

ABRASIVE ARTICLES AND METHODS OF FORMING SAME

ABSTRACT

[0001] The present disclosure is directed to abrasive articles, and in particular, coated abrasive articles and methods of forming coated abrasive articles.

BACKGROUND

[0002] Abrasive articles, such as coated abrasives, are used in various industries to machine work pieces, such as by lapping, grinding, and polishing. Surface processing using abrasive articles spans a wide industrial scope from initial coarse material removal to high precision finishing and polishing of surfaces at a submicron level. There continues to be a demand for improved abrasive products and methods that can offer enhanced abrasive processing performance, efficiency, and improved surface quality.

DESCRIPTION

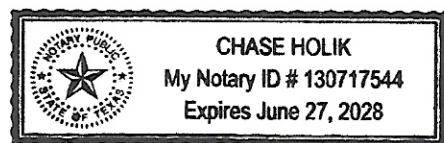
[0003] An abrasive article, according to an embodiment, can include fixed abrasive article including, for example, coated abrasive articles, nonwoven abrasive articles, engineered abrasive articles, or combinations thereof. Abrasive articles can be in the form of sheets, discs, belts, tapes, or wheels. A particular example may include flap wheels, flap discs, polishing films, narrow belts, file belts, and the like. A more particular example of the abrasive article may comprise a flap disc.

[0004] In an embodiment, the abrasive article can include a coated abrasive article including an abrasive layer disposed on a backing material (also called herein a “backing”). The abrasive layer can include a plurality of abrasive particles dispersed on or in a layer of polymeric binder composition (also called herein a “make coat”).

[0005] In a further embodiment, the coated abrasive article may include an abrasive layer disposed on a backing material and a layer of polymeric size coat composition (also called herein a “size coat”) disposed over the polymeric binder composition and abrasive particles. An optional layer of polymeric supersize coat composition can be disposed over the size coat composition.

[0006] The backing may be flexible or rigid. The backing may be made of any number of various materials including those conventionally used as backings in the manufacture of coated abrasives. An exemplary flexible backing can include a polymeric film (for example, a primed

Chase Holik
05/22/24



film), such as polyolefin film (e.g., polypropylene including biaxially oriented polypropylene), polyester film (e.g., polyethylene terephthalate), polyamide film, or cellulose ester film; metal foil; mesh; foam (e.g., natural sponge material or polyurethane foam); cloth (e.g., cloth made from fibers or yarns comprising polyester, nylon, silk, cotton, poly-cotton, rayon, or combinations thereof); paper; vulcanized paper; vulcanized rubber; vulcanized fiber; nonwoven materials; a combination thereof, or a treated version thereof. Cloth backings can be woven or stitch bonded. For example, the backing material may include plain weave, satin, twill, jersey, or the like, or any combination thereof. In particular examples, the backing can be selected from the group consisting of paper, polymer film, cloth (e.g., cotton, poly-cotton, rayon, polyester, poly-nylon), vulcanized rubber, vulcanized fiber, metal foil and a combination thereof. In other examples, the backing can include polypropylene film or polyethylene terephthalate (PET) film. In other embodiments, the backing may be a paper backing. The paper can be a single ply paper or a multi-ply paper, such as a laminate paper. The paper can be saturated or unsaturated.

[0007] The backing can optionally have at least one of a saturant, a presize layer (also called a “front fill layer”), or a backsize layer (also called a “back fill layer”). The purpose of these layers is typically to seal the backing or to protect yarn or fibers in the backing. If the backing is a cloth material, at least one of these layers is typically used. The addition of the presize layer or backsize layer can additionally result in a “smoother” surface on either the front or the back side of the backing. Other optional layers known in the art can also be used, such as a tie layer.

