 minutes, and Formulation 2 was mixed 15 minutes. Thus, mix time has a direct correlation to grinding performance. In this particular example, the 15 minute mix time used for Formulation 2 was effectively too short when compared to the improved performance of Formulation 1 and its 45 minute mix time.

Example 4

[0056] Example 4, which includes Tables 11, 12, and 13, demonstrates grinding performance as a function of active fillers with and without mineral wool. As can be seen in Table 11, components of four sample composites are provided (in vol%). The composite samples A and B are identical, except that sample A includes chopped strand fiber, and no brown fused alumina (220 Grit) or Sloss PMF® mineral wool. Sample B, on the other hand, includes Sloss PMF® mineral wool and brown fused alumina (220 Grit), and no chopped strand fiber. The composite density (which is measured in grams per cubic centimeter) is slightly higher for sample B relative to sample A. The composite samples C and D are identical, except that sample C includes chopped strand fiber and no Sloss PMF® mineral wool. Sample D, on the other hand, includes Sloss PMF® mineral wool and no chopped strand fiber. The composite density is slightly higher for sample C relative to sample D. In addition, a small but sufficient amount of furfural (about 1 vol% or less of total abrasive) was used to wet the abrasive particles, which in this case were alumina grains for samples C and D and alumina-zirconia grains for samples A and B.

Table 11: Grinding performance as a Function of Active Fillers

Component	Composite Content (vol%)			
	A	B	C	D
Alumina Grain	0.00	0.00	52.00	52.00
Alumina-Zirconia Grain	54.00	54.00	0.00	0.00
Durez 29722	20.52	20.52	19.68	19.68
Iron Pyrite	7.20	7.20	8.36	8.36

(continued)

Component	Composite Content (vol%)			
	A	B	C	D
Potassium Sulfate (K2SO4)	0.00	0.00	3.42	3.42
K2SO4/KCl (60:40 blend)	3.60	3.60	0.00	0.00
MKC-S	3.24	3.24	3.42	3.42
Lime	1.44	1.44	1.52	1.52
Brown Fused Alumina - 220 Grit	0.00	3.52	0.00	0.00
Porosity	2.00	2.00	2.00	2.00
Sloss PMF	0.00	8.00	0.00	8.00
Chop Strand Fiber	8.00	0.00	8.00	0.00
Furfural	1 wt% of total abrasive			
Density (g/cc)	3.07	3.29	3.09	3.06
Wheel Dimensions (mm)	760x76x203	760x76x203	610x63x203	610x63x203

[0057] Table 12 demonstrates tests conducted to compare the grinding performance between the samples B and D, both of which were made with a mixture of mineral wool and the example active filler manganese dichloride (MKC-S, available from Washington Mills), and samples A and C, which were made with chopped strand instead of mineral wool.

Table 12: Demonstrates the Grinding Performance

Test Number	Sample	Slab Material	MRR (kg/hr)	WWR (dm3/hr)	G-ratio (kg/dm3)	Percentage Improvement
1	A	Austenitic Stainless Steel	193.8	0.99	196	27.77%
	B		222.6	0.89	250	
2	A	Ferritic Stainless Steel	210	1.74	121	27.03%
	B		208.5	1.36	153	
3	C	Austenitic Stainless Steel	833.1	4.08	204	35.78%
	D		808.8	2.92	277	
4	C	Carbon Steel	812.4	2.75	296	30.07%
	D		784.1	2.03	385	

[0058] As can be seen, grinding wheels made from each sample were used to grind various workpieces, referred to as slabs. In more detail, samples A and B were tested on slabs made from austenitic stainless steel and ferritic stainless steel, and samples C and D were tested on slabs made from austenitic stainless steel and carbon steel. As can further be seen in Table 12, using a mixture of mineral wool and manganese dichloride samples B and D provided about a 27% to 36% improvement relative to samples A and C (made with chopped strand instead of mineral wool). This clearly shows improvements in grinding performance due to a positive reaction between mineral wool and the filler (in this case, manganese dichloride). No such positive reaction occurred with the chopped strand and manganese dichloride combination. Table 13 lists the conditions under which the composites A through D were tested.

