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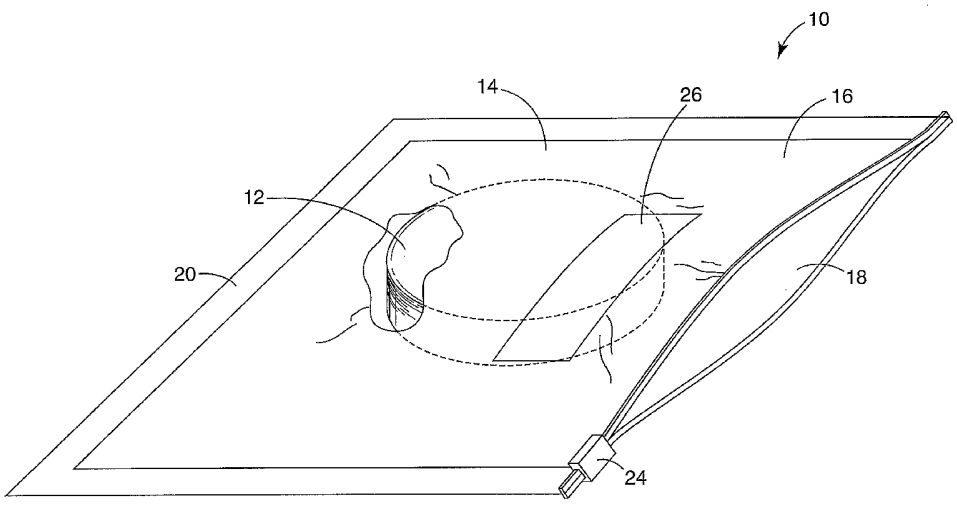
(54) Title: ABRASIVE ARTICLE PACKAGING AND METHOD OF MAKING SAME



(57) Abstract: A system for packaging abrasive articles having a flexible package comprising at least one sidewall defining an enclosed volume and at least one coated abrasive article positioned within the enclosed volume. The sidewall comprises a multilayer barrier composite having a water vapor transmission rate that is less than 0.5 grams per 645 square centimeters (100 square inches) per 24 hours.

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ABRASIVE ARTICLE PACKAGING AND METHOD OF MAKING SAME

BACKGROUND

[0001] Abrasive articles, such as fibre-backed abrasive discs, are generally manufactured with a substantially flat abrasive surface. During shipment and storage, changes in environmental conditions can cause the abrasive article, including its abrasive surface, to deform. For example, a change in humidity level has been observed to cause some abrasive articles to develop a twist or curl if left unrestrained. In some instances, the deformation becomes substantially permanent and negatively impacts the utility of the abrasive article.

[0002] Shrink wrap has been used to package a variety of abrasive articles to help reduce packaging costs and reduce exposure to environmental conditions. When shrink wrap is used, the abrasive articles to be packaged are typically enclosed in the shrink wrap. The enclosure is then subjected to an environment with an elevated temperature that causes the shrink wrap to shrink around the abrasive articles to produce a tight wrapping that closely conforms to the outer contour of the abrasive articles. Vents, such as a series of pinholes, are usually provided in the shrink wrap to allow the enclosed air to evacuate during the shrinking process. After wrapping, the vented shrink wrap allows air and moisture to transfer through the shrink wrap and subjects the packaged abrasive article to environmental fluctuations.

SUMMARY

[0003] The present invention provides a system for packaging abrasive articles. In one aspect, the present invention provides a system for packaging abrasive articles having a flexible package comprising at least one sidewall defining an enclosed volume. The sidewall comprise a multilayer barrier composite having an inner surface proximate the enclosed volume, an outer surface opposite the inner surface, and a water vapor

transmission rate that is less than 0.5 grams per 645 square centimeters (100 square inches) per 24 hours. At least one coated abrasive article is positioned within the enclosed volume. The coated abrasive article comprises a backing having a major surface and an abrasive layer proximate at least a portion of the major surface. The abrasive layer comprises a plurality of abrasive particles and at least one binder resin.

[0004] In some embodiments, the multilayer barrier composite comprises aluminum. In certain embodiments, the multilayer barrier composite comprises at least one of polyethylene, polypropylene, and nylon.

[0005] In some embodiments, the multilayer barrier composite has a water vapor transmission rate that is less than 0.1 grams per 645 square centimeters (100 square inches) per 24 hours. In other embodiments, the multilayer barrier composite has a water vapor transmission rate that is less than 0.01 grams per 645 square centimeters (100 square inches) per 24 hours.

[0006] In some embodiments, the system for packaging abrasive articles comprises a plurality of abrasive discs. The abrasive discs can comprise a backing comprising cellulose fibers and an abrasive layer comprising a phenolic resin and abrasive particles.

[0007] The present invention also provides methods for making a system for packaging abrasive articles according to the present invention.

[0008] Packaging systems of the present invention have been observed to be effective at reducing deformation caused by changing environmental conditions.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The drawing is a perspective view of a quantity of abrasive discs in an exemplary packaging system of the present invention.

