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(54) **ABRASIVE ARTICLES AND METHODS OF
MAKING AND USING THE SAME**

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ABSTRACT

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A coated abrasive article having a reinforced vulcanized fiber backing with an abrasive layer affixed thereto and methods of making and using the same. The reinforced vulcanized fiber backing has a backsize that comprises a reaction product of components selected from the group consisting of curable latex emulsions, phenolic resins, and combinations thereof.

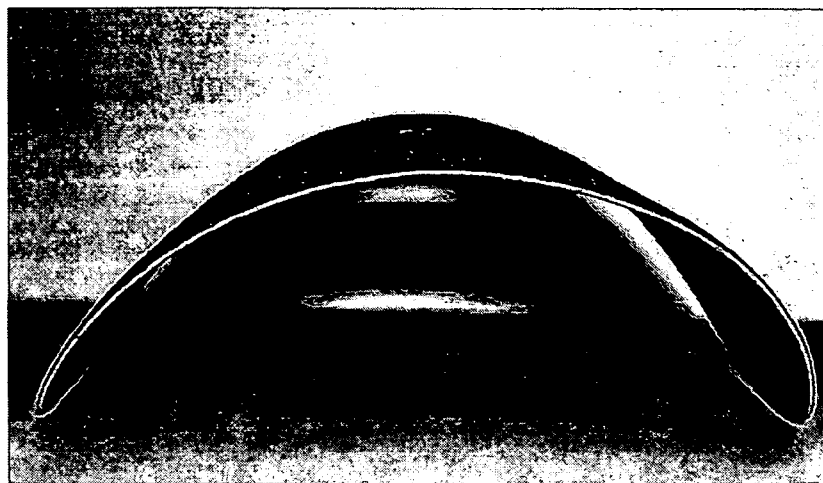


Fig. 1
Prior Art

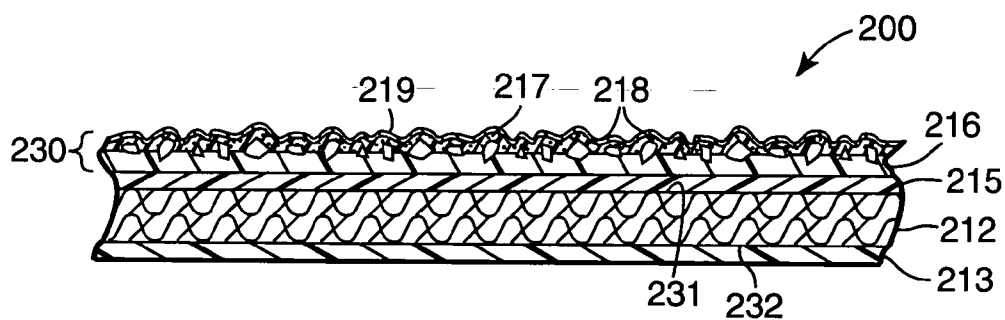


Fig. 2

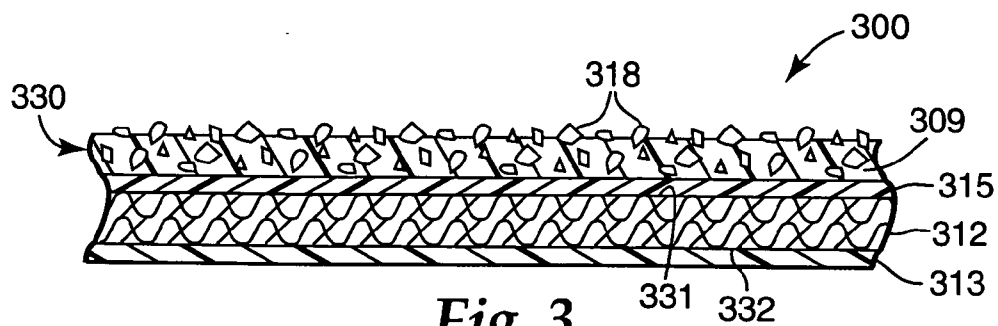


Fig. 3

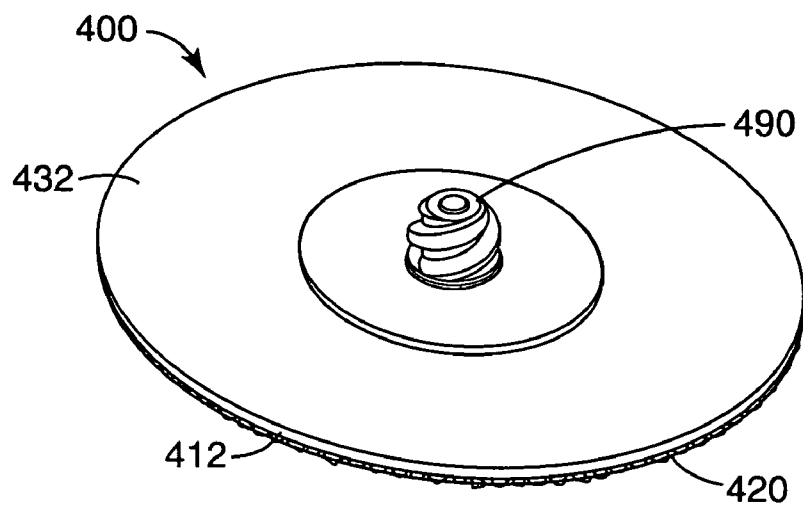


Fig. 4

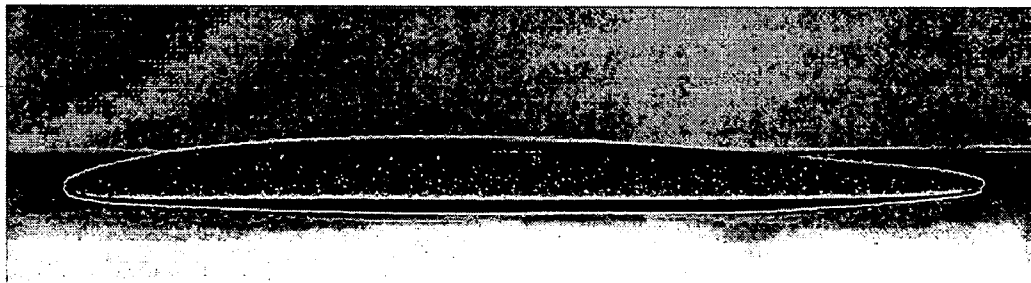


Fig. 5

ABRASIVE ARTICLES AND METHODS OF MAKING AND USING THE SAME

BACKGROUND

[0001] Vulcanized fiber has been in commerce since the 19th century. The term “vulcanized fiber”, sometimes also referred to as “vulcanized fibre” or “fish paper”, refers to a leather-like material generally formed from cellulose by compressing layers of chemically treated (e.g., as with metallic chlorides) cellulose derived from paper, paper pulp, rayon or cloth. Due to its hydrophilic nature, vulcanized fiber is typically prone to absorb moisture.