[0008] The backing can be a fibrous reinforced thermoplastic such as described, for example, in U.S. Pat. No. 5,417,726 (Stout et al.), or an endless spliceless belt, as described, for example, in U.S. Pat. No. 5,573,619 (Benedict et al.). Likewise, the backing can be a polymeric substrate having hooking stems projecting therefrom such as that described, for example, in U.S. Pat. No. 5,505,747 (Chesley et al.). Similarly, the backing can be a loop fabric such as that described, for example, in U.S. Pat. No. 5,565,011 (Follett et al.).

[0009] The backing may be treated to have certain surface finishing before a binder composition is disposed according to an example. For example, techniques, such as roughening, scratching, abrading, emerising, scraping, scrubbing, brushing, sanding, sueding, or the like, or any combination thereof may be utilized to treat the backing. One or more tools may be utilized to treat the backing. Exemplary tools may include coated abrasives, such as sandpaper; non-woven abrasives, such as sanding belts, hand pads, discs (e.g., coarse grit and medium grit discs), or the

like; abrasive rods (e.g., metal and plastic); wire brushes, e.g., a metallic brush, such as brass brush, stainless steel wire brush, carbon steel wire brush, or the like; plastic brushes, such as a nylon brush, abrasive rollers, e.g., emery-covered rollers; scraping blades; or the like; or any combination thereof. In a further example, contactless techniques may be utilized to facilitate formation of a particular surface finishing. For example, treating the backing may include the use of a high flux of air to create an aerofinishing. Other techniques known in the art to provide an aerofinishing may be utilized. It is to be appreciated any techniques noted herein may be used in combination to create a surface finishing of the backing that may facilitate improved property of the backing and/or improved performance of the coated abrasives.

[0010] In a further embodiment, the backing may be treated such that the treated surface may form a smooth pile to provide a soft, velvet-like touch. In another embodiment, treating the backing may include cutting and/or extracting fibers from the coating of the backing material, i.e., the front and/or back fill layer, modifying surface morphology and/or increasing specific surface area of the back and/or front surface of the backing. In a particular embodiment, the backing may be treated in a manner such that adverse effect on the construction of the backing and/or strength of the finished backing, e.g., tensile strength and tear strength is minimized.

[0011] In an embodiment, the backing to be treated may include a greige cloth or a backing having a saturant, a front and/or a back fill layer.

[0012] In a particular embodiment, the backing may be emerised utilizing any of the technologies noted herein, such as by using tools like abrasive rollers, wire brushes, non-woven abrasive discs or belts, and/or coated abrasives. Technologies otherwise known in the art may also be utilized to provide an emerised backing. It is surprisingly noted that different emerising processes, different tools, and/or process conditions can result in different surface morphologies that are believed to affect performance of abrasive articles.

[0013] In a particular embodiment, treating the backing can include improving morphology of the front surface of the backing. For example, the front surface may have improved roughness and/or specific surface area that may facilitate improved adhesion to the abrasive layer disposed thereon. As used herein, the front surface of the backing is in reference to the surface on which an abrasive layer is disposed. The back surface is opposite the front surface and faces away from the abrasive layer.

[0014] In still another embodiment, treating the backing may include increasing specific surface area, improving roughness, or both of the front surface of the backing. In a further embodiment, the treated backing may have improved adhesion to the abrasive layer disposed thereon.

[0015] In a particular implementation, a non-woven abrasive belt may be utilized to create suede finishing on the front surface of the backing. After reading this disclosure, a skilled artisan appreciates that parameters, such as backing speed, backing tension, abrasive belt rotation speed, and/or abrasive belt pressure on the backing, can be selected to facilitate improved specific surface area and/or roughness of the front surface.

[0016] The binder composition can be formed of a single polymer or a blend of polymers. For example, the binder composition can be formed including epoxy, acrylic polymer, a phenolic composition, a polyurethane composition, a urea formaldehyde composition, a melamine formaldehyde composition, a polysiloxane composition, or a combination thereof. In addition, the binder composition can include filler, such as nano-sized filler or a combination of nano-sized filler and micron-sized filler. In another embodiment, the binder composition can include a colloidal binder material or a colloidal suspension including filler that may be cured to form the binder. Alternatively, or in addition, the binder composition can include a nanocomposite binder material including sub-micron particulate filler. In a further example, the binder composition may optionally include additives as described herein.

