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(54) MULTI-PIECE SOLID GOLF BALL

(76) Inventors: **Takashi Sasaki**, Kobe-shi (JP); **Keiji Moriyama**, Kobe-shi (JP)

Correspondence Address:
BIRCH STEWART KOLASCH & BIRCH
PO BOX 747
FALLS CHURCH, VA 22040-0747 (US)

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(57) **ABSTRACT**

The present invention provides a multi-piece solid golf ball, which is superior in flight distance, shot feel and controllability. The present invention relates to a multi-piece solid golf ball comprising a core consisting of a center and an intermediate layer formed on the center, and a cover covering the core, wherein

the center has a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.7 to 4.5 mm,

the intermediate layer has a thickness of 0.5 to 2.0 mm and a hardness in Shore D hardness of 65 to 85, and

the cover has a thickness of 0.3 to 1.5 mm and a hardness in Shore D hardness of 30 to 55.

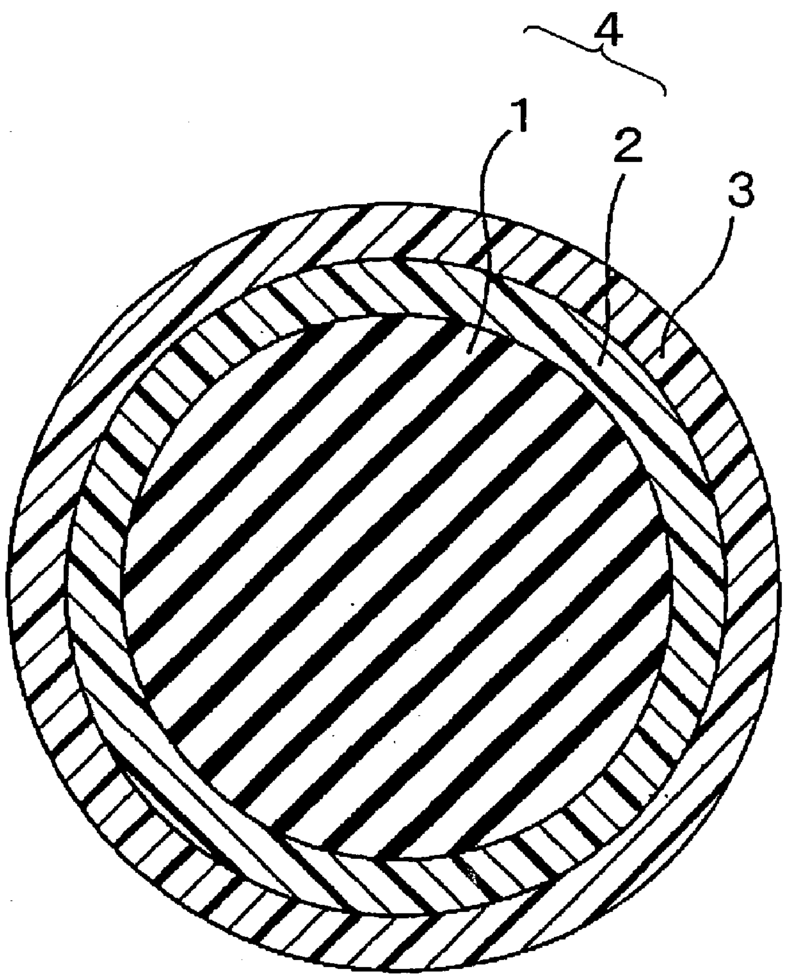
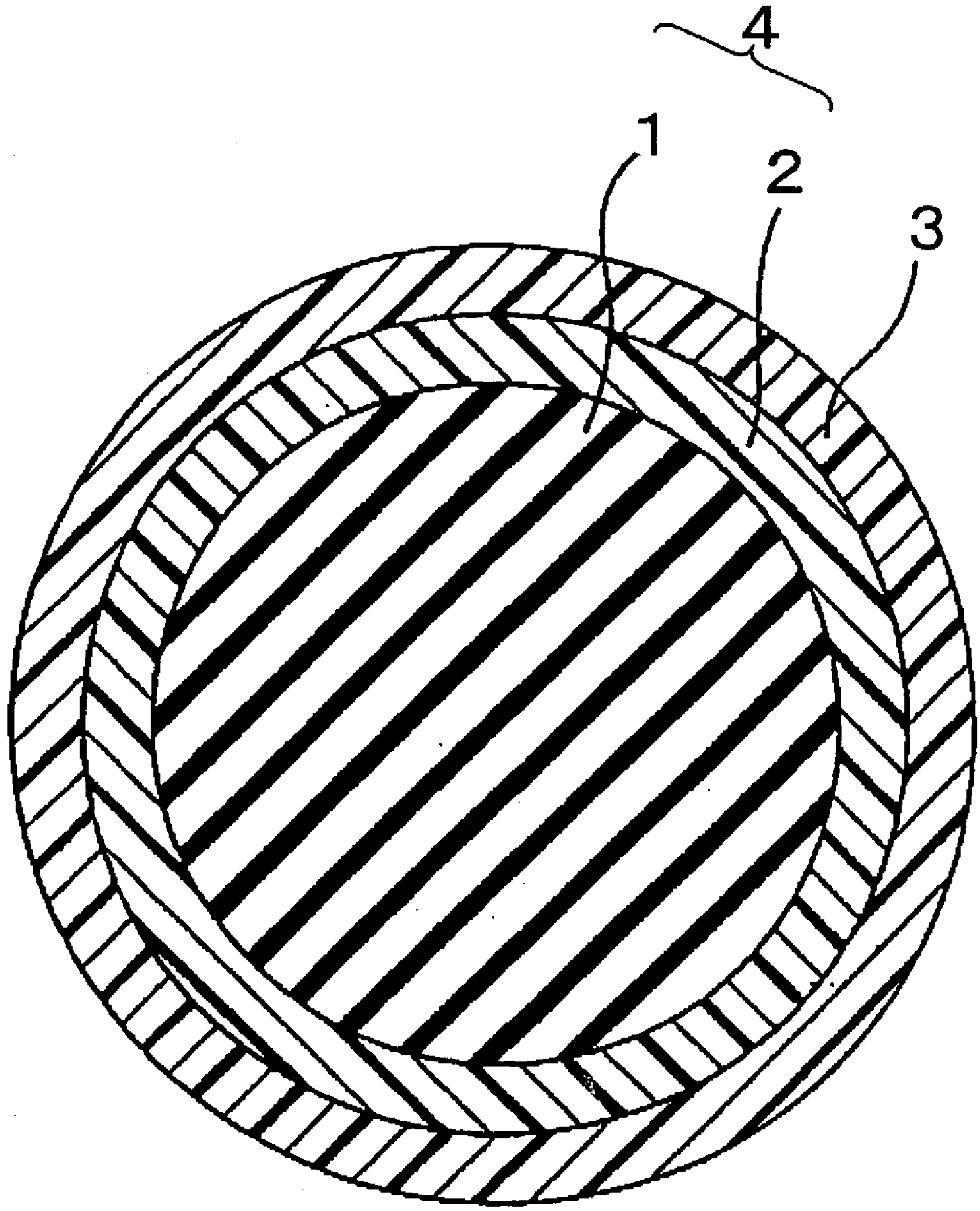


Fig. 1



MULTI-PIECE SOLID GOLF BALL

FIELD OF THE INVENTION

[**0001**] The present invention relates to a multi-piece solid golf ball. More particularly, it relates to a multi-piece solid golf ball, which is superior in flight distance, controllability and shot feel.

BACKGROUND OF THE INVENTION

[**0002**] As golf balls having high spin performance at approach shot and long flight distance, two-layer structured core type or two-layer structured cover type golf balls, which comprise a center formed from soft rubber, an intermediate layer formed on the center and from rubber or resin that is relatively harder than the center and a cover formed from soft material, have been proposed (Japanese Patent No. 2910516, Japanese Patent Publication Nos. 151226/1998, 151320/1999 and the like).