Table 13: Demonstrates Grinding Conditions

Test Number	Grinding Power (kw)	Slab Material	Slab Condition
1	First path at 120 and followed by 85	Austenitic Stainless Steel	Cold
2	First path at 120 and followed by 85	Ferritic Stainless Steel	Cold
3	105	Austenitic Stainless Steel	Hot

(continued)

Test Number	Grinding Power (kw)	Slab Material	Slab Condition
4	105	Carbon Steel	Hot

Examples 5

[0059] Experiments were undertaken to explore the effects of fiber type and levels of MKCS on wheel grinding performance. Wheels were prepared as in Example 4 and only differed with respect to the type of fibers and level of MKCS present. Specifically, wheels included either 8 vol % of (glass) chopped strand fibers (CSF) or 8 vol % of microfibers of mineral wool (MW). For each category, the level of MKCS was either 0 or 3.42 vol %.

[0060] As seen in Table 14, the G-ratio for the wheels containing 8 vol% CSF was decreased by about 10% when MKCS was added (from 330 kg/dm3 without any MKCS to 296 kg/dm3 with MKCS). An opposite trend was observed with the wheels prepared with mineral wool, where adding MKCS resulted in an increase of about 20 % in the G-ratio (from 311 kg/dm3 at 0 levels of MKCS to 385 kg/dm3 when 3.42 vol % MKCS was added). This clearly demonstrates that MKCS interacts differently with the two fiber types and that a synergistic effect is obtained by combining MW microfibers with MKCS. No such effect was observed with the MKCS-CSF combination. On the contrary, adding MKCS to compositions that contain CSF had a negative effect on G-ratio.

Table 14: Effects of MKCS levels and fiber types on G-ratios

Fiber Type	G-Ratio (kg/dm3)	
	Level of MKCS (vol%)	
	0.00	3.42
CSF (8 vol%)	330.00	296.00 (Std.)
MW (8 vol%)	311.00	385.00

Example 6

[0061] Example 6, which includes Table 15 and Figure 2, demonstrates grinding performance as a function of active fillers in combination with mineral wool and chopped strand fibers. As can be seen in Table 15, components of eight sample composites are provided (in vol%).

[0062] All samples (Exp1 through Exp8) included the same type and amount of abrasive grain. Two levels of fiberglass chopped strand fibers (CSF) were employed: a high level of 6 volume % (Exp1, Exp2, Exp5 and Exp 6) and a low level of 4 volume % (Exp 3, Exp. 4, Exp7 and Exp8).

[0063] In all cases, the bond included (organic) resin, Sloss PMF® mineral wool (MW) microfibers, iron compound (pyrite), lime, and the active filler manganese dichloride (MKCS). Exp5 through Exp8 samples also included potassium sulfate filler, while the remaining samples (Exp1 through Exp4) did not.

[0064] The synergy between mineral wool microfibers and the manganese compound active filler was particularly significant in samples that had low levels of (fiberglass) CSF. As glass fiber level was increased, the MKCS/MW advantage was less pronounced. These results demonstrated that the manganese compound active filler does not provide the same benefits with respect to glass CSF as it does with MW microfibers.

[0065] The data also showed that adding potassium sulfate (Exp5 through Exp8) had a deleterious effect on the cumulative G-ratio. Generally, highest cumulative Q-ratio (defined as metal removed (lbs)/wheel wear (lbs)) values were observed for samples that did not contain potassium sulfate, and this was particularly significant at low levels of (fiberglass) CSF. (See, e.g., Exp3 and Exp4). In comparison to the effects of MKCS, potassium sulfate provided no increase in grinding performance or provided a diminished grinding performance.