[0017] The binder composition generally includes a polymer matrix, which binds abrasive particles to the backing or to a compliant coat, if such a compliant coat is present. Typically, the binder composition is formed of cured binder composition. In an embodiment, the binder composition includes a polymer component and a dispersed phase.

[0018] The binder composition can include one or more reaction constituents or polymer constituents for the preparation of a polymer. A polymer constituent can include a monomeric molecule, a polymeric molecule, or a combination thereof. The binder composition can further comprise components selected from the group consisting of solvents, plasticizers, chain transfer agents, catalysts, stabilizers, dispersants, curing agents, reaction mediators and agents for influencing the fluidity of the dispersion.

[0019] The polymer constituents can form thermoplastics or thermosets. By way of example, the polymer constituents can include monomers and resins for the formation of polyurethane, polyurea, polymerized epoxy, polyester, polyimide, polysiloxanes (silicones), polymerized alkyd,

styrene-butadiene rubber, acrylonitrile-butadiene rubber, polybutadiene, or, in general, reactive resins for the production of thermoset polymers. Another example includes an acrylate or a methacrylate polymer constituent. The precursor polymer constituents are typically curable organic material (i.e., a polymer monomer or material capable of polymerizing or crosslinking upon exposure to heat or other sources of energy, such as electron beam, ultraviolet light, visible light, etc., or with time upon the addition of a chemical catalyst, moisture, or other agent which cause the polymer to cure or polymerize). A precursor polymer constituent example includes a reactive constituent for the formation of an amino polymer or an aminoplast polymer, such as alkylated urea-formaldehyde polymer, melamine-formaldehyde polymer, and alkylated benzoguanamine-formaldehyde polymer; acrylate polymer including acrylate and methacrylate polymer, alkyl acrylate, acrylated epoxy, acrylated urethane, acrylated polyester, acrylated polyether, vinyl ether, acrylated oil, or acrylated silicone; alkyd polymer such as urethane alkyd polymer; polyester polymer; reactive urethane polymer; phenolic polymer such as resole and novolac polymer; phenolic/latex polymer; epoxy polymer such as bisphenol epoxy polymer; isocyanate; isocyanurate; polysiloxane polymer including alkylalkoxysilane polymer; or reactive vinyl polymer. The binder composition can include a monomer, an oligomer, a polymer, or a combination thereof. In a particular embodiment, the binder composition includes monomers of at least two types of polymers that when cured can crosslink.

[0020] In an embodiment, the binder composition can include epoxy constituents and acrylic constituents that when cured form an epoxy/acrylic hybrid polymer. Alternatively, the binder composition can comprise a butyl acrylate polymer. In an embodiment, the binder composition can comprise a cycloaliphatic epoxy resin, a di-acrylate resin, or a combination thereof. In a specific embodiment, the binder composition can comprise a hydrogenated diphenylolpropane (DPP) epoxy resin, an oxetane resin (4-member cyclic ether), a bisphenol A Epoxy Diacrylate resin (diacrylate ester of a bisphenol A epoxy resin), a propoxylated neopentyl glycol diacrylate resin, or combinations thereof.

[0021] Abrasive particles can include essentially single phase inorganic materials, such as alumina, silicon carbide, silica, ceria, and harder, high performance superabrasive grains such as cubic boron nitride and diamond. Additionally, the abrasive particles can include composite particulate materials. Such materials can include aggregates, which can be formed through slurry processing pathways that include removal of the liquid carrier through volatilization or

evaporation, leaving behind green aggregates, optionally followed by high temperature treatment (i.e., firing) to form usable, fired aggregates. Further, the abrasive layers can include engineered abrasives including macrostructures and particular three-dimensional structures.