[**0003**] In Japanese Patent No. 2910516, a multi-piece golf ball, of which the center has a diameter of not less than 29 mm, the intermediate layer has a JIS-C hardness of not less than 85, and the specific gravity of the center is larger than that of the intermediate layer, is described. However, since the cover has large thickness, the rebound characteristics of the resulting golf ball are poor, and the flight distance when hit by a driver is not sufficiently obtained.

[**0004**] In Japanese Patent Publication No. 151226/1998, a multi-piece golf ball, of which the center has a distortion of at least 2.5 mm under a load of 100 kg, the hardness in Shore D hardness of the intermediate layer is at least 13 degrees higher than that of the cover, and the ball as a whole has an inertia moment of at least 83 g-cm^2, is described. However, since the cover is soft and has large thickness, the rebound characteristics of the resulting golf ball are poor and the spin amount is large, and the flight distance when hit by a driver is not sufficiently obtained.

[**0005**] In Japanese Patent Kokai Publication No. 151320/1999, a three-piece solid golf ball which comprises a two-layer structured core composed of an inner core (center) and outer core (intermediate layer), and a cover is described. The inner core and outer core are formed from rubber composition comprising polybutadiene rubber as a main component, and the inner core has a diameter of 15 to 22 mm and a hardness in Shore D hardness of 40 to 70. However, since the diameter of the inner core (center) is too small, the rebound characteristics of the resulting golf ball are poor, and the flight distance when hit by a driver is not sufficiently obtained.

[**0006**] There has been no golf ball, which is superior in flight distance, shot feel and controllability as described above.

OBJECTS OF THE INVENTION

[**0007**] A main object of the present invention is to provide a multi-piece solid golf ball, which is superior in flight distance, controllability and shot feel.

[**0008**] According to the present invention, the object described above has been accomplished by providing a multi-piece solid golf ball comprising a center, intermediate layer and cover, and by adjusting the deformation amount under the load of the center, the thickness and hardness of the intermediate layer, and the thickness and hardness of the cover to specified ranges, thereby providing a multi-piece solid golf ball, which is superior in flight distance, controllability and shot feel.

[**0009**] This object as well as other objects and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the accompanying drawings.

BRIEF EXPLANATION OF DRAWINGS

[**0010**] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

[**0011**] **FIG. 1** is a schematic cross section illustrating one embodiment of the golf ball of the present invention.

SUMMARY OF THE INVENTION

[**0012**] The present invention provides a multi-piece solid golf ball comprising a core consisting of a center and an intermediate layer formed on the center, and a cover covering the core, wherein

[**0013**] the center has a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.7 to 4.5 mm,

[**0014**] the intermediate layer has a thickness of 0.5 to 2.0 mm and a hardness in Shore D hardness of 65 to 85, and

[**0015**] the cover has a thickness of 0.3 to 1.5 mm and a hardness in Shore D hardness of 30 to 55.

[**0016**] In order to put the present invention into a more suitable practical application, it is desired that

[**0017**] the intermediate layer be formed from thermoplastic resin other than ionomer resin as a main component;

[**0018**] the cover be formed from polyurethane-based thermoplastic elastomer as a main component; and

[**0019**] the polyurethane-based thermoplastic elastomer be formed by using cycloaliphatic diisocyanate.

DETAILED DESCRIPTION OF THE INVENTION

[**0020**] The multi-piece solid golf ball of the present invention will be explained with reference to the accompanying drawing in detail. **FIG. 1** is a schematic cross section illustrating one embodiment of the multi-piece solid golf ball of the present invention. As shown in **FIG. 1**, the golf ball of the present invention comprises a core **4** consisting of a center **1** and an intermediate layer **2** formed on the center **1**, and a cover **3** covering the core **4**. The cover may have single-layer structure or multi-layer structure, which has two or more layers. In **FIG. 1**, in order to explain the golf ball of the present invention simply, a golf ball having one layer of cover **3**, that is, a three-piece solid golf ball will be used hereinafter for explanation.