[0002] Coated abrasive articles typically have an abrasive layer affixed to a backing. Vulcanized fiber has been used as a backing material for coated abrasive articles for more than 60 years. One well-recognized problem of using vulcanized fiber backings in abrasive articles is shape distortion (e.g., curling or cupping) of the coated abrasive article due to changes in environmental moisture content (e.g., humidity). Shape distortion may occur, for example, during manufacturing, during storage, or during use. Further, the shape distortion may occur toward and/or away from the abrasive layer. An example of such distortion of a prior art coated abrasive article having a vulcanized fiber backing is shown in **FIG. 1**, wherein the coated abrasive article exhibits curling directed away from the abrasive layer. If excessive shape distortion occurs during manufacturing the coated abrasive article, then it is typically discarded as scrap material. Further, if excessive shape distortion occurs during storage, or in use, it typically results in product complaints, reduced product sales, and/or reduced product performance.

[0003] Attempts to solve the problem of shape distortion date back more than 50 years. For example, U.S. Pat. No. 2,431,258 to H. P. Kirchner, filed Feb. 5, 1946, issued Nov. 18, 1947 states in col. 2, lines 23-30: “Although it is possible by this process to make discs which are initially of the desired curvature, a great deal of trouble is experienced by abrasive manufacturers by reason of the fact that vulcanized fiber is very susceptible to changes in atmospheric moisture content, particularly when one side of the material has been coated as is the case with the abrasive discs of this invention.” In that patent, the problem was addressed by drying the article to achieve the desired level of curvature and then covering the vulcanized fiber backing with a sheet of material that is impermeable to moisture vapor. From that time until the present, there have been developed various other alternative moisture insensitive and dimensionally stable backings for coated abrasive articles incorporating vulcanized fiber.

[0004] Notwithstanding these various products, and primarily for economic reasons, vulcanized fiber backings are still used today in the commercial manufacture of coated abrasive articles primarily. For example, the major coated abrasives manufacturers each market coated abrasive products with vulcanized fiber backings that are prone to humidity problems, even though alternative moisture insensitive and dimensionally stable backings for coated abrasive articles are known. Accordingly, there remains a need in the coated abrasives industry for coated abrasive products with vulcanized fiber backings that are economical to manufacture and that are not prone to unacceptable levels of shape distortion with changes in humidity levels.

SUMMARY

[0005] In one aspect, the present invention provides a coated abrasive article comprising a vulcanized fiber backing having first and second opposed major surfaces, an abrasive layer affixed to the first major surface, and a backsize affixed to the second major surface, wherein the backsize has a dry basis weight of from 8 to 90 grams per square meter of the coated abrasive article, and wherein the backsize comprises a reaction product of components selected from the group consisting of curable latex emulsions, phenolic resins, and combinations thereof.

[0006] In another aspect, the present invention provides a method of abrading a surface of a workpiece, the method comprising: providing a coated abrasive article according to the present invention, frictionally contacting the abrasive layer with a surface of the workpiece, and moving at least one of the abrasive layer and the surface of the workpiece relative to the other to abrade at least a portion of the surface of the workpiece.

[0007] In yet another aspect, the present invention provides a method of making a coated abrasive article, the method comprising:

[0008] providing a vulcanized fiber backing having first and second opposed major surfaces;

[0009] coating a curable backsize precursor onto the second major surface of the vulcanized fiber backing, and curing the backsize precursor to provide a backsize, wherein the backsize has a dry basis weight of from 8 to 90 grams per square meter of the coated abrasive article, and wherein the backsize precursor comprises at least one material selected from the group consisting of curable latex emulsions, phenolic resins, and combinations thereof; and

[0010] affixing an abrasive layer to the first major surface of the vulcanized fiber backing.

[0011] Coated abrasive articles according to the present invention typically exhibit industry acceptable levels of shape distortion with changes in humidity. Surprisingly, it is also found that such articles enable attachment of mechanical fasteners to the backsize and hence the vulcanized fiber backing by a welding process, whereas before the present invention this was not possible.

BRIEF DESCRIPTION OF THE DRAWING

[0012] **FIG. 1** is a photograph of a coated abrasive disc of the prior art;

[0013] **FIG. 2** is a cross-sectional side view of an exemplary coated abrasive article according to one embodiment of the present invention;

[0014] **FIG. 3** is a cross-sectional side view of an exemplary coated abrasive article according to one embodiment of the present invention;

[0015] **FIG. 4** is a perspective view of an exemplary coated abrasive disc with a welded mechanical fastener according to one embodiment of the present invention; and

[0016] **FIG. 5** is a photograph of a coated abrasive disc prepared according to Example 1.

DETAILED DESCRIPTION

[0017] In general, coated abrasive articles have abrasive particles affixed to a backing. More typically, coated abra-

sive articles comprise a backing having two major opposed surfaces and an abrasive layer affixed to one major surface of the backing. The abrasive layer typically comprises abrasive particles and a binder, wherein the binder serves to secure the abrasive particles to the backing.

[0018] In one embodiment, the coated abrasive article has an abrasive layer comprising a make layer, a size layer, and abrasive particles. In making such a coated abrasive article, a make layer comprising a first binder precursor is applied to one major surface of the backing, and optionally partially cured. Abrasive particles are then at least partially embedded into the make layer (e.g., via electrostatic coating), and the first binder precursor is sufficiently cured (i.e., crosslinked) to secure the particles to the make layer. A size layer comprising a second binder precursor is then applied over the make layer and abrasive particles, followed by curing of the binder precursors. Such coated abrasive articles may further comprise an optional supersize layer disposed on at least a portion of the abrasive layer. If present, the supersize layer typically includes grinding aids and/or anti-loading materials.

[0019] In another embodiment, the coated abrasive article has an abrasive layer affixed to one major surface of a backing, wherein the abrasive layer is provided by applying a slurry comprised of binder precursor and abrasive particles onto a major surface of a backing, and then curing the binder precursor.

[0020] The backing comprises vulcanized fiber, a dense material of partially regenerated cellulose in which the fiber structure is retained and which is typically calendered to provide a relatively smooth surface. Vulcanized fiber is widely available from commercial sources such as, for example, Franklin Fibre—Lamitex Corporation (Wilmington, Del.) or Yangmin Ind. Trade Co., Ltd. (Sanmenxia, Henan, China).

[0021] Typically, vulcanized fiber backing useful-for preparing coated abrasive articles according to the present invention has a thickness in a range of from 0.02 to 5 millimeters, for example, from 0.05 to 2.5 millimeters or from 0.1 to 1 millimeter, although thinner and thicker vulcanized paper backings may also be used. Further, the density of the vulcanized fiber is typically in a range of from 0.9 to 1.5 grams per cubic centimeter, although higher and lower density vulcanized fiber may also be used.

[0022] At least a portion, typically substantially all, of one major surface of the vulcanized fiber backing is coated with curable resin, which then is at least partially cured, for example, by drying and heating to provide a backsize on the vulcanized fiber backing. Coating of the vulcanized fiber backing with the curable material may be achieved by any suitable coating method including, for example, roll coating, bar coating, knife coating, kiss coating, or spraying.