[0066] The results demonstrated that grinding performance increased as MKCS and MW were increased and that the synergistic effects observed with these two ingredients did not extend to fiberglass chopped strand fibers or other fillers (e.g., potassium sulfate). The experiments showed that there is an unexpected performance advantage when the combination of MW and MKCS are used in a grinding wheel.

[0067] The data also indicate that potassium salts have an increased effect on performance in compositions which include the higher levels of glass chopped strand fibers, mineral wool microfibers and a manganese compound, and less of an effect in compositions that include mineral wool microfibers, a manganese compound and lower levels of chopped strand fibers.

Table 15: Performance of tool with combined MW, CSF and fillers

Component	Composite Content (vol%)							
	1	2	3	4	5	6	7	8
Grain	55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5
Chopped Strand Fiber	6.0	6.0	4	4	6.0	6.0	4	4
Bond	38.5	38.5	40.5	40.5	38.5	38.5	40.5	40.5
Resin	19.25	19.48	20.23	20.49	19.25	19.48	20.23	20.49
Sloss PMF	1.44	0.97	1.52	1.02	1.25	0.84	1.31	0.88
MKC-S	3.65	3.69	3.83	3.88	2.50	2.53	2.63	2.66
Iron Pyrite	12.66	12.82	13.31	13.48	11.85	11.99	12.46	12.61
Lime	1.52	1.54	1.60	1.62	1.15	1.16	1.21	1.22
Potassium Sulfate	0.00	0.00	0.00	0.00	2.50	2.53	2.63	2.66
Cumulative Q-Ratio	70.1	68.4	84.0	71.4	69.4	65.4	68.0	55.3

Claims

1. An abrasive article, comprising:

an organic bond material;
an abrasive material, dispersed in the organic bond material;
chopped strand fibers dispersed in the organic bond material, the chopped strand fibers comprising about 0.1 volume % to about 10 volume % in the abrasive article;
mineral wool microfibers that are uniformly dispersed in the organic bond material, wherein said microfibers are individual filaments; and
one or more fillers, the one or more fillers including a manganese compound.

2. The abrasive article of claim 1, wherein the manganese compound is manganese dichloride, and from 2% by volume to 8% by volume chopped strand fibers in the abrasive article.

3. The abrasive article of claim 1, wherein the manganese compound is present in the abrasive article in an amount within the range of from about 1 to about 10 volume %.

4. The abrasive article of claim 1, wherein the mineral wool microfibers are present in the abrasive article in an amount within the range of from about 0.5 to about 10 volume %.

5. The abrasive article of claim 1, wherein the abrasive article does not include potassium salts.

6. The abrasive article of claim 1, wherein the chopped strand fibers are fiberglass glass chopped strand fibers, and the abrasive article includes one or more glass web reinforcements.

7. The abrasive article of claim 1, wherein the mineral wool microfibers have a reinforcing aspect ratio of at least 10 and the chopped strand fibers have an aspect ratio of less than 3.

8. The abrasive article of claim 1, wherein the abrasive article includes: from 25% by volume to 40% by volume of the organic bond material; from 50% by volume to 60% by volume of the abrasive material; from 0.5% by volume to 10% by volume of the microfibers; from 3% by volume to 6% by volume chopped strand fibers; and from 1% by volume to 10% by volume manganese compound.

9. A method of abrasive processing a workpiece, the method comprising:

mounting the workpiece onto a machine capable of facilitating abrasive processing;
operatively coupling an abrasive article to the machine, the abrasive article comprising an organic bond material;
an abrasive material dispersed in the organic bond material;
chopped strand fibers dispersed in the organic bond material comprising from 0.1 % by volume to 10% by volume of the abrasive article;
mineral wool microfibers, uniformly dispersed in the organic bond material, wherein said microfibers are individual filaments; and
one or more fillers, the one or more fillers including a manganese compound; and contacting the abrasive article to a surface of the workpiece.