[0021] It is desired for the center 1 to comprise polybutadiene rubber as a main component. The center is preferably obtained by press-molding a rubber composition under applied heat. The rubber composition essentially contains polybutadiene, a co-crosslinking agent, an organic peroxide and a filler.

[0022] The polybutadiene used for the center 1 of the present invention may be one, which has been conventionally used for cores of solid golf balls. Preferred is high-cis polybutadiene rubber containing a cis-1, 4 bond of not less than 40%, preferably not less than 80%. The high-cis polybutadiene rubber may be optionally mixed with natural rubber, polyisoprene rubber, styrene-butadiene rubber, ethylene-propylene-diene rubber (EPDM) and the like.

[0023] The co-crosslinking agent can be a metal salt of α,β-unsaturated carboxylic acid, including mono or divalent metal salts, such as zinc or magnesium salts of α,β-unsaturated carboxylic acids having 3 to 8 carbon atoms (e.g. acrylic acid, methacrylic acid, etc.), or a functional monomers (such as trimethylolpropane trimethacrylate, and the like) and the like. The preferred co-crosslinking agent is a zinc salt of α,β-unsaturated carboxylic acid, particularly zinc acrylate, because it imparts high rebound characteristics to the resulting golf ball. The amount of the co-crosslinking agent is from 10 to 60 parts by weight, preferably from 10 to 50 parts by weight, more preferably from 20 to 40 parts by weight, based on 100 parts by weight of the polybutadiene. When the amount of the co-crosslinking agent is larger than 60 parts by weight, the center is too hard, and the shot feel of the resulting golf ball is poor. On the other hand, when the amount of the co-crosslinking agent is smaller than 10 parts by weight, it is required to increase an amount of the organic peroxide in order to impart a desired hardness to the center, and the rebound characteristics are degraded, which reduces the flight distance.

[0024] The organic peroxide includes, for example, dicumyl peroxide, 1,1-bis (t-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di(t-butylperoxy) hexane, di-t-butyl peroxide and the like. The preferred organic peroxide is dicumyl peroxide. The amount of the organic peroxide is from 0.3 to 4.0 parts by weight, preferably 0.4 to 3.0 parts by weight, more preferably 0.5 to 2.0 parts by weight, based on 100 parts by weight of the polybutadiene. When the amount of the organic peroxide is smaller than 0.3 parts by weight, the center is too soft, and the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance. On the other hand, when the amount of the organic peroxide is larger than 4.0 parts by weight, it is required to decrease an amount of the co-crosslinking agent in order to impart a desired hardness to the center, and the rebound characteristics are degraded, which reduces the flight distance.

[0025] The filler, which can be typically used for the core of solid golf ball, includes for example, inorganic filler (such as zinc oxide, barium sulfate, calcium carbonate, magnesium oxide and the like), high specific gravity metal powder filler (such as tungsten powder, molybdenum powder and the like), and the mixture thereof. The amount of the filler is from 5 to 30 parts by weight, preferably from 5 to 25 parts by weight, based on 100 parts by weight of the polybutadiene. When the amount of the filler is smaller than 5 parts by weight, it is difficult to adjust the weight of the resulting golf ball. On the other hand, when the amount of the filler is larger than 30 parts by weight, the weight ratio of the rubber component in the center is small, and the rebound characteristics reduce too much.

[0026] The rubber compositions for the center of the golf ball of the present invention can contain other components, which have been conventionally used for preparing the core of solid golf balls, such as organic sulfide compound or antioxidant. If used, it is desired for the amount thereof to be 0.2 to 5.0 parts by weight, preferably 0.3 to 4.0 parts by weight, more preferably 0.5 to 2.0 parts by weight, based on 100 parts by weight of the polybutadiene.

[0027] The center 1 used for the golf ball of the present invention is obtained by mixing the rubber composition, followed by vulcanizing and press-molding the mixture in a mold. The vulcanization condition is not limited, but the vulcanization may be conducted at 140 to 180° C. and 2.9 to 11.8 MPa for 10 to 60 minutes. The vulcanization may be conducted in two or more stages of the temperature.