DETAILED DESCRIPTION

[0010] As shown in the drawing, a quantity of abrasive discs 12 are in a flexible package 10. The flexible package 10 has a sidewall 14 with an outer surface 16, an inner surface 18, and a seal 20. Attached to the sidewall is reclosable zipper 24. The drawing also shows a label 26 affixed to the outer surface 16 of the flexible package. When the zipper is closed, flexible package 10 has an enclosed volume formed from sidewall 16. The abrasive discs 12 are positioned within the enclosed volume of the flexible package.

[0011] In the embodiment shown in the drawing, the stack of abrasive discs 12 are wrapped with shrink-wrap. The shrink-wrap provides a protective layer between the abrasive discs and the inner surface 18 of the sidewall 14. The protective layer reduces the potential for the abrasive discs to damage the sidewall of the flexible package. The shrink-wrap also provides additional protection from changing environmental conditions.

[0012] The packaging system of the present invention can be used to protect a variety of abrasive articles from environmental conditions, including for example, coated abrasive articles, nonwoven abrasive articles, and bonded abrasive articles.

[0013] Coated abrasives typically comprise a plurality of abrasive particles bonded to a backing in one or several layers. In some embodiments, the coated abrasive product comprises a flexible backing material having an abrasive layer thereon comprised of abrasive particles and a cured binder material. Coated abrasives can be made, for example, by applying a make coat of a binder precursor to the backing, applying abrasive particles to the make coat while it is sufficiently tacky to adhere to the abrasive particles and then coating the make coat containing the abrasive particles with a size coating. Thereafter, the coated abrasive material can be converted into various abrasive products by cutting the material into a desired shape. Coated abrasives are often utilized where the abrasive article needs to conform to the workpiece surface.

[0014] A variety of backing materials are useful in the manufacture of coated abrasive products. The selection of backing material is typically made based upon the intended use of the product. Suitable backings include those known in the art for making coated abrasive articles.

[0015] Typically, the backing has two opposed major surfaces. The thickness of the backing of the abrasive articles that can be packaged using the packaging system of the present invention generally ranges from about 0.02 to about 5 millimeters. In some coated abrasives, the backing thickness ranges from about 0.05 to about 2.5 millimeters. In other coated abrasives, the thickness of the backing ranges from about 0.1 to about 0.4 millimeter.

[0016] The backing may be flexible or rigid, and may be made of any number of various materials including those conventionally used as backings in the manufacture of coated abrasives. Examples include paper, fabric, film, polymeric foam, vulcanized fiber,

woven and nonwoven materials, combinations of two or more of these materials. The backing may also be a laminate of two materials (e.g., paper/film, cloth/paper, film/cloth).

[0017] Exemplary flexible backings include polymeric film (including primed films) such as polyolefin film (e.g., polypropylene including biaxially oriented polypropylene, polyester film, polyamide film, cellulose ester film), metal foil, mesh, foam (e.g., natural sponge material or polyurethane foam), cloth (e.g., cloth made from fibers or yams comprising polyester, nylon, silk, cotton, and/or rayon), paper, vulcanized paper, vulcanized fiber, nonwoven materials, and combinations thereof. Cloth backings may be woven or stitch bonded.

[0018] Examples of more rigid backings include metal plates, ceramic plates, and the like. The coated abrasive backings may also comprise two or more backings laminated together, as well as reinforcing fibers within a polymeric material.

[0019] The backing may be a treated backing having one or more treatments applied thereto such as, for example, a presize, a backsize, a subsize, and/or a saturant. A pressure sensitive adhesive can be laminated to the nonabrasive side of the backing. Likewise, a foam substrate can be laminated to the backing. A mechanical mounting system may also be affixed to the backing.

[0020] Typically, the make layer of a coated abrasive is prepared by coating at least a portion of the backing (treated or untreated) with a make layer precursor. Abrasive particles are then at least partially embedded (e.g., by electrostatic coating) to the make layer precursor comprising a first binder precursor, and the make layer precursor is at least partially cured.

[0021] Next, the size layer is prepared by coating at least a portion of the make layer and abrasive particles with a size layer precursor comprising a second binder precursor (which may be the same as, or different from, the first binder precursor), and at least partially curing the size layer precursor. In some coated abrasive articles, a supersize is applied to at least a portion of the size layer. If present, the supersize layer typically includes grinding aids and/or anti-loading materials.

[0022] Useful first and second binder precursors are well known in the abrasive art and include, for example, free-radically polymerizable monomer and/or oligomer, epoxy resins, phenolic resins, melamine-formaldehyde resins, aminoplast resins, cyanate resins, or combinations thereof.