10. The method of claim 9, wherein the manganese compound is manganese dichloride, and the abrasive article does not include potassium salts.

11. The method of claim 9, wherein the manganese compound is present in the abrasive article in an amount within the range of from about 1 to about 10 volume %, and from 2% by volume to 8% by volume chopped strand fibers in the abrasive article.

12. The method of claim 9, wherein the mineral wool microfibers are present in the abrasive article in an amount within the range of from about 0.5 to about 10 volume %.

13. The method of claim 9, wherein the chopped strand fibers are fiberglass glass chopped strand fibers, and the abrasive article includes one or more glass web reinforcements.

14. The method of claim 9, wherein the mineral wool microfibers have a reinforcing aspect ratio of at least 10 and the chopped strand fibers have an aspect ratio of less than 3.

15. The method of claim 9, wherein the abrasive article includes: from 25% by volume to 40% by volume of the organic bond material; from 50% by volume to 60% by volume of the abrasive material; from 0.5% by volume to 10% by volume of the microfibers; from 3% by volume to 6% by volume of the chopped strand fibers; and from 1% by volume to 10% by volume manganese compound.

Patentansprüche

1. Schleifartikel, umfassend:

ein organisches Verbundmaterial;
ein Schleifmaterial, das in dem organischen Verbundmaterial dispergiert ist;
geschnittene Faserbündel, die in dem organischen Verbundmaterial dispergiert sind, wobei die geschnittenen Faserbündel von etwa 0,1 Volumenprozent bis etwa 10 Volumenprozent in dem Schleifmaterial ausmachen;
Mineralwolle-Mikrofasern, die in dem organischen Verbundmaterial gleichförmig dispergiert sind, wobei die Mikrofasern einzelne Filamente sind; und
ein oder mehrere Füllstoffe, wobei der eine oder die mehreren Füllstoffe eine Manganverbindung einschließen.

2. Schleifartikel nach Anspruch 1, wobei die Manganverbindung Mangan(II)-chlorid ist, sowie 2 Volumenprozent bis 8 Volumenprozent geschnittene Faserbündel in dem Schleifartikel.

3. Schleifartikel nach Anspruch 1, wobei die Manganverbindung in dem Schleifartikel in einer Menge im Bereich von etwa 1 bis etwa 10 Volumenprozent vorliegt.

4. Schleifartikel nach Anspruch 1, wobei die Mineralwolle-Mikrofasern in dem Schleifartikel in einer Menge im Bereich von etwa 0,5 bis etwa 10 Volumenprozent vorliegen.

5. Schleifartikel nach Anspruch 1, wobei der Schleifartikel keine Kaliumsalze einschließt.

6. Schleifartikel nach Anspruch 1, wobei die geschnittenen Faserbündel aus Fiberglas geschnittene Faserbündel sind und der Schleifartikel eine oder mehrere Glasfasermatten-Verstärkungen einschließt.

7. Schleifartikel nach Anspruch 1, wobei die Mineralwolle-Mikrofasern ein verstärkendes Höhe-Breite-Verhältnis mindestens 10 und die geschnittenen Faserbündel ein Höhe-Breite-Verhältnis von kleiner als 3 haben.

8. Schleifartikel nach Anspruch 1, wobei der Schleifartikel einschließt: 25 Volumenprozent bis 40 Volumenprozent des organischen Verbundmaterials; 50 Volumenprozent bis 60 Volumenprozent des Schleifmaterials; 0,5 Volumenprozent bis 10 Volumenprozent Mikrofasern; 3 Volumenprozent bis 6 Volumenprozent geschnittene Faserbündel und 1 Volumenprozent bis 10 Volumenprozent Manganverbindung.