[0028] In the golf ball of the present invention, it is desired for the center 1 to have a diameter of 37 to 41 mm, preferably 37 to 40 mm, more preferably 38 to 40 mm. When the diameter of the center is smaller than 37 mm, the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance. In addition, the spin amount at the time of hitting of the resulting golf ball is increased, and the hit golf ball creates blown-up trajectory, which reduces the flight distance. On the other hand, when the diameter of the center is larger than 41 mm, the thickness of the intermediate layer or the cover is too small, and the technical effects accomplished by the presence of the intermediate layer or the cover are not sufficiently obtained.

[0029] In the golf ball of the present invention, it is required for the center 1 to have a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.7 to 4.5 mm, preferably 2.8 to 4.2 mm, more preferably 3.0 to 4.0 mm. When the deformation amount of the center is smaller than 2.7 mm, the center is too hard, and the shot feel of the resulting golf ball is hard and poor. On the other hand, when the deformation amount is larger than 4.5 mm, the core is too soft, and the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance.

[0030] In the golf ball of the present invention, it is desired for the center 1 to have a central point hardness in Shore D hardness of 15 to 40, preferably 20 to 40, more preferably 20 to 35. When the central point hardness is lower than 15, the center is too soft, and the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance. In addition, the shot feel of the resulting golf ball is heavy and poor. On the other hand, when the surface hardness is higher than 40, high launch angle at the time of hitting is not sufficiently accomplished, which reduces the flight distance. In addition, the center is too hard, and the shot feel of the resulting golf ball is poor such that the impact force at the time of hitting is large.

[0031] In the golf ball of the present invention, it is desired for the center 1 to have a surface hardness in Shore D hardness of 40 to 65, preferably 40 to 60, more preferably 45 to 60. When the surface hardness is lower than 40, the center is too soft, and the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance. In addition, the shot feel is heavy and poor. On the other hand, when the surface hardness is higher than 65, the center is too hard, and the shot feel of the resulting golf ball is hard and poor.

[**0032**] The term "a surface hardness of the center" as used herein refers to the hardness, which is determined by measuring a hardness at the surface of the center prepared by press molding as described above, that is, at the surface of the center before covering with the intermediate layer. The term "a central point hardness of the center" as used herein refers to the hardness, which is determined by cutting the resulting center into two equal parts and then measuring a hardness at its central point in section. The intermediate layer **2** is then formed on the center **1**.

[**0033**] In the golf ball of the present invention, it is required for the intermediate layer **2** to have a thickness of 0.5 to 2.0 mm, preferably 0.5 to 1.6 mm, more preferably 0.7 to 1.4 mm. When the thickness is smaller than 0.5 mm, the technical effect accomplished by the hardness of the intermediate layer is not sufficiently obtained, and the spin amount at the time of hitting can not be sufficiently restrained. On the other hand, when the thickness is not less than 2.0 mm, since the intermediate layer is formed from a relatively hard material, the shot feel is hard and poor.

[**0034**] In the golf ball of the present invention, it is required for the intermediate layer **2** to have a hardness in Shore D hardness of 65 to 85, preferably 67 to 82, more preferably 70 to 80. When the hardness is lower than 65, the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance. On the other hand, when the hardness is higher than 85, the shot feel is hard and poor, or the durability is degraded. The term "a hardness of the intermediate layer" as used herein refers to the hardness, which is determined by measuring a hardness (slab hardness) using a sample of a stack of the three or more heat and press molded sheets having a thickness of about 2 mm from the intermediate layer composition, which had been stored at 23° C. for 2 weeks.

[**0035**] In the golf ball of the present invention, it is desired that the hardness of the intermediate layer **2** be higher than the surface hardness of the center **1**, and the hardness difference between the intermediate layer and the surface of the center is 5 to 35, preferably 5 to 30, more preferably 10 to 25. When the hardness difference is smaller than 5, the center is too hard, and the shot feel of the resulting golf ball is hard and poor. On the other hand, when the hardness difference is larger than 35, the durability is degraded.