[0023] Suitable abrasive particles for abrasive articles that can be packaged using the packaging system of the present invention can be any known abrasive particles or materials commonly used in abrasive articles. Examples of useful abrasive particles for coated abrasives include, for example, fused aluminum oxide, heat treated aluminum oxide, white fused aluminum oxide, black silicon carbide, green silicon carbide, titanium diboride, boron carbide, tungsten carbide, titanium carbide, diamond, cubic boron nitride, garnet, fused alumina zirconia, sol gel abrasive particles, silica, iron oxide, chromia, ceria, zirconia, titania, silicates, metal carbonates (such as calcium carbonate (e.g., chalk, calcite, marl, travertine, marble and limestone), calcium magnesium carbonate, sodium carbonate, magnesium carbonate), silica (e.g., quartz, glass beads, glass bubbles and glass fibers) silicates (e.g., talc, clays, (montmorillonite) feldspar, mica, calcium silicate, calcium metasilicate, sodium aluminosilicate, sodium silicate) metal sulfates (e.g., calcium sulfate, barium sulfate, sodium sulfate, aluminum sodium sulfate, aluminum sulfate), gypsum, aluminum trihydrate, graphite, metal oxides (e.g., tin oxide, calcium oxide), aluminum oxide, titanium dioxide) and metal sulfites (e.g., calcium sulfite), metal particles (e.g., tin, lead, copper), plastic abrasive particles formed from a thermoplastic material (e.g., polycarbonate, polyetherimide, polyester, polyethylene, polysulfone, polystyrene, acrylonitrile-butadiene-styrene block copolymer, polypropylene, acetal polymers, polyvinyl chloride, polyurethanes, nylon), plastic abrasive particles formed from crosslinked polymers (e.g., phenolic resins, aminoplast resins, urethane resins, epoxy resins, melamine-formaldehyde, acrylate resins, acrylated isocyanurate resins, urea-formaldehyde resins, isocyanurate resins, acrylated urethane resins, acrylated epoxy resins), and combinations thereof. The abrasive particles may also be agglomerates or composites that include additional components, such as, for example, a binder. Criteria used in selecting abrasive particles used for a particular abrading application typically include: abrading life, rate of cut, substrate surface finish, grinding efficiency, and product cost.

[0024] In another exemplary embodiment of a coated abrasive article that can be packaged using the packaging system of the present invention, the abrasive layer is made by coating a slurry comprising abrasive particles dispersed in a binder precursor onto a major surface of the backing, and then at least partially curing the binder precursor. Suitable binder precursors and abrasive particles include, for example, free-radically

polymerizable monomer and/or oligomer, epoxy resins, phenolic resins, melamine-formaldehyde resins, aminoplast resins, cyanate resins, or combinations thereof.

[0025] Coated abrasives can further comprise optional additives, such as, abrasive particle surface modification additives, coupling agents, plasticizers, fillers, expanding agents, fibers, antistatic agents, initiators, suspending agents, photosensitizers, lubricants, wetting agents, surfactants, pigments, dyes, UV stabilizers, and suspending agents. The amounts of these materials are selected to provide the properties desired. Additives may also be incorporated into the binder, applied as a separate coating, held within the pores of the agglomerate, or combinations of the above.

[0026] Coated abrasive articles may be converted, for example, into belts, rolls, discs (including perforated discs), and/or sheets. For belt applications, two free ends of the abrasive sheet may be joined together using known methods to form a spliced belt.

[0027] One form of a coated abrasive useful in metalworking is a fibre disc. Fibre discs have an abrasive layer affixed to a vulcanized fibre backing and are often used for the maintenance and repair of automotive bodies. The discs can be configured for use with a variety of tools, including, for example, electric or air grinders. The fibre discs typically have a hole in their center for attachment to the tool. Fibre discs are available from 3M Company, St. Paul, Minnesota, and marketed under various trade designations, including, for example, "3M REGALITE GRINDING DISCS 785C"; "3M TYPE C DISCS 381C"; and "3M TYPE C FIBRE DISC 281C".

[0028] An exemplary fibre disc suitable for packaging with the system of the present invention comprises a durable backing made from cellulose fibers. The durable backing is coated on one side with an abrasive layer comprising a phenolic resin make coat and abrasive particles.

[0029] In some embodiments, the backing of the fibre disk suitable for packaging with the system of the present invention has a basis weight of at least about 200 grams per square meter. In other embodiments, the backing of the fibre disk has a basis weight of at least about 500 grams per square meter. In yet further embodiments, the backing of the fibre disk has a basis weight of at least about 900 grams per square meter. In some embodiments, the backing of the fibre disk has a basis weight of less than about 2000 grams per square meter. In other embodiments, the backing of the fibre disk has a basis weight of less than about 1500 grams per square meter. In yet further embodiments, the

backing of the fibre disk has a basis weight of less than about 1300 grams per square meter.

[0030] In addition to disc shapes, coated abrasive articles can be configured in other ways, including, for example, sheets, rolls, belts, flap discs, and flap wheels. Coated abrasive sheets are available from 3M Company, St. Paul, Minnesota, and marketed under various trade designations, including, for example, "3M BLUE GRIT UTILITY CLOTH SHEETS"; "3M PRODUCTION PAPER SHEETS"; "3M TRI-M-ITE FRE-CUT PAPER SHEETS"; and "3M WETORDRY ABRASIVE SHEETS". Coated abrasive rolls are available from 3M Company, St. Paul, Minnesota, and marketed under various trade designations, including, for example, "3M BLUE GRIT UTILITY CLOTH ROLLS"; and "3M™ THREE-M-ITE ELEK-TRO-CUT CLOTH UTILITY ROLLS". Coated abrasive belts are also available from 3M Company, St. Paul, Minnesota, and marketed under various trade designations, including, for example, "3M PUMP SLEEVE 200D"; "3M REGALITE BELTS"; and "3M THREE-M-ITE CLOTH BELTS".