9. Verfahren zum abrasiven Bearbeiten eines Werkstücks, welches Verfahren umfasst:

Aufspannen des Werkstücks auf eine Maschine, die zum Erleichtern des abrasiven Bearbeitens geeignet ist;
operatives Verbinden des Schleifartikels mit der Maschine, wobei der Schleifartikel ein organisches Verbundmaterial aufweist;
ein Schleifmaterial, das in dem organischen Verbundmaterial dispergiert ist;
geschnittene Faserbündel, die in dem organischen Verbundmaterial dispergiert sind, umfassend 0,1 Volumenprozent bis 10 Volumenprozent des Schleifartikels;
Mineralwolle-Mikrofasern, die in dem organischen Verbundmaterial gleichförmig dispergiert sind, wobei die Mikrofasern einzelne Filamente sind; und
ein oder mehrere Füllstoffe, wobei der eine oder die mehreren Füllstoffe eine Manganverbindung einschließen;
sowie Kontaktieren des Schleifartikels mit einer Oberfläche des Werkstücks.

10. Verfahren nach Anspruch 9, wobei die Manganverbindung Mangan(II)-chlorid ist und der abrasive Artikel keine Kaliumsalze einschließt.

11. Verfahren nach Anspruch 9, wobei die Manganverbindung in dem Schleifartikel in einer Menge im Bereich von etwa 1 bis etwa 10 Volumenprozent vorliegt und die geschnittenen Faserbündel in dem Schleifartikel von 2 Volumenprozent bis 8 Volumenprozent vorliegen.

12. Verfahren nach Anspruch 9, wobei die Mineralwolle-Mikrofasern in dem Schleifartikel in einer Menge im Bereich von etwa 0,5 bis etwa 10 Volumenprozent vorliegen.

13. Verfahren nach Anspruch 9, wobei die geschnittenen Faserbündel aus Fiberglas geschnittene Faserbündel sind und der Schleifartikel eine oder mehrere Glasfasermatten-Verstärkungen einschließt.

14. Verfahren nach Anspruch 9, wobei die Mineralwolle-Mikrofasern ein verstärkendes Höhe-Breite-Verhältnis mindestens 10 und die geschnittenen Faserbündel ein Höhe-Breite-Verhältnis von kleiner als 3 haben.

15. Verfahren nach Anspruch 9, wobei der Schleifartikel einschließt: 25 Volumenprozent bis 40 Volumenprozent des organischen Verbundmaterials; 50 Volumenprozent bis 60 Volumenprozent des Schleifmaterials; 0,5 Volumenprozent bis 10 Volumenprozent Mikrofasern; 3 Volumenprozent bis 6 Volumenprozent geschnittene Faserbündel und 1 Volumenprozent bis 10 Volumenprozent Manganverbindung.

Revendications

1. Article abrasif, comprenant :

un matériau de liaison organique ;
un matériau abrasif, dispersé dans le matériau de liaison organique ;
des fibres hachées en brins dispersées dans le matériau de liaison organique, les fibres hachées en brins comprenant environ 0,1 % en volume à environ 10 % en volume dans l’article abrasif ;
des microfibres de laine minérale qui sont uniformément dispersées dans le matériau de liaison organique, lesdites microfibres étant des filaments individuels ; et
au moins une charge, l’au moins une charge contenant un composé à base de manganèse.

2. Article abrasif selon la revendication 1, dans lequel le composé à base de manganèse est du dichlorure de manganèse, et où de 2 % en volume à 8 % en volume des fibres hachées en brins sont présentes dans l’article abrasif.

3. Article abrasif selon la revendication 1, dans lequel le composé à base de manganèse est présent dans l'article abrasif en quantité comprise entre environ 1 et environ 10 % en volume.

4. Article abrasif selon la revendication 1, dans lequel les microfibres de laine minérale sont présentes dans l'article abrasif à hauteur d'environ 0,5 à environ 10 % en volume.