[0023] The curable material should typically be coated onto the vulcanized fiber such that it is distributed over at least a substantial portion of the body of the vulcanized fiber, typically in a substantially uniform manner, although this is not a requirement. For example, it will be recognized that a minor amount of local variations or interruptions in the distribution (e.g., coating voids) may be tolerated without significant adverse effects.

[0024] The backsize treated vulcanized fiber backing may optionally further comprise additional backing treatments a

presize (i.e., a layer affixed to the backing on the major surface having the abrasive layer), a tie layer (i.e., a layer between the abrasive layer and the major surface to which the abrasive layer is affixed), a saturant (i.e., a backing treatment applied by a process that includes saturating the backing with the saturant) and/or a subsize treatment. A subsize is similar to a saturant, except that it is applied to a previously treated backing. An antistatic material may be included in any of these backing treatments. The addition of an antistatic material can reduce the tendency of the coated abrasive article to accumulate static electricity when sanding wood or wood-like materials. Additional details regarding antistatic backings and backing treatments can be found in, for example, U.S. Pat. No. 5,108,463 (Buchanan); U.S. Pat. No. 5,137,542 (Buchanan et al.); U.S. Pat. No. 5,328,716 (Buchanan); and U.S. Pat. No. 5,560,753 (Schnabel et al.); the disclosures of which are incorporated herein by reference.

[0025] The backsize has a dry basis weight of from 8 to 90 grams per square meter, typically selected according to the composition of the backsize. For example, in one embodiment wherein the reinforcing material is a reaction product of components comprising a curable latex emulsion, the backsize typically has a dry basis weight of from 8 to 25 grams per square meter, 10 to 20 grams per square meter, or even a basis weight of from 12 to 17 grams per square meter. In another embodiment, wherein the reinforcing material is a reaction product of components comprising a phenolic resin, the backsize typically has a dry basis weight of from 15 to 90 grams per square meter, 45 to 55 grams per square meter, or even a basis weight of from 50 to 55 grams per square meter.

[0026] Typically, the backsize treated vulcanized fiber backing will have a thickness in a range of from 0.15 to 2.0 millimeters, for example, 0.5 to 1.3 millimeters, or even 0.8-0.9 millimeters, although thicker and thinner backsize treated vulcanized fiber backings may also be used.

[0027] The backsize comprises at least one material that is a reaction product of at least one curable material selected from the group consisting of phenolic resins, curable latex emulsions, and combinations thereof. In addition, the reinforcing material may include one or more optional additives such as, for example, fillers, antistatic agents, antioxidants, or colorants.

[0028] The general term “phenolic resin” includes phenol-formaldehyde resins as well as resins comprising other phenol-derived compounds and aldehydes. For example, a portion of the phenol can be substituted with one or more other phenols such as resorcinol, m-cresol, 3,5-xyleneol, t-butylphenol and p-phenylphenol. Likewise, a portion of the formaldehyde can be substituted with other aldehyde groups such as acetaldehyde, chloral, butyraldehyde, furfural, or acrolein.

[0029] Examples of phenolic resins include resole-phenolic resins and novolak phenolic resins. Resole phenolic resins have a molar ratio of formaldehyde to phenol of greater than or equal to one to one, typically in a range of from 1.5:1.0 to 3.0:1.0. Novolak phenolic resins have a molar ratio of formaldehyde to phenol of less than one to one.

[0030] Typical resole phenolic resins contain a base catalyst. The presence of a basic catalyst speeds up the reaction

or polymerization rate of the phenolic resin. The pH of resole phenolic resins is typically from 6 to 12, more typically from 7 to 10, and even more typically from 7 to 9. Examples of suitable basic catalysts include sodium hydroxide, potassium hydroxide, calcium hydroxide, magnesium hydroxide, barium hydroxide, and combinations thereof. Typical catalysts for the reaction of formaldehyde with phenol are chosen from group I and II metal salts, generally because of their high reactivity and low cost. Amines are also used to catalyze the phenol/aldehyde reaction. The amount of basic catalyst is typically 5 percent by weight or less, more typically 2 percent by weight or less, and even more typically 1 percent by weight or less based on the weight of the phenolic resin. Resole phenolic resins are usually made from phenol and formaldehyde.

[0031] Phenolic resins are typically coated as a solution with water and/or organic solvent (e.g., alcohol). Typically, the solution includes about 70 percent to about 85 percent solids, although other concentrations may be used. If the solids content is very low, then more energy is required to remove the water and/or solvent. If the solids content is very high, then the viscosity of the resulting phenolic resin is too high which typically leads to processing problems.

[0032] Examples of useful curable latex emulsions include those curable latex emulsions derived from styrene, butadiene, acrylonitrile, neoprene, polyvinyl acetate, acrylate esters, acrylamides, and copolymers thereof. Mixtures of curable latex emulsions may also be used.

[0033] Commercially available curable latex emulsions include, for example, those available under the trade designations "RHOPLEX" and "ACRYSOL" from Rohm and Haas Company (Philadelphia, Pa.); "FLEXCRYL" and "VALTAC" from Air Products & Chemicals Inc. (Allentown, Pa.); "SYNTHEMUL", "TYCRYL", and "TYLAC" from Dow Reichold Specialty Latex, LLC (Research Triangle Park, N.C.); "HYCAR", "CARBOCURE", "GOOD-RITE", "SANCURE" and "VYCAR" from NOVEON (Cleveland, Ohio); "CHEMIGUM" commercially available from Goodyear Tire and Rubber Co. (Akron, Ohio); "NEOCRYL" commercially available from ICI; and "BUTAFON" commercially available from BASF. Unless the latex is self-curing (i.e., self-crosslinking), it is typically used in combination with at least one additive (e.g., a crosslinker) that facilitates curing or it may also be used in combination with another curable material.

[0034] Examples of commercially available self-curing latexes include those emulsions having the trade designations "CARBOCURE TSR-72" and "CARBOCURE TSR-201"; styrene butadiene emulsions having the trade designation "GOOD-RITE SB-1168", "GOOD-RITE SB-0706", "GOOD-RITE 1800x73"; a polyurethane dispersion having the trade designation "SANCURE AU-4010" (acrylic urethane hybrid); a polyvinyl acetate emulsion having the trade designation "VYCAR VA-0450"; and a pvc-acrylic copolymer having the trade designation "VYCAR TN-810"; all marketed by Noveon, Cleveland, Ohio.

[0035] The curable material may optionally contain one or more curatives, for example, as described above, or in addition thereto. The choice of curative is typically determined by the curable material selected and may include, for example, acid, base, photocatalyst, hardeners, crosslinkers (e.g., polyepoxides, melamine resins, polyaziridines, poly-

valent metal ions, dicyandiamide, urea-formaldehyde resins, and mixtures thereof). If present, the amount of optional added curative is typically less than about 5 percent of the dry weight of the latex that it is intended to cure (i.e., crosslink), although higher amounts may be used. Examples of curatives for various latexes may be found, for example, in U.S. Pat. No. 6,306,514 (Weikel et al.).