[0031] The packaging system of the present invention can be used to protect a single abrasive article or a plurality of abrasive articles. For example, a large belt may be packaged independently. Alternatively, a plurality of fibre discs or abrasive sheets may be packaged together.

[0032] In certain embodiments for packaging abrasive discs, such as, for example, fibre discs, the abrasive discs are stacked such that the outer edge of each abrasive disc is aligned with the outer edges of the other abrasive discs in the stack. In some embodiments, each of the abrasive discs in the stack faces the same direction (i.e., the abrasive side of one abrasive disc is proximate the back surface of an adjacent abrasive disc). In other embodiments, at least one of the abrasive discs may face the opposite direction of the other abrasive discs in the stack. The adjacent abrasive discs facing opposite directions may be positioned with their back surfaces proximate one another. Alternatively, the adjacent abrasive discs facing opposite directions may be positioned with their abrasive surfaces proximate one another.

[0033] In certain embodiments, approximately 50 percent of the abrasive discs face a first direction and the remaining abrasive discs face an opposite direction. The abrasive discs facing the first direction can be positioned proximate one another such that there is

one group of abrasive discs facing a first direction and a second group of abrasive discs facing an opposite direction. This configuration is referred to as a divided stack.

[0034] Alternatively, the abrasive discs facing the first direction can be commingled with the abrasive discs facing the opposite direction. For example, every other abrasive disc in a stack can face the opposite direction of the remaining abrasive discs. In other embodiments, every other group of abrasive discs (e.g., five consecutive abrasive discs) can face the opposite direction of the adjacent two groups of abrasive discs.

[0035] Other substantially planar abrasive articles, such as, for example, abrasive sheets, can also be stacked in a similar manner to the abrasive discs described above. Varying the direction of abrasive articles within a stack may facilitate stacking and reduce disc curl caused by changes in environmental conditions. Although not wanting to be bound by any particular theory, it is believed that varying the direction of abrasive articles within a stack reduces disc curl by having forces associated with the environmentally-induced disc curl of one abrasive disc opposed by the substantially equal, but opposite, forces of an abrasive disc facing the opposite direction.

[0036] In other embodiments, the abrasive articles within the packaging system of the present invention are not stacked. The abrasive articles can be positioned proximate one another, for example, in a random or patterned arrangement. In other embodiments, such as, for example, abrasive belts, the abrasive articles are placed within one another prior to packaging.

[0037] The sidewall for the system for packaging abrasive articles of the present invention comprises a multilayer barrier composite having a water vapor transmission rate that is less than 0.5 gram per 645 square centimeters (100 square inches) per 24 hours.

[0038] The term multilayer barrier composite refers to any combination of metal, plastic, or cellulosic layers (e.g., foils, films, and paper). The combination of metal, plastic, or cellulosic layers can include multiple layers of different materials, such as, for example, a metal combined with a plastic layer. The combination of metal, plastic, or cellulosic layers can also include multiple layers of similar materials, such as, for example, two layers of plastic.

[0039] The layers can be combined substantially permanently using any processes known in the art, including, for example, coating, laminating, coextrusion, and deposition. Alternatively, the substrates can be temporarily combined by overlying one substrate over

another. For example, an abrasive article can be wrapped with a polyethylene film and then wrapped in aluminum foil. In another embodiment, two plastic substrates can be combined for example, by wrapping an abrasive article with a first polyethylene film and then wrapping the wrapped abrasive article with a second polyethylene film. The first and second wraps of polyethylene film can be the same or be different from one another.

[0040] The term "water vapor transmission rate" refers to the rate of water vapor transmission through the multilayer barrier composite as measured using the test described in ASTM F1249-01, (Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor, Published December 2001), incorporated herein by reference. The water vapor transmission rate for the multilayer barrier composite is determined using the composite structure. For example, if the sidewall comprises a film and a foil combined by overlying one another, the water vapor transmission rate would be determined by measuring the rate of vapor transmission through the combination of the film and foil. Likewise, the water vapor transmission rate of an abrasive article wrapped in three layers of shrink wrap would be determined by measuring the rate of vapor transmission through the combination of the three shrink wrap films.

[0041] Multilayer barrier composites useful in the packaging system of the present invention include multilayer barrier films with multiple layers that are affixed to one another, for example, by coating, laminating, coextrusion, or deposition. Multilayer barrier films useful in the packaging system of the present invention can comprise layers of low-density polyethylene, high-density polyethylene, polypropylene, polyester, and nylon. In some embodiments, a multilayer barrier film having a layer of metal, such as, for example, aluminum is used. Multilayer barrier films are known and appropriate films and processes for manufacturing multilayer barrier films useful in the packaging system of the present invention are described in the Wiley Encyclopedia of Packaging Technology 2nd ed., *Multilayer Flexible Packaging*, ed. Dunn, Thomas J., 659-665, New York: Wiley, 1997, which pages are incorporated by reference.

[0042] In some embodiments, the sidewall comprises a multilayer barrier film having a layer of nylon adhesively affixed to a layer of aluminum, which is adhesively affixed to a layer of polyester film, which is adhesively affixed to a layer of polyethylene film. The

polyethylene layer of the sidewall is located at the inner surface of the sidewall and the nylon layer is located at the outer surface of the sidewall.