5. Article abrasif selon la revendication 1, dans lequel l'article abrasif ne contient pas de sels de potassium.

6. Article abrasif selon la revendication 1, dans lequel les fibres hachées en brins sont des fibres hachées en brins à base de fibre de verre, et où l'article abrasif contient au moins un renfort en toile de verre.

7. Article abrasif selon la revendication 1, dans lequel les microfibres de laine minérale ont un rapport de forme de renfort d'au moins 10 et où les fibres hachées en brins ont un rapport de forme inférieur à 3.

8. Article abrasif selon la revendication 1, l'article abrasif contenant : de 25 % en volume à 40 % en volume du matériau de liaison organique ; de 50 % en volume à 60 % en volume du matériau abrasif ; de 0,5 % en volume à 10 % en volume des microfibres ; de 3 % en volume à 6 % en volume des fibres hachées en brins ; et de 1 % en volume à 10 % en volume du composé à base de manganèse.

9. Procédé de traitement abrasif d'une pièce à usiner, ce procédé comprenant :

le montage de la pièce à usiner sur une machine à même de faciliter un traitement abrasif ;
le couplage en fonctionnement d'un article abrasif sur la machine, l'article abrasif comprenant un matériau de liaison organique ;
un matériau abrasif dispersé dans le matériau de liaison organique ;
des fibres hachées en brins dispersées dans le matériau de liaison organique et comprenant de 0,1 % en volume à 10 % en volume de l'article abrasif ;
de la laine minérale ;
des microfibres, dispersées uniformément dans le matériau de liaison organique, lesdites microfibres étant des filaments individuels ; et
au moins une charge, l'au moins une charge contenant un composé à base de manganèse ; et la mise en contact de l'article abrasif avec une surface de la pièce à usiner.

10. Procédé selon la revendication 9, dans lequel le composé à base de manganèse est du dichlorure de manganèse, et où l'article abrasif ne contient pas de sels de potassium.