[0036] Commercially available curatives for latexes include, for example, melamine resins such as those available from Cytec Industries, West Paterson, N.J. under the trade designation "AEROTEX" (e.g., "AEROTEX M-3", "AEROTEX 3730", and "AEROTEX 3030"), glycolurils available from Cytec Industries under the trade designations "CYMEL 1172" and "CYMEL 1171", and alkylated melamine resins such as those available from Cytec Industries under the trade designations "CYMEL 300", "CYMEL 303", "CYMEL 373" and "CYMEL 350"; polyaziridines such as those available from Bayer Corporation, Pittsburgh, Pa., under the trade designation "XAMA" (e.g., "XAMA-7" and "XAMA-2"); waterborne aliphatic epoxies such as those available from Resolution Performance Products, Houston, Tex., under the trade designation "EPI-REZ"; melamine-formaldehyde resins such as that available from Cytec Industries under the trade designation "BEETLE 65".

[0037] As noted above, coated abrasive articles typically have an abrasive layer affixed to a backing. Typically, the abrasive layer comprises make and size layers and abrasive particles or, alternatively, a layer of abrasive particles dispersed in a binder.

[0038] According to one embodiment of the present invention, the coated abrasive article has an abrasive layer comprising make and size layers and abrasive particles as shown, for example, in FIG. 2. Referring now to FIG. 2, exemplary coated abrasive article 200 comprises vulcanized fiber backing 212 having first and second opposed major surfaces 231, 232. Backsize 213 is affixed to second major surface 232. Overlaying optional presize 215 and affixed to backing 212 is abrasive layer 230 comprising: make layer 216 in which are embedded abrasive grits 218, and size layer 217 which overlays and is affixed to make layer 216 and abrasive grits 218. Optional supersize 219 overlays size layer 217.

[0039] The basis weight of the make layer utilized may depend, for example, on the intended use(s), type(s) of abrasive particles, and nature of the coated abrasive article being prepared, but generally will be in the range of from 1, 2, or 5 to 20, 25, 400, or even 600 grams per square meter. The make layer is generally applied as a make layer precursor that upon subsequent solidification (e.g., by curing or cooling) forms a layer of binder material of sufficient strength to secure abrasive particles to the backing. The make layer precursor may be applied by any known coating method for applying a make layer precursor to a backing, including, for example, roll coating, extrusion die coating, curtain coating, knife coating, gravure coating, and spray coating. Examples of make layer precursors include curable materials comprising phenolics, aminoplasts, poly(meth)acrylates, polyepoxides, polyisocyanates, hide glue, and combinations thereof.

[0040] After applying a make layer precursor to the backsize treated vulcanized fiber backing, and prior to solidification of the make layer precursor (e.g., by curing), abrasive particles are deposited onto the make layer.

[0041] Exemplary useful abrasive particles include fused aluminum oxide based materials such as aluminum oxide, ceramic aluminum oxide (which may include one or more metal oxide modifiers and/or seeding or nucleating agents), and heat-treated aluminum oxide, silicon carbide, co-fused alumina-zirconia, diamond, ceria, titanium diboride, cubic boron nitride, boron carbide, garnet, flint, emery, sol-gel derived abrasive particles, and blends thereof. Examples of sol-gel abrasive particles include those described U.S. Pat. No. 4,314,827 (Leitheiser et al.); U.S. Pat. No. 4,518,397 (Leitheiser et al.); U.S. Pat. No. 4,623,364 (Cottringer et al.); U.S. Pat. No. 4,744,802 (Schwabel); U.S. Pat. No. 4,770,671 (Monroe et al.); U.S. Pat. No. 4,881,951 (Wood et al.); U.S. Pat. No. 5,011,508 (Wald et al.); U.S. Pat. No. 5,090,968 (Pellow); U.S. Pat. No. 5,139,978 (Wood); U.S. Pat. No. 5,201,916 (Berg et al.); U.S. Pat. No. 5,227,104 (Bauer); U.S. Pat. No. 5,366,523 (Rowenhorst et al.); U.S. Pat. No. 5,429,647 (Larmie); U.S. Pat. No. 5,498,269 (Larmie); and U.S. Pat. No. 5,551,963 (Larmie); the disclosures of which are incorporated herein by reference. The abrasive particles may be in the form of, for example, individual particles, agglomerates, abrasive composite particles, and mixtures thereof.

[0042] Exemplary agglomerates are described, for example, in U.S. Pat. No. 4,652,275 (Bloecher et al.) and U.S. Pat. No. 4,799,939 (Bloecher et al.), the disclosures of which are incorporated herein by reference. It is also within the scope of the present invention to use diluent erodible agglomerate grains as described, for example, in U.S. Pat. No. 5,078,753 (Broberg et al.), the disclosure of which is incorporated herein by reference. Abrasive composite particles comprise abrasive grains in a binder.

[0043] Exemplary abrasive composite particles are described, for example, in U.S. Pat. No. 5,549,962 (Holmes et al.), the disclosure of which is incorporated herein by reference.

[0044] Coating weights for the abrasive particles may depend, for example, on the specific coated abrasive article desired, the process for applying the abrasive particles, and the size of the abrasive particles, but typically range from 1 to 2000 g/m².

[0045] The basis weight of the size layer will also necessarily vary depending on the intended use(s), type(s) of abrasive particles, and nature of the coated abrasive article being prepared, but generally will be in the range of from 1 or 5 g/m² to 300, or even 800 g/m², or more.

[0046] The size layer is generally applied as a size layer precursor that upon subsequent solidification (e.g., by curing or cooling) forms a layer of binder material of sufficient strength to secure the abrasive particles to the make layer. The size layer precursor may be applied by any known coating method for applying a size layer precursor to a backing, including, for example, roll coating, extrusion die coating, curtain coating, knife coating, gravure coating, and spray coating. Examples of size layer precursors include curable materials comprising at least one of phenolic resins, aminoplasts, poly(meth)acrylates, polyepoxides, polyisocyanates, hide glue, urea-formaldehyde resins, melamine-formaldehyde resins, and combinations thereof.

[0047] Details concerning coated abrasive articles comprising abrasive particles and make and size layers, and

optional supersize are well known and are described, for example, in U.S. Pat. No. 4,734,104 (Broberg); U.S. Pat. No. 4,737,163 (Larkey); U.S. Pat. No. 5,203,884 (Buchanan et al.); U.S. Pat. No. 5,152,917 (Pieper et al.); U.S. Pat. No. 5,378,251 (Culler et al.); U.S. Pat. No. 5,417,726 (Stout et al.); U.S. Pat. No. 5,436,063 (Follett et al.); U.S. Pat. No. 5,496,386 (Broberg et al.); U.S. Pat. No. 5,609,706 (Benedict et al.); U.S. Pat. No. 5,520,711 (Helmin); U.S. Pat. No. 5,954,844 (Law et al.); U.S. Pat. No. 5,961,674 (Gagliardi et al.); U.S. Pat. No. 4,751,138 (Tumey et al.); U.S. Pat. No. 5,766,277 (DeVoe et al.); U.S. Pat. No. 6,077,601 (DeVoe et al.); U.S. Pat. No. 6,228,133 (Thurber et al.); and U.S. Pat. No. 5,975,988 (Christianson); the disclosures of which are incorporated herein by reference.