[0043] In other embodiments, the sidewall comprises a multilayer barrier film having a layer of nylon affixed to a layer of polyethylene film, which is affixed to a layer of aluminum, which is affixed to a layer of polyethylene film. The polyethylene layer of the sidewall is located at the inner surface of the sidewall and the nylon layer is located at the outer surface of the sidewall.

[0044] In some embodiments, the sidewall comprises a multilayer barrier film having a heat sealable material at the inner surface of the sidewall. The heat sealable material can be used to convert the multilayer barrier film into a flexible package using commercially available sealing equipments such as, for example, a model "RTP1" sealer available from Packrite Division of Mettler-Toledo, Inc. Racine, Wisconsin.

[0045] In certain embodiments, the flexible package of the present invention comprises a reclosable seal such as shown in the drawing. The reclosable seal can be a mechanical zipper, an adhesive strip, a string or wire tie, or other reclosable seals known in the art. In other embodiments, the abrasive article is sealed within the flexible package such that the sidewall must be breached to remove the abrasive article. In yet further embodiments, the flexible package of the present invention includes a sealed sidewall that must be breached and a reclosable seal.

[0046] Multilayer barrier composites useful in the packaging system of the present invention also include multiple layers of films, metals, or cellulosic substrates that are not affixed to one another. For example, in some embodiments, the multilayer barrier composite can comprise multiple layers of shrink wrap films, such as, for example, linear low-density polyethylene (LLDPE) shrink-wrap film available from Bemis Clysar, Oshkosh, Wisconsin, and marketed under the trade designation "CLYSAR ABL". Shrink wrapping is well known and appropriate films and processes for shrink wrapping are described in the Wiley Encyclopedia of Packaging Technology 2nd ed., *Films, Shrink*, ed. Jolley, Charles R., and George D. Wofford, 431-34, New York: Wiley, 1997, which pages are hereby incorporated by reference herein.

[0047] Heat shrinkable material useful for the packaging system of the present invention may comprise any of the uniaxially or biaxially oriented polymeric films that upon application of heat are shrunk to a decreased surface area. Suitable films include, for

example, oriented polyolefinic films such as polyethylene, polypropylene, polyisopropylethylene, polyisobutylethylene, and copolymers thereof. Other films that may be useful are polyvinyl chloride, polyethylene terepthalate, polyethylene-2,6-napthalate, polyhexamethylene adipamide, as well as polymers of alpha mono-olefinically unsaturated hydrocarbons having polymer producing unsaturation such as butene, vinyl acetate, methylacrylate, 2-ethyl hexyl acrylate, isoprene, butadiene acrylamide, ethylacrylate, N-methyl-n-vinyl acetamide, and the like. In certain embodiments, polyolefin, preferably biaxially oriented polyethylene, is used.

[0048] In some embodiments, the abrasive articles are wrapped in a single layer of shrink wrap and then placed in flexible package. If the shrink wrap covers a substantial portion of the abrasive article, the shrink wrap can function as a layer of a multilayer composite that forms the sidewall of the flexible package. The shrink wrap can also serve as a protective layer to help reduce the likelihood of the abrasive article positioned within the enclosed volume of the flexible package from damaging the flexible package. For example, if a multilayer barrier film with an aluminum layer is used as the sidewall, shrink wrap over the abrasive article can reduce the potential for the abrasive article to damage the sidewall and potentially puncture the aluminum layer.

[0049] The protective layer can also be made from other materials, such as, for example, paper, cardboard, foam, or plastic. In some embodiments, the protective layer is positioned proximate the abrasive surface and/or back surface of the abrasive article and does not fully cover the abrasive article. For example, a protective layer comprising a sheet of cardboard may be placed on the top and bottom of a stack of abrasive discs prior to placement in the flexible package. In other embodiments, a protective layer can be placed around the side of a stack of abrasive discs.

[0050] In certain embodiments, a humidity control packet can be included along with the abrasive article in the flexible package. A disposable two-way humidity control packet useful in the present invention is available from Humidipak, Inc., Minneapolis, Minnesota, under the trade designation "HUMIDIPAK."

[0051] Advantages and other embodiments of this invention are further illustrated by the following examples, but the particular materials and amounts thereof recited in this example, as well as other conditions and details, should not be construed to unduly limit this invention. For example, the type of abrasive article wrapped and the particular

packaging geometries used to create the inner and outer wrappers and their vents can vary. All parts and percentages are by weight unless otherwise indicated.

EXAMPLES

Example 1

[0052] A roll of 0.9 meter (36 inches) wide x 32 micrometers (0.00125 inch) thick linear low-density polyethylene (LLDPE) shrink-wrap film available from Bemis Clysar, Oshkosh, Wisconsin, and marketed under the trade designation "CLYSAR ABL" was folded widthwise to present a top and bottom layer of film that was 0.46 meter (18 inches) wide. As the folded film entered the packaging apparatus, the two layers were separated to allow a 6.4 millimeters (0.25 inch) vent opening to be punched in the top layer at about the center of the 0.46 meter dimension of the film and every 30.5 centimeters (12 inches) along the length of the top layer.