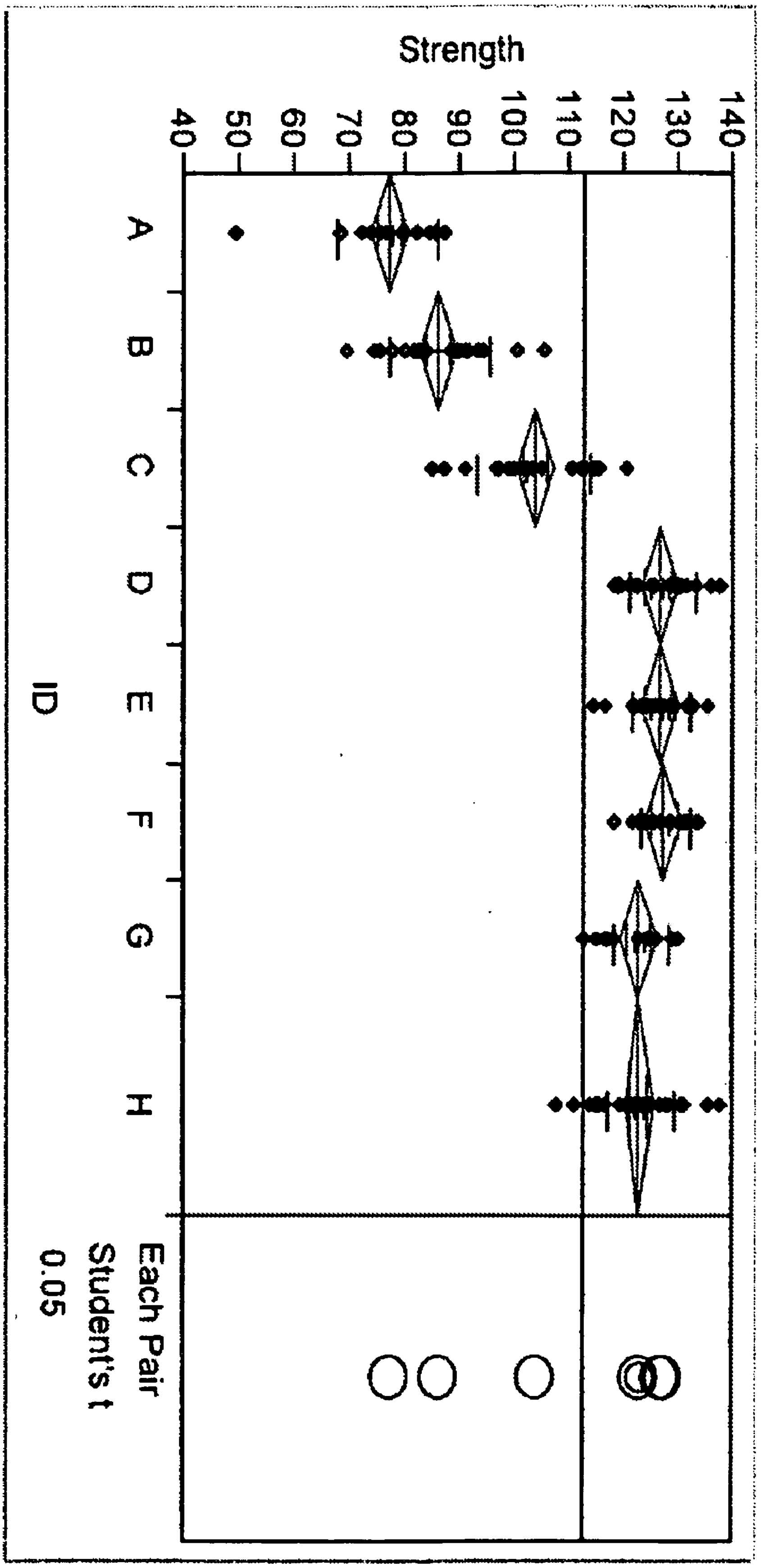
11. Procédé selon la revendication 9, dans lequel le composé à base de manganèse est présent dans l'article abrasif à hauteur comprise entre environ 1 et environ 10 % en volume, et de 2 % en volume à 8 % en volume de fibres hachées en brins dans l'article abrasif.