[0048] According to another embodiment of the present invention, the coated abrasive article has an abrasive layer comprising a layer of abrasive particles dispersed in a binder as shown, for example, in FIG. 3. Referring now to FIG. 3, exemplary coated abrasive article 300 comprises vulcanized fiber backing 312 having first and second opposed major surfaces 331, 332. Backsize 313 is affixed to second major surface 332. Optional presize 315 is affixed to major surface 331. Overlaying optional presize 315 and affixed to backing 312 is abrasive layer 330, which comprises a plurality of abrasive grits 318 distributed throughout binder 309.

[0049] In some embodiments of coated abrasive articles according to the present invention, the abrasive layer comprises a dispersion of abrasive particles in a binder (typically coated as a slurry of abrasive particles in a binder precursor). Slurry coating techniques are well known in the abrasive art, and include those described, for example, in U.S. Pat. No. 5,378,251 (Culler et al.); U.S. Pat. No. 5,942,015 (Culler et al.); and U.S. Pat. No. 6,277,160 (Stubbs et al.); the disclosures of which are incorporated herein by reference. Examples of suitable binder precursors include curable materials comprising phenolics, aminoplasts, poly-(meth)acrylates, polyepoxides, polyisocyanates, and combinations thereof. Abrasive particles used in this embodiment include all of those previously listed hereinabove.

[0050] Coated abrasive articles according to the present invention can be converted, for example, into belts, tapes, rolls, discs (including perforated discs), and/or sheets.

[0051] According to the present invention, it is found that problems of cupping and/or curling due to moisture absorption are greatly reduced, generally to a degree that they are no longer objectionable to users. This is surprising since the moisture uptake (e.g., by weight) of the inventive coated abrasives is typically virtually the same as for corresponding coated abrasives of the prior art.

[0052] Further, it is also surprisingly observed that coated abrasives according to the present invention typically have improved cut under at least some conditions (e.g., under elevated humidity conditions) as compared to corresponding coated abrasives of the prior art.

[0053] For belt applications, two free ends of the abrasive sheet may be joined together using known methods to form a spliced belt. A spliceless belt may also be formed as described, for example, in U.S. Pat. No. 5,573,619 (Benedict et al.), the disclosure of which is incorporated herein by reference.

[0054] In one embodiment, coated abrasive discs according to the present invention may have a mechanical fastener

affixed to the vulcanized paper backing. For example, referring now to **FIG. 4**, exemplary coated abrasive disc **400** has mechanical fastener **490** affixed to backsize-coated major surface **432** of vulcanized fiber backing **412** of abrasive disc **420**. Abrasive disc **420** may be, for example, a disc made from either of coated abrasive articles **200** or **300**.

[0055] Suitable techniques for attaching the mechanical fastener include, for example, adhesives, rivets, welding. Exemplary welding techniques include, for example, ultrasonic welding, infrared welding, vibration welding, and frictional welding (including spin welding). Welding may also be accomplished as a stepwise process in which at least a portion of the thermoplastic is heated until it is at least partially softened or melted, and then the softened or melted thermoplastic is bonded to the abrasive article. Of the abovementioned techniques, at least spin welding is typically simple, effective, and convenient. It is surprising found that mechanical fasteners can be successfully spin welded to the backsize coated vulcanized fiber backings, while this is not typically possible using vulcanized fiber backings. Further details concerning mechanical fasteners and welding techniques may be found, for example, in commonly assigned U.S. Ser. No. 10/828,119 (Fritz et al.), filed Apr. 20, 2004, the disclosure of which is incorporated herein by reference.

[0056] Coated abrasive articles according to the present invention are useful for abrading a workpiece. One such method includes frictionally contacting at least a portion of the abrasive layer of a coated abrasive article with at least a portion of a surface of the workpiece, and moving at least one of the coated abrasive article or the workpiece relative to the other to abrade at least a portion of the surface.

[0057] Examples of workpiece materials include metal, metal alloys, exotic metal alloys, ceramics, glass, wood, wood-like materials, composites, painted surfaces, plastics, reinforced plastics, stone, and/or combinations thereof. The workpiece may be flat or have a shape or contour associated with it. Examples of specific workpieces include metal components, plastic components, particleboard, camshafts, crankshafts, furniture, and turbine blades.

[0058] Coated abrasive articles according to the present invention may be used by hand and/or used in combination with a machine. At least one or both of the coated abrasive article and the workpiece is generally moved relative to the other when abrading. Abrading may be conducted under wet or dry conditions. Exemplary liquids for wet abrading include water, water containing conventional rust inhibiting compounds, lubricant, oil, soap, and cutting fluid. The liquid may also contain defoamers, degreasers, and/or the like.

[0059] Objects and advantages of this invention are further illustrated by the following non-limiting examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and, details, should not be construed to unduly limit this invention.

EXAMPLES

[0060] Unless otherwise noted, all parts, percentages, ratios, etc. in the examples and the rest of the specification are by weight, and all reagents used in the examples were obtained, or are available, from general chemical suppliers such as, for example, Sigma-Aldrich Company, Saint Louis, Mo., or may be synthesized by conventional methods.

[0061] Vulcanized Fiber Discs used in the Examples had a diameter of 7 inches (18 cm), and had a center hole of $\frac{7}{8}$ -inch.

[0062] The following abbreviations are used throughout the examples.

ABBREVIATION	DESCRIPTION
VF	vulcanized fiber web, 33.5 mils thickness, obtained under the trade designation "DYNOS FIBRE" from H. T. Troplast AG, Troisdorf, Germany. This product is supplied with a green-colored back side and a brown-colored front side.
AR1	acrylic polymer emulsion, 35 wt. % solids, obtained under the trade designation "CARBOCURE TSR 72" from Noveon, Inc., Cleveland, Ohio
SBR	styrene/butadiene/acrylonitrile copolymer, obtained under the trade designation "STYRONAL NX 4681" from BASF Corporation, Ludwigshafen, Germany
AR2	acrylic emulsion, 49 wt. % solids, obtained under the trade designation "HYCAR 2679" from Noveon, Inc., Cleveland, Ohio
PR1	resole phenolic resin, 75 wt. % solids, obtained under the trade designation "GP387D51" from Georgia-Pacific Corporation, Atlanta, Georgia
PR2	phenol-formaldehyde resin having phenol to formaldehyde ratio of 1.5–2.1:1, catalyzed with 2.5 percent potassium hydroxide
AP	ceramic aluminum oxide abrasive particles, 50 grit, ANSI grade 50, obtained under the trade designation "CUBITRON" from 3M Company, Saint Paul, Minnesota.
AP2	ceramic aluminum oxide abrasive particles, 36 grit, ANSI grade 36, obtained under the trade designation "CUBITRON" from 3M Company.
CACO	calcium carbonate filler obtained under the trade designation "HUBERCARB Q325" from J. M. Huber Corporation, Fairmount, Georgia
CRY	filler, obtained under the trade designation "CRYOLITE TYPE RTN-C" from Koppers Trading, Pittsburgh, Pennsylvania
RIO	red iron oxide obtained from Elementis Pigments Inc., East St. Louis, Illinois
PM1	a premix prepared by combining 31.9% AR2, 53.9% PR1, and 14.2% water
PM2	a premix prepared by combining 59.6% PR2, 38.3% CACO, and 2.1% water
PM3	a premix prepared by combining 35.2% PR2, 54.4% CRY, 1.7% RIO, and 8.7% water
PM4	a premix prepared by combining 35.7% PR2, 55.3% CRY, 1.7% RIO, and 7.3% water