[0022] The abrasive particles can be formed of any one of or a combination of abrasive grains, including silica, alumina (fused or sintered), zirconia, zirconia/alumina oxides, silicon carbide, garnet, diamond, cubic boron nitride, silicon nitride, ceria, titanium dioxide, titanium diboride, boron carbide, tin oxide, tungsten carbide, titanium carbide, iron oxide, chromia, flint, emery. For example, the abrasive particles can be selected from a group consisting of silica, alumina, zirconia, silicon carbide, silicon nitride, boron nitride, garnet, diamond, co-fused alumina zirconia, ceria, titanium diboride, boron carbide, flint, emery, alumina nitride, and a blend thereof. Particular embodiments have been created by use of dense abrasive particles comprised principally of alumina or diamond.

[0023] The abrasive particles can also have a particular shape. An example of such a shape includes a rod, a triangle, a pyramid, a cone, a solid sphere, a hollow sphere, or the like. Alternatively, the abrasive grain can be randomly shaped.

[0024] In an embodiment, the abrasive particles can be diamond particles (also referred to herein as “diamonds”), cubic boron nitride particles, or combinations thereof. In an embodiment, the abrasive particles comprise diamonds. The diamonds can be monocrystalline, polycrystalline, or a combination thereof. The diamonds can be natural diamonds, synthetic diamonds, metal coated diamonds, resin coated diamonds, or combinations thereof. The abrasive particles can be loose diamonds, diamond agglomerates, diamond aggregates, or a combination thereof.

[0025] In specific embodiments, superabrasive particles include cubic boron nitride and diamond particles. These superabrasive particles can be natural (e.g. natural diamond) or synthetic (e.g. cubic boron nitride and synthetic diamond) products. The superabrasive particles may have a blocky shape associated with them or alternatively, a needle-like shape. The superabrasive particles may be surface coated or not surface coated. In an embodiment, a blend of superabrasive particles and conventional abrasive particles (e.g. alumina, silicon carbide, ceria, and silica) can be used.

[0026] The abrasive particles can be in a beneficial size range, conform to a beneficial size distribution, or a combination thereof. In an embodiment, the abrasive particles can have an average particle size of not less than 1 micron, such as at least 2 microns, at least 3 microns, at

least 5 microns, at least 10 microns, at least 15 microns, at least 20 microns, or at least 25 microns. In an embodiment, the average particle size can be not greater than 2mm, such as not greater than 1.7mm, not greater than 1.7mm, not greater than 1.4mm, not greater than 1mm, not greater than 800 microns, not greater than 700 microns, not greater than 600 microns, not greater than 500 microns, not greater than 400 microns, not greater than 300 microns, not greater than 200 microns, not greater than 150 microns, or not greater than 125 microns. The average particle size can be within a range comprising any of the minimum and maximum values noted herein. In an embodiment, the abrasive particles can have an average particle size not less than 1 microns to not greater than 1.7mm, such as 5 microns to 800 microns.

[0027] As described above, a layer of polymeric size coat composition (a “size coat”) can be disposed over the polymeric binder composition and abrasive particles. The size coat composition can be the same as or different from the polymeric binder composition of the abrasive layer (i.e., the size coat composition can be the same as or different than the make coat composition). The size coat composition can include one or more fillers, additives, or a combination thereof.

[0028] The size coat composition can comprise an epoxy resin, an acrylic resin, an acrylate resin, an epoxy acrylate resin, or a combination thereof. In an embodiment, the size coat composition can comprise a reinforcing additive, such as amorphous silica. In a specific embodiment, the size coat composition can comprise a cycloaliphatic epoxy resin, an epoxide, a diepoxide, a butanediol, a triacrylate, a hexaacrylate, a cyclohexylcarboxylate, or a combination thereof. In a specific embodiment, the size coat composition can comprise a silica reinforced cycloaliphatic epoxy resin, an aliphatic epoxidized butanediol, trimethylolpropane triacrylate (TMPTA), dipentaerythritol hexaacrylate (DPHA), (3,4-epoxycyclohexane) methyl 3,4-epoxycyclohexylcarboxylate, or a combination thereof.