[0053] Two adjacent open edges of the folded sheet were then sealed using a model "A-26 Automatic" L-sealer available from Shanklin Corporation, Ayer, Massachusetts. The L-sealer was set at 193 °C (380 °F) and actuated to 551.6 kPa (80 psi) pressure for 0.7 second to create an open-ended pouch. A stack of twenty-five 17.8 centimeters (7 inches) diameter abrasive discs marketed under the trade designation "281C FIBRE DISCS", available from 3M Company, St. Paul, Minnesota, was inserted into the open-ended pouch. Within the stack, the top 12 fibre discs were oriented with their abrasive side up and the bottom 13 fibre discs were oriented with their abrasive side down. The open end of the pouch was then sealed using the L-sealer set at 193°C (380°F) and actuated at 551.6 kPa (80 psi) pressure for 0.7 second. The sealed pouch containing the stack of abrasive discs was then transported through a 1.12 meter (44 inches) model "853" tunnel oven available from Clamco Corporation, Cleveland, Ohio. The oven was set at 160 °C (320 °F) and operated at a speed of 7.3 meters/minute (24 feet/minute). The resulting shrink-wrapped stack of abrasive discs was then wrapped a second time with an outer wrapper using the identical sealing, wrapping, and shrinking technique just described, except that the vent for the second wrapping procedure was purposefully disposed in the bottom layer rather than the top layer such that the vent of the first wrapper and the second wrapper were on opposite sides of the stack.

[0054] Following the application of the outer wrapper, the twice wrapped stack of abrasive discs was inserted into a foil pouch constructed from a 94 micrometer (0.0037 inch) barrier film available from Flexicon, Inc., Carey, Illinois, and marketed under the trade designation "FLEXI S-10348". The pouch was then sealed using a model "RTP1" sealer available from Packrite Division of Mettler-Toledo, Inc. Racine, Wisconsin.

Example 2

[0055] Example 2 was prepared as described for Example 1, except that the twice wrapped stack of abrasive discs was not inserted into a foil pouch.

Comparative Example A

[0056] Comparative Example A was prepared as described for Example 1, except the wrapping process was terminated before the second layer of shrink wrap was applied. Comparative Example A had a single layer of shrink wrap and a foil pouch was not used.

[0057] The resulting packages were tested for their response to changes in environmental conditions.

[0058] The wrapped abrasive disc packages from each of the examples were preweighed and placed in an environmental test chamber "Model SM-32C" available from Thermotron, Holland, Michigan. Each of the examples was exposed to a sequential series of seven sets of environmental conditions as shown in Table 1, below.

[0059] Table 1

	Temperature, °C	Percent Relative Humidity	Time, hours
First Condition	-23	10	65
Second Condition	10	42	48
Third Condition	25	55	48
Fourth Condition	40	80	72
Fifth Condition	25	55	48
Sixth Condition	10	42	48
Seventh Condition	-23	10	72

[0060] After each step in the series of conditions, each wrapped abrasive disc package was again weighed and the change in weight recorded. After weighing the wrapped

abrasive disc packages following the final step of the series of conditions, the weight changes for each example was summed and recorded as indicated in Table 1.

[0061] Table 1

Example	Total weight change, grams
1	1.7
2	8.5
Comparative A	22.7

Examples 3-7

[0062] Twenty-five 17.8 centimeters (7 inches) diameter abrasive discs marketed under the trade designation "281C FIBRE DISCS", available from 3M Company, St. Paul, Minnesota, were placed in a stack. The height of the stack was then measured. The stacks for each of Examples 3-7 were then placed in packages of various constructions having varying water vapor transmission rates (WVTR). The package for each of the examples comprised a 32 micrometers (0.00125 inch) thick linear low-density polyethylene (LLDPE) shrink-wrap film available from Bemis Clysar, Oshkosh, Wisconsin, and marketed under the trade designation "CLYSAR ABL" having a reported water vapor transmission rate of 1 gram per 100 square inches per 24 hours as measured using ASTM F1249-01, (Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor, Published December 2001).

[0063] Examples 3-7 were each wrapped using the equipment and process described in Example 1, except all 25 discs were stacked facing the same direction and the number of shrink wrap layers was varied. Example 3 had two layers of shrink wrap. Example 4 had three layers of shrink wrap. Example 5 had 4 layers of shrink wrap. Example 6 had 10 layers of shrink wrap. Example 7 had two layers of shrink wrap and was also sealed in a foil bag having a reported water vapor transmission rate of less than 0.0004 gram per 100 square inches per 24 hours as measured using ASTM F1249-01, (Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor, Published December 2001). The foil bag used for Example 7 is available from Cadillac Products Packaging Company, Troy, Michigan, and is marketed under the trade designation "CADPAK N".

[0064] Water vapor transmission rates for multiple layers were calculated as resistance in series as described in the Handbook of Package Engineering, 3rd ed., Hanlon, Joseph F., Robert J. Kelsey, and Hallie E. Forcinio, 106-107, Lancaster, PA: Technomic, 1998.

[0065] The packaged stacks for examples 3-7 were then placed in an environmental chamber that was maintained at 49°C (120°F) at a relative humidity that was between 11.1 and 13.2%. After 279 hours, the packaged stacks were removed from the environmental chamber, the stacks were removed from their packages, and the stack height was measured. The percent change in stack height is shown in Table 2, below.