Test Methods

Shape Measurement Procedure A

[0063] The abrasive discs to be evaluated were removed from the restricting bales, and laid out individually (abrasive side down) on the shelves of a chamber controlled to 15% RH (relative humidity), 24° C. for 48 hours. Four discs per example of material were studied. The shape of each disc was measured using a laser height gauge capable of measuring to the nearest 10 micrometers (Model LG10, obtained from Banner Engineering, Minneapolis, Minn.). The laser device was used to measure the height of individual discs in four points: the two lowest points and the two highest points. The difference between the average highest and lowest values was reported for each disc as Delta Height. Net shape out-of-plane toward the backing side was designated positive (+). Net shape out-of-plane toward the abrasive side was

reported as negative (–). This procedure was repeated for 30%, 45%, 60% and 75% RH environments, the temperature being held at 24° C. The reported number in each case is an average of the difference in measurements taken on four replicate discs.

Shape Measurement Procedure B

[0064] Eight abrasive discs were removed from the bales and laid out individually (abrasive side down) to precondition in a chamber controlled to 45% RH, 24° C. After 48 hours preconditioning, the shape of each disc was measured with the laser as described in “Shape Measurements Procedure A”, above. Four of the discs were then placed in a chamber controlled to 20% RH, 24° C., and the remaining four placed in a chamber controlled to 60% RH, 24° C. After 48 hours, the discs were taken out of the chambers eight at a time and measured with the laser gauge. The reported number in each case is an average of the measurements taken on four replicate discs. Four additional measurements were made after each 48-hour period for a total test duration of 10 days.

Shape Measurement Procedure C

[0065] The abrasive discs to be evaluated were removed from the restricting bales and the shape (i.e., the deviation from planarity) of each disc was measured using a laser height gauge capable of measuring to the nearest 10 micrometers (Model LG10, obtained from Banner Engineering, Minneapolis, Minn.). Each disc was placed on a table with the center hole most distal from the table. The height of the center hole from the table was measured using the laser height gauge. Net shape out-of-plane toward the backing side was designated positive (+). Net shape out-of-plane toward the abrasive side was reported as negative (–). After the initial measurement, three groups of ten discs each were suspended from their center holes on horizontal rods in chambers controlled to 20% RH (relative humidity) at 24° C., 45% RH at 24° C., and 70% RH (relative humidity) at 24° C., respectively, for 2 weeks. The shape for each disc was then measured and the absolute value of the change from the initial state to the final state after humidity treatment, i.e., height, was reported for an average of ten discs.

Grinding Test

[0066] The Grinding Test was designed to measure the cut rate of the coated abrasive disc. Test discs were conditioned at 45% RH and 24° C. for 2 days. Prior to testing, half of these pre-conditioned discs were then placed into a 20% RH, 24° C. and the other half into a 60% RH, 24° C. environment for one week prior to testing. Each finally conditioned abrasive disc was used to grind the face of a 1.25 cm by 18 cm 1018 mild steel workpiece. The grinder used was a constant load hydraulic disc grinder. The constant load between the workpiece and the abrasive disc was provided by a load spring. The back-up pad for the grinder was an aluminum back-up pad, beveled at approximately 7 degrees, extending from the edge and in towards the center 3.5 cm. The disc was secured to the aluminum pad by a retaining nut and was driven at 5,500 rpm. The load between the back-up pad and disc and workpiece was about 6.8 kg. Each disc was used to grind a separate workpiece for each of 15 60-second intervals. The initial cut was the amount of metal removed in the first 60 seconds of grinding. The final cut was the amount of metal removed during the 15th 60-second interval. Unless otherwise noted, total cut is the cumulative amount of metal removed during the test. Initial, final, and total cut in grams are reported.

Grinding Test 2

[0067] Grinding Test 2 was also designed to measure the cut rate of the coated abrasive disc. Test discs were conditioned at 45% RH and 24° C. for 2 days. Each abrasive disc was used to grind the face of a 1.25 cm by 18 cm 1018 mild steel workpiece. The grinder used was a constant load hydraulic disc grinder. The constant load between the workpiece and the abrasive disc was provided by a load spring. The back-up pad for the grinder was an aluminum back-up pad, beveled at approximately 7 degrees, extending from the edge and in towards the center 3.5 cm. The disc was secured to the aluminum pad by a retaining nut and was driven at 5,500 rpm. The load between the back-up pad and disc and workpiece was about 5.9 kg. Each disc was used to grind a workpiece for 60-second intervals. At the end of each interval the workpiece was changed. The cut (the amount of metal removed) was measured after each 60 seconds of grinding. The end of the test was defined as when the cut was less than 40 grams in a 60-second interval. Unless otherwise noted, total cut is the cumulative amount of metal removed during the test. Total cut in grams (average of six discs) is reported.

Spin Welding Procedure

[0068] Spin welding trials were made according to the procedure of U.S. Pat. No. 5,931,729 (Penttila et al.) using a spin welding apparatus, obtained under the trade designation “PMA SPINWELD 90” from Powell, McGee Associates, Inc., Shoreview, Minn. Adjustable parameters for this apparatus include input air pressure in psi (kPa) and weld time in arbitrary units. Evaluation criteria for this procedure are reported in Table I (below).

TABLE I

RATING	DESCRIPTION	FAILURE MODE
Fail	Button never adheres	adhesive failure
P/F	Button adheres sometimes	adhesive failure
Marginal	Button adheres weakly to web	adhesive failure
Pass	Button adheres strongly to web	cohesive failure in fiber web

Examples 1-4 and Comparative Example A

[0069] Examples 1-4 and Comparative Example A illustrate the effects of composition and wet add-on of the various backsize compositions on the shape stability of resulting abrasive discs. Composition and wet add-on of the backsize for these examples are reported in Table II (below).