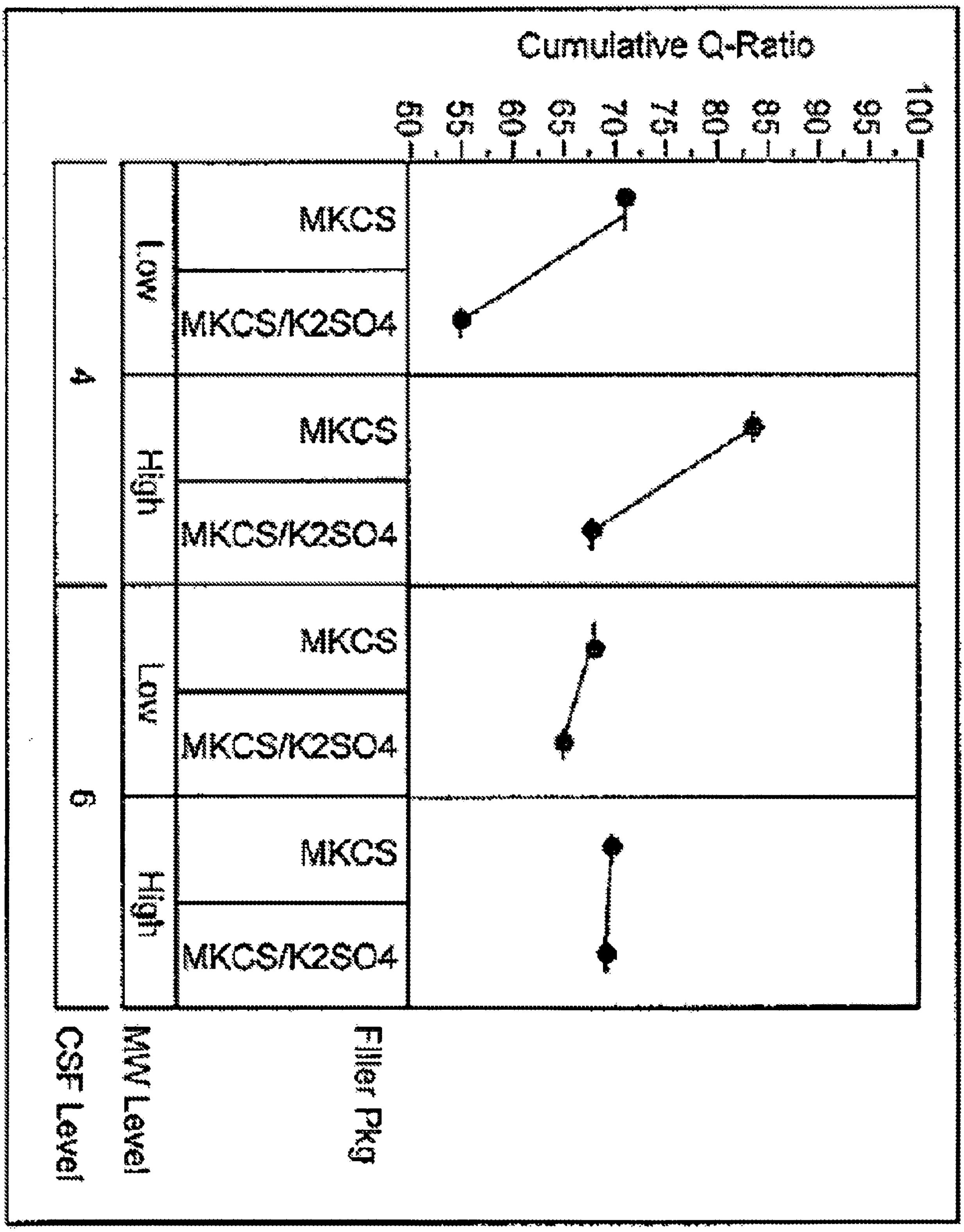
12. Procédé selon la revendication 9, dans lequel les microfibres de laine minérale sont présentes dans l'article abrasif à hauteur comprise entre environ 0,5 à environ 10 % en volume.

13. Procédé selon la revendication 9, dans lequel les fibres hachées en brins sont des fibres hachées en brins de fibre de verre, et où l'article abrasif contient au moins un renfort en toile de verre.

14. Procédé selon la revendication 9, dans lequel les microfibres de laine minérale ont un rapport de forme de renfort d'au moins 10 et où les fibres hachées en brins ont un rapport de forme inférieur à 3.

15. Procédé selon la revendication 9, dans lequel l'article abrasif contient : de 25 % en volume à 40 % en volume du matériau de liaison organique ; de 50 % en volume à 60 % en volume du matériau abrasif ; de 0,5 % en volume à 10 % en volume des microfibres ; de 3 % en volume à 6 % en volume des fibres hachées en brins ; et de 1 % en volume à 10 % en volume du composé à base de manganèse.


Strength
40
50
60
70
80
90
100
110
120
130
140
A
B
C
D
E
F
G
H
ID
Each Pair
Student's t
0.05


Cumulative Q-Ratio
50
55
60
65
70
75
80
85
90
95
100
MKCS
MKCS/K2SO4
MKCS
MKCS/K2SO4
MKCS
MKCS/K2SO4
MKCS
MKCS/K2SO4
Low
High
Low
High
4
6
Filler Pkg
MW Level
CSF Level

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 20080072500 A1 **[0005]**
- US 3838543 A, Lakhani **[0036]**
- US 6749496 B, Mota **[0036]**
- US 6942561 B, Mota **[0036]**