[0066] Table 2

Example	Package	WVTR, grams/100 in^2/24 hr	% Change in Stack Height
3	2 layers shrink wrap	0.5	20
4	3 layers shrink wrap	0.33	6
5	4 layers shrink wrap	0.25	8
6	10 layers shrink wrap	0.1	4
7	Foil package with double shrink wrapped discs	<0.0004	3

[0067] It is to be understood that even in the numerous characteristics and advantages of the present invention set forth in above description and examples, together with details of the structure and function of the invention, the disclosure is illustrative only. Changes can be made to detail, especially in matters of shape, size and arrangement of the abrasive article packaging and methods of making within the principles of the invention to the full extent indicated by the meaning of the terms in which the appended claims are expressed and the equivalents of those structures and methods.

WHAT IS CLAIMED IS:

1. A system for packaging at least one abrasive article comprising:

a flexible package comprising at least one sidewall defining an enclosed volume, said sidewall comprising a multilayer barrier composite having an inner surface proximate said enclosed volume, an outer surface opposite said inner surface, and a water vapor transmission rate that is less than 0.5 grams per 645 square centimeters (100 square inches) per 24 hours; and

at least one coated abrasive article positioned within said enclosed volume, said coated abrasive article comprising a backing having a major surface and an abrasive layer proximate at least a portion of said major surface, said abrasive layer comprising a plurality of abrasive particles and at least one binder resin.

2. The system of claim 1 wherein said multilayer barrier composite comprises aluminum.

3. The system of claim 1 wherein said multilayer barrier composite comprises at least one of polyethylene, polypropylene, and nylon.

4. The system of claim 2 wherein said multilayer barrier composite comprises at least one of polyethylene, polypropylene, and nylon.

5. The system of claim 1 wherein said multilayer barrier composite has a water vapor transmission rate that is less than 0.1 grams per 645 square centimeters (100 square inches) per 24 hours.

6. The system of claim 1 wherein said multilayer barrier composite has a water vapor transmission rate that is less than 0.01 grams per 645 square centimeters (100 square inches) per 24 hours.

7. The system of claim 1 wherein said at least one abrasive article comprises at least one of an abrasive belt, an abrasive sheet, or an abrasive disc.

8. The system of claim 1 wherein said at least one abrasive article comprises a plurality of abrasive discs.

9. The system of claim 8 wherein said plurality of abrasive discs comprise:
a backing comprising cellulose fibers, and
an abrasive layer comprising a phenolic resin and abrasive particles.

10. The system of claim 9 wherein said plurality of abrasive discs comprises a first quantity of abrasive discs facing a first direction, and a second quantity of discs facing a second direction, wherein said first direction is opposite said second direction.

11. The system of claim 1 further comprising a protective layer positioned between at least a portion of said at least one coated abrasive article and said inner surface of said sidewall.

12. The system of claim 11 wherein said protective layer comprises at least one of paper, cardboard, foam, or plastic.

13. The system of claim 12 wherein said protective layer comprises a shrink wrap film covering at least a portion of said at least one coated abrasive article.

14. The system of claim 1 wherein said flexible package comprises a reclosable seal.

15. The system of claim 1 further comprising a humidity control packet positioned within said enclosed volume.

16. A method for packaging at least one abrasive article comprising:
providing a flexible package comprising at least one sidewall defining an enclosed volume, said sidewall comprising a multilayer barrier composite having an inner surface

proximate said enclosed volume, an outer surface opposite said inner surface, and a water vapor transmission rate that is less than 0.5 grams per 645 square centimeters (100 square inches) per 24 hours; and;

sealing said at least one abrasive article within said enclosed volume of said flexible package.

17. The method of claim 16 wherein said multilayer barrier composite comprises aluminum.

18. The method of claim 16 wherein said multilayer barrier composite comprises at least one of polyethylene, polypropylene, and nylon.

19. The method of claim 17 wherein said multilayer barrier composite comprises at least one of polyethylene, polypropylene, and nylon.

20. The method of claim 16 wherein said multilayer barrier composite has a water vapor transmission rate that is less than 0.1 grams per 645 square centimeters (100 square inches) per 24 hours.

21. The method of claim 16 wherein said multilayer barrier composite has a water vapor transmission rate that is less than 0.01 grams per 645 square centimeters (100 square inches) per 24 hours.