TABLE II

Example	AR1	SBR	PM1
1	35.6	0	0
2	21.6	0	0
3	0	24.5	0
4	0	0	38.9
Comparative Example A	0	0	0

[0070] Example 1 was prepared by applying via a 3-roll coater AR1 to one side of a 305 mm wide VF web. The backsize coating was allowed to dry for 3 minutes in an oven set at 85° C. to a dry weight of about 12.4 grams per square meter (gsm). The backsize treated web was wound into a roll and allowed to condition 7 to 10 days in a 50% RH

environment. An abrasive coating consisting of 184 gsm of a make coating (PM2), 552 gsm particle coating (AP), and 339 gsm of a size coating (PM3) was applied to the conditioned, backsize treated web and cured. Short pieces of cured abrasive web were wound into loose rolls and steamed for 1 hour at 65° C. 178 mm diameter discs with 22 mm center holes were cut from the moist webs using a punch press. The discs were then passed twice through a 3.8 cm (1.5-inch) bar flexor in orthogonal directions across the disc face. The flexed discs were stacked and banded between wooden flanges into a bale and then cured further for 24 hours at 100° C. The baled discs were finally allowed to condition for 10 days in a 45% RH, 24° C. environment.

[0071] Example 2 was prepared as in Example 1, except the weight of AR1 was 21.6 gsm (drying down to about 7.5 gsm).

[0072] Example 3 was prepared as in Example 1, except that SBR was applied to the vulcanized fiber web at a weight of 24.5 gsm (drying down to about 12.5 gsm).

[0073] Example 4 was prepared as in Example 1, except that PM1 was applied to the vulcanized fiber web at a weight of 38.9 gsm (drying down to about 20.8 gsm). The oven temperature was increased to 121° C.

[0074] Comparative Example A was a control example, prepared according to Example 1, but having no backsize applied to the vulcanized fiber web.

[0075] Examples 1-4 and Comparative Example A were evaluated for shape change according to Shape Measurement Procedure A. The results in mm are reported in Table III (below). A coated abrasive disc prepared according to Example I is shown in FIG. 5.

TABLE III

EXAMPLE	DELTA HEIGHT, mm
1	13.88
2	24.16
3	23.15
4	19.63
Comparative Example A	25.25

Examples 5-11 and Comparative Example B

[0076] Examples 5-11 and Comparative Example B illustrate the effects of composition and wet add-on of the various backsize compositions on the shape stability of resulting abrasive discs. Composition and wet add-on of the backsize for these examples are reported below.

[0077] Example 5 was prepared as in Example 4, except that PM2 was applied to the vulcanized fiber web at a weight of 105 gsm (drying down to about 86.3 gsm). The oven temperature was 121° C.

[0078] Example 6 was prepared as in Example 5, except that PM2 was applied to the vulcanized fiber web at a weight of 62.4 gsm (drying down to about 51.8 gsm).

[0079] Example 7 was prepared as in Example 5, except that PM2 was applied to the vulcanized fiber web at a weight of 20.8 gsm (drying down to about 17.3 gsm).

[0080] Example 8 was prepared as in Example 1, except the weight of AR1 was 62.3 gsm (drying down to about 21.8 gsm).

[0081] Example 9 was prepared as in Example 1, except the weight of AR1 was 37.4 gsm (drying down to about 13.1 gsm).

[0082] Example 10 was prepared as in Example 1, except the weight of AR1 was 18.5 gsm (drying down to about 6.5 gsm).

[0083] Example 11 was prepared as in Example 1, except that AR1 was applied to the same side of the vulcanized fiber web in three separate trips. The total add-on for the three trips was approximately 178 gsm (62.3 gsm dry). When abrasive discs were cut and flexed from this material, the backsize tended to flake off and no longer provided a uniform back side coating. These discs curled more severely than the untreated comparatives.

[0084] Comparative Example B was prepared according to Example 1, with the exception that no backsize was applied to the backing.

[0085] Examples 5-11 and Comparative Example B were evaluated for shape change according to Shape Measurement Procedure B.

[0086] Comparative Examples C and D were ANSI grade 50 abrasive vulcanized fiber discs, 7 inches (18 cm) in diameter with a 7/8-inch (2.2 cm) center hole, obtained from Marvel Abrasives, Chicago, Ill., under the trade designation "50 GRIT CG CERAMIC RESIN BOND FREE DISC") and Norton Company, Worcester, Mass., under the trade designation "50 GRIT F986 GREENLYTE PLUS", respectively. The shape results, in mm, are recorded in Table IV (below).

TABLE IV

EXAMPLE	20% RH, DELTA HEIGHT, mm	60% RH, DELTA HEIGHT, mm
5	3.17	-9.66
6	4.80	-3.80
7	3.97	-31.48
8	5.75	-5.53
9	3.45	1.95
10	1.39	-25.00
Comparative Example B	10.08	-17.76
Comparative Example C	6.55	-21.63
Comparative Example D	19.45	not measured

[0087] Abrasive discs of Example 10 and Comparative Examples B and C were evaluated using the Grinding Test. Test results are reported in Table V (below).

TABLE V

EXAMPLE	FINAL HUMIDITY CON-DITION, % RH	DISC	INITIAL CUT, g	FINAL CUT, g	TOTAL CUT, g	AVER-AGE TOTAL CUT, g
Comparative Example B	20	1	88.7	25.4	985.6	902.9
Comparative Example B	20	2	91.3	14.7	854.3	
Comparative Example B	20	3	88.2	18.1	868.8	
Example 10	20	1	91.0	26.9	1004.6	926.6
"	20	2	90.1	20.0	891.5	
"	20	3	93.1	14.1	883.8	
Comparative Example C	20	1	73.3	13.9	712.6	650.3

TABLE V-continued

EXAMPLE	FINAL HUMIDITY CON- DITION, % RH	DISC	INI- TIAL CUT, g	FINAL CUT, g	TOTAL CUT, g	AVER- AGE TOTAL CUT, g
Comparative Example C	20	2	72.0	15.5	588.0	
Comparative Example B	60	1	79.8	17.7	864.1	841.8
Comparative Example B	60	2	84.0	13.4	824.8	
Comparative Example B	60	3	81.7	16.3	875.5	
Comparative Example B	60	4	81.5	7.6	802.9	
Example 10	60	1	80.5	18.8	904.7	919.8
"	60	2	87.1	12.1	887.3	
"	60	3	87.1	23.9	982.4	
"	60	4	86.5	19.8	904.9	
Comparative Example C	60	1	67.1	8.1	473.8	494.1
Comparative Example C	60	2	67.3	3.5	492.1	
Comparative Example C	60	3	68.0	5.1	460.3	
Comparative Example C	60	4	65.5	18.3	550.3	

Examples 12-14 and Comparative Example E (Spin Welding)

[0088] Example 12 was prepared using a 51-mm diameter disc cut from the abrasive disc according to Example 1. A nylon button was applied to the web according to the Spin Welding Procedure with machine settings as shown in Table VII.

[0089] Example 13 was prepared and tested according to Example 12 with the exception that the abrasive disc was from Example 4.

[0090] Example 14 was prepared and tested according to Example 12 with the exception that the abrasive disc was from Example 5.