[0029] In a specific embodiment, the size coat composition can include 5 wt% to 45 wt% of a reinforcing filler, such 10 wt% to 35 wt% of a reinforcing filler.

[0030] As previously described, the coated abrasive article can optionally comprise a layer of supersize coat composition disposed on the size coat composition. The supersize coat composition can be the same as or different from the polymeric binder composition of the abrasive layer and can be same as or different than the size coat composition disposed thereon. In another aspect, the supersize coat composition may comprise an anti-loading agent (such as a

stearate, such as a metal stearate, such as zinc stearate or calcium stearate) or a grinding aid (such as cryolite, potassium borofluorate), or a combination thereof.

[0031] In a particular aspect, the front fill layer, the back fill layer, the binder composition, the size coat composition, or the supersize coat composition can include one or more additives. Additives can be available in any amount to provide the properties desired. For example, additives may be present in an amount of 0 wt% to 85 wt% of any polymer layer (i.e., make coat layer, size coat layer, or supersize layer). Suitable additives, for example, can include grinding aids, fibers, lubricants, fillers, wetting agents, thixotropic materials, surfactants, thickening agents, pigments, dyes, antistatic agents, coupling agents, plasticizers, suspending agents, pH modifiers, adhesion promoters, lubricants, bactericides, fungicides, flame retardants, degassing agents, anti-dusting agents, dual function materials, initiators, chain transfer agents, stabilizers, dispersants, reaction mediators, colorants, and defoamers. These optional additives can be present in any part of the overall system of the coated abrasive product according to embodiments of the present disclosure. Suitable filler materials can be inorganic based; such as halide salts, for example cryolite, wollastonite, and potassium fluoroborate; lime; calcium carbonate; pyrite; or the like; or organic based, such as sodium lauryl sulphate, or chlorinated waxes, such as polyvinyl chloride. In an embodiment, the filler material can be an environmentally sustainable material. The amounts of these additive materials can be selected to provide the properties desired. For example, a size coat may include 10 wt% to 80 wt% of one or more filler materials. In another example, the supersize coat may include 30 wt% to 85 wt% of one or more filler materials.

[0032] In a particular embodiment, the abrasive article may include a flap disc including a backing plate and a plurality of abrasive flaps disposed along the periphery of the backing plate. In an embodiment, the abrasive flaps can include any of the features described herein with respect to the coated abrasive article. In particular, the abrasive flaps can include an abrasive layer disposed on a backing material, a size coat, and optionally, , a supersize coat, , or any other number of compliant or intermediary layers known in the art of making an abrasive flap can be applied to construct an abrasive flap.

[0033] The backing plate may be rigid or wearable. In another example, the backing plate may be made of plastic, nylon, or other materials having some degree of flexibility. In still another example, the backing plate may be made of fiber glass, such as a resin-coated fiber glass mesh.

It can be appreciated that the backing plate may be made of any suitable materials utilizing the technologies known in the art.

[0034] Grinding tests are performed on carbon steel using flap disc samples. Sample S1 is available from Saint-Gobain Abrasives under the commercial designation of R996 P40 flap disc. Sample S2 is made having a different backing but otherwise the same as Sample S1. Samples S2 and S1 have the same backing material, but only the backing of Sample S2 has a suede finish on the front surface. The backing finish of Sample S2 was obtained by abrasion using a non-woven coarse-grit belt operated on a drum sander machine with the rotation speed of 1440 rpm, backing speed of 5 m/min, and backing tension at 1kN. Sample S2 demonstrates improved cut for the initial cutting time of 10 minutes and improved total material removal over Sample S1. Sample S2 further demonstrates improved peel strength over S1 at the interface between the backing and abrasive layer.

Key Words: Abrasives, coated abrasives, flap discs, abrasive rollers, abrasive discs, abrasive belts, flap wheels, polishing films, abrading, extracting, scratching, emerising, sueding, roughening