22. The method of claim 16 wherein said at least one abrasive article comprises a plurality of abrasive discs.

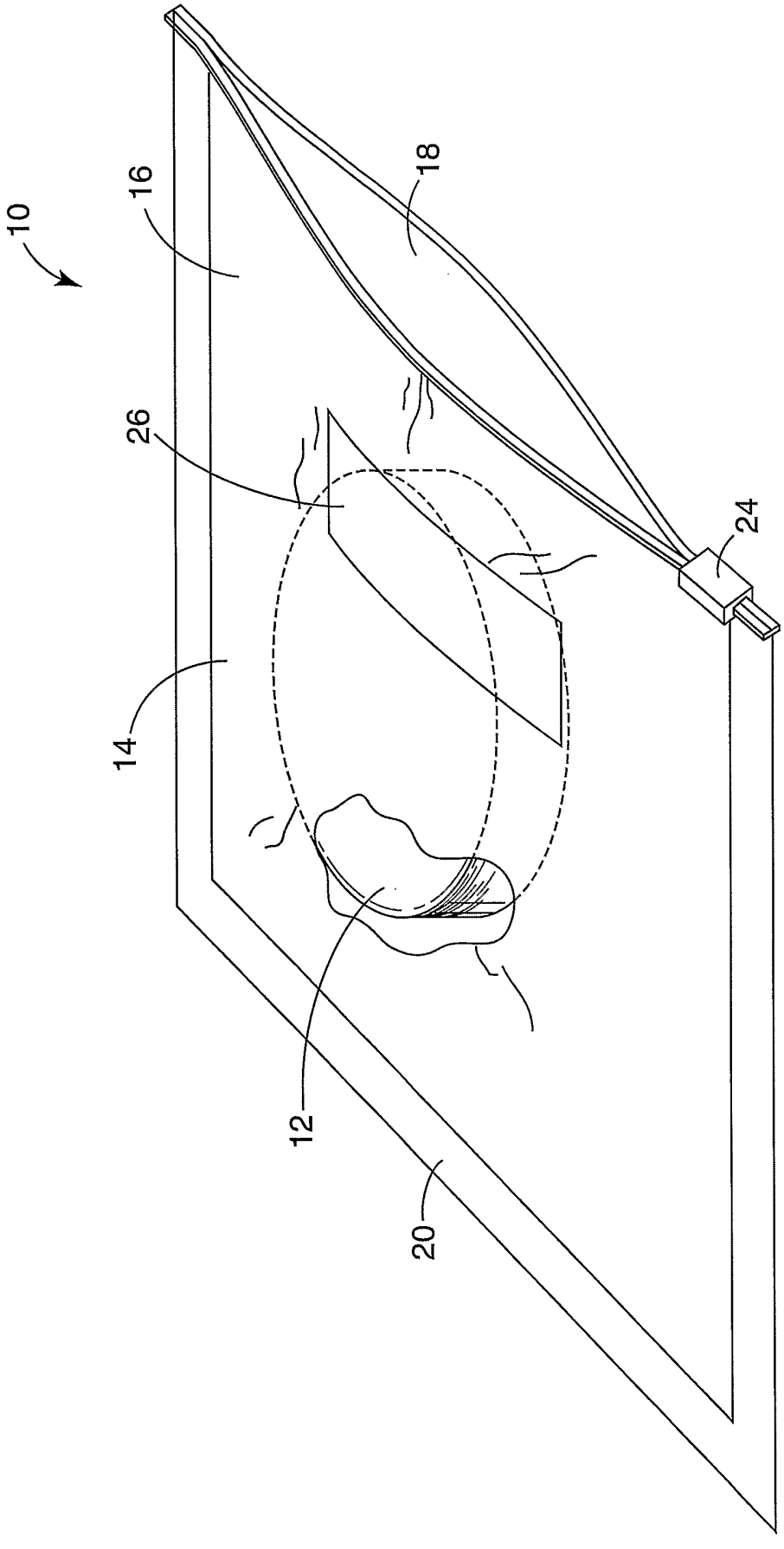
23. The method of claim 16 wherein said plurality of abrasive discs comprise:

a backing comprising cellulose fibers, and

an abrasive layer comprising a phenolic resin and abrasive particles.

24. The method of claim 16 further comprising placing a protective layer between at least a portion of said coated abrasive article and said inner surface of said sidewall.

25. The method of claim 16 further comprising covering at least a portion of said at least one coated abrasive article with a protective layer comprising shrink wrap film comprising at least one of polyethylene, polypropylene, and copolymers thereof.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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/016645

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65D30/08 B65D65/40

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65D

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 139 878 A (KIM ET AL) 18 August 1992 (1992-08-18) column 8, lines 47-50 - column 12, lines 30-40; claim 5	1-6, 11-14, 16-21, 24,25
X	US 4 190 477 A (OSSIAN, WILLIAM F ET AL) 26 February 1980 (1980-02-26) column 2, line 17 - column 3, line 31; claim 1	1-6, 11-14, 16-21, 24,25

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 August 2005	02. 11. 2005

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

Internat[redacted] Application No
PCT/US2005/016645

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/172435 A1 (COLOMBO FRANK J ET AL) 21 November 2002 (2002-11-21) paragraphs [0047] - [0054]; claims 13,14,16	1-6, 11-14, 16-21, 24,25
X	US 5 888 648 A (DONOVAN ET AL) 30 March 1999 (1999-03-30) column 12, lines 5-25; claim 2	1-6, 11-14, 16-21, 24,25
X	US 5 874 035 A (TSAI ET AL) 23 February 1999 (1999-02-23) column 7, line 25 - column 8, line 55	1,3-6, 11-14, 16, 18-21, 24,25

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2005/016645

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

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

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

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

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

see additional sheet

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

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

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

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

1-6,11-14,16-21,24,25

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/ US2005/ 016645

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 11-14, 16-21, 24, 25

   multilayer barrier composite structure
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2. claims: 7-10 and 22, 23

   abrasive article
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3. claim: 15

   humidity control packet

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat[redacted] Application No
PCT/US2005/016645

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