[0091] Comparative Example E was prepared and tested according to Example 12 with the exception that the abrasive disc was from Comparative Example A.

[0092] Results from the spin welding evaluation for Examples 12-14 and Comparative Example E are reported in Table VI (below).

TABLE VI

EXAMPLE	PRESSURE, psi (kPa)	WELD TIME (UNITS ON CONTROL PANEL)		
		50	70	90
12	60 (410)	Marginal	Pass	Pass
13	60 (410)	Pass	Pass	Pass
14	60 (410)	Pass	Pass	Pass
E	60 (410)	Fail	Fail	Fail

Example 15

[0093] Example 15 was prepared by applying via a 2-roll coater PM2 to one side of a 305 mm wide VF web. This

backsize coating was allowed to dry for 3 minutes in an oven set at 116° C. to a dry add-on weight of about 8.8 gsm. The backsize web was inverted and the coating and drying steps repeated to produce a presize treated (i.e., presized) and backsize treated (i.e., backsize) web. The presized and backsize web was wound into a roll and allowed to condition 7 to 10 days in a 50% RH environment. An abrasive coating consisting of 188 gsm of a make coating (PM2), 799 gsm particle coating (AP2), and 448 gsm of a size coating (PM3) was applied to the conditioned, backsize and presized web and cured. Short pieces of cured abrasive web were wound into loose rolls and steamed for 1 hour at 65° C. 178 mm diameter discs with 22 mm center holes were cut from the moist webs using a punch press. The discs were then passed twice through a 2.5 cm (1.0-inch) bar flexor in orthogonal directions across the disc face. The flexed discs were stacked and banded between wooden flanges into a bale and then cured further for 24 hours at 100° C. The baled discs were finally allowed to condition for 5 days at 70% RH, 24° C., and then 5 more days in a 45% RH, 24° C. environment.

Comparative Example F

[0094] Comparative Example F was prepared as Example 15 with the exception that both the backsize and presize coatings were omitted.

[0095] Example 15 and Comparative Example F were tested according to Shape Measurement Procedure C and Grinding Test 2. The results are reported in Table VII (below).

TABLE VII

	Height Change @ Humidity Condition			Total
	20% RH, HEIGHT, mm	45% RH, HEIGHT, mm	70% RH, HEIGHT, mm	Cut, grams
Example 15	5.12	1.40	29.65	1715.5
Comparative Example F	5.50	2.96	35.55	1511.8

Example 16

[0096] Example 16 was prepared identically to Example 4 with the additional step of applying a presize (PM1, 38.9 gsm wet add-on (20.8 gsm dry add-on)) to the front side of the VF web by the same procedure as described for the backsize application in Example 4.

[0097] Example 16 was tested according to Shape Measurement Procedure A. The Delta Height was 16.65 mm.

What is claimed is:

1. A coated abrasive article comprising a vulcanized fiber backing having first and second opposed major surfaces, an abrasive layer affixed to the first major surface, and a backsize affixed to the second major surface, wherein the backsize has a dry basis weight of from 8 to 90 grams per square meter of the coated abrasive article, and wherein the backsize comprises a reaction product of components selected from the group consisting of curable latex emulsions, phenolic resins, and combinations thereof.

2. A coated abrasive article according to claim 1, wherein a presize is affixed to the first major surface of the vulcanized fiber backing.

3. A coated abrasive article according to claim 2, wherein the presize comprises the same components as the backsize.

4. A coated abrasive article according to claim 1, wherein the abrasive article comprises an abrasive disc or an endless belt.

5. A coated abrasive article according to claim 1, wherein the backsize comprises a curable latex emulsion and has a dry basis weight of from 8 to 25 grams per square meter of the coated abrasive article.

6. A coated abrasive article according to claim 1, wherein the backsize comprises a phenolic resin and has a dry basis weight of from 15 to 90 grams per square meter of the coated abrasive article.

7. A coated abrasive article according to claim 1, wherein the vulcanized fiber backing has a thickness in a range of from 0.5 to 1.3 millimeters.

8. A coated abrasive article according to claim 1, wherein the abrasive layer comprises make and size layers.

9. A coated abrasive article according to claim 1, wherein the abrasive layer comprises a dispersion of abrasive particles in a binder.

10. A coated abrasive article according to claim 1, wherein the abrasive layer comprises a reaction product of components comprising at least one of a polyepoxide, a poly(meth)acrylate, urea-formaldehyde resin, melamine-formaldehyde resin, phenolic resin, or a combination thereof.

11. A coated abrasive article according to claim 1, wherein the abrasive article further comprises at least one of a presize, subsize, saturant, tie layer or supersize.

12. A coated abrasive article according to claim 1, wherein the abrasive article comprises a disc, and wherein the abrasive article further comprises a mechanical fastener welded to the backsize.

13. A method of abrading a surface of a workpiece, the method comprising:

providing a coated abrasive article according to claim 1, frictionally contacting the abrasive layer with a surface of the workpiece; and

moving at least one of the abrasive layer and the surface of the workpiece relative to the other to abrade at least a portion of the surface of the workpiece.

14. A method of making a coated abrasive article, the method comprising:

providing a vulcanized fiber backing having first and second opposed major surfaces;

coating a curable backsize precursor onto the second major surface of the vulcanized fiber backing, and curing the backsize precursor to provide a backsize, wherein the backsize has a dry basis weight of from 8 to 90 grams per square meter of the coated abrasive article, and wherein the backsize precursor comprises at least one material selected from the group consisting of curable latex emulsions, phenolic resins, and combinations thereof; and

affixing an abrasive layer to the first major surface of the vulcanized fiber backing.

15. A method of making a coated abrasive article according to claim 14, further comprising converting the coated abrasive article into an abrasive disc or an endless belt.

16. A method of making a coated abrasive article according to claim 14, wherein the backsize comprises a curable latex emulsion and has a dry basis weight of from 8 to 25 grams per square meter of the coated abrasive article

17. A method of making a coated abrasive article according to claim 14, wherein the backsize comprises a phenolic resin and has a dry basis weight of from 15 to 90 grams per square meter of the coated abrasive article.

18. A method of making a coated abrasive article according to claim 14, wherein the vulcanized fiber backing has a thickness in a range of from 0.5 to 1.3 millimeters.

19. A method of making a coated abrasive article according to claim 14, wherein the abrasive layer comprises make and size layers.

20. A method of making a coated abrasive article according to claim 19, further comprising applying a supersize to the size layer.

21. A method of making a coated abrasive article according to claim 14, wherein the abrasive layer comprises abrasive particles distributed in a binder.

22. A method of making a coated abrasive article according to claim 14, wherein the abrasive layer comprises a reaction product of components comprising at least one of a polyepoxide, a poly(meth)acrylate, urea-formaldehyde resin, melamine-formaldehyde resin, phenolic resin, or a combination thereof.

23. A method of making a coated abrasive article according to claim 14, further comprising welding a mechanical fastener to the backsize.

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