[**0036**] In the golf ball of the present invention, a material for the intermediate layer **2** is not limited as long as it has properties as described above, but it is desired for the intermediate layer **2** to be formed from hard and high rebound characteristics material, particularly thermoplastic resin other than ionomer resin as a main component. Examples thereof include thermoplastic elastomer, such as polyester-based thermoplastic elastomer, polyamide-based thermoplastic elastomer and polyurethane-based thermoplastic elastomer; polyamide resin, polyacetal resin, polycarbonate resin, acrylic resin, polyolefin resin and modified compounds thereof. Examples of the commercially available materials for the intermediate layer include polyester-based thermoplastic elastomer, which is commercially available from Toray-Du Pont Co., Ltd. under the trade name of "Hytrel" (such as "Hytrel 7247"); polyamide-based thermoplastic elastomer, which is commercially available from Atofina Japan Co., Ltd. under the trade name of "Pebax" (such as "Pebax 7233"); polyurethane-based elastomer, which is commercially available from BASF Polyurethane Elastomers Co., Ltd. under the trade name of "Elastollan" (such as "Elastollan XHM76D"); and the like.

[**0037**] A method of covering the center **1** with the intermediate layer **2** is not specifically limited, but may be conventional methods, which have been known to the art and used for forming the cover of the golf balls. For example, there can be used a method comprising molding the intermediate layer composition into a semi-spherical half-shell in advance, covering the core with the two half-shells, followed by press molding at 130 to 170° C. for 1 to 5 minutes, or a method comprising injection molding the intermediate layer composition directly on the center, which is covered with the cover, to cover it. The intermediate layer **2** is formed on the center **1** to form the core **4** having two-layered structure by using the above method.

[**0038**] In the golf ball of the present invention, it is desired for the core **4** to have a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.0 to 3.7 mm, preferably 2.2 to 3.5 mm, more preferably 2.5 to 3.3 mm. When the deformation amount of the core is smaller than 2.0 mm, the core is too hard, and the shot feel of the resulting golf ball is poor. On the other hand, when the deformation amount is larger than 3.7 mm, the core is too soft, the rebound characteristics of the resulting golf ball are degraded, which reduces the flight distance.

[**0039**] At least one layer of cover **3** are then covered on the core **4**. In the golf ball of the present invention, it is required for the cover **3** to have a thickness of 0.3 to 1.5 mm, preferably 0.5 to 1.2 mm, more preferably 0.5 to 1.0 mm. When the thickness is smaller than 0.3 mm, the technical effects accomplished by softening the cover are not sufficiently obtained, and the spin amount at short iron shot to approach shot is small, which degrades the controllability. On the other hand, when the thickness of the cover is larger than 1.5 mm, the rebound characteristics of the resulting golf ball are degraded and the spin amount at the time of hitting is increased, and the hit golf ball creates blown-up trajectory, which reduces the flight distance.

[**0040**] In the golf ball of the present invention, it is required for the cover **3** to have a hardness in Shore D hardness of 30 to 55, preferably 33 to 52, more preferably 35 to 50. When the hardness of the cover **3** is lower than 30, the spin amount when hit by a driver or middle iron club is increased, which reduces the flight distance. On the other hand, when the hardness of the cover is higher than 55, the spin amount when hit by a short iron club is decreased, and the controllability is degraded. In addition, the shot feel is poor. The term "a hardness of the cover" as used herein is determined by measuring a hardness (slab hardness) using a sample of a stack of the three or more heat and press molded sheets having a thickness of about 2 mm from the composition for the cover, which had been stored at 23° C. for 2 weeks.

[**0041**] In the golf ball of the present invention, it is desired that the hardness in Shore D hardness of the intermediate layer **2** be higher than that of the cover **3**, and the hardness difference between the intermediate layer and cover is within the range of preferably 10 to 50, more preferably 10 to 40, most preferably 15 to 30. When the hardness difference between the intermediate layer and the cover is smaller than 10 or larger than 50, it is difficult to adjust the hardness of each layer in the resulting golf ball to specified ranges, which degrades the controllability or reduces the flight distance.

[**0042**] In the golf ball of the present invention, a material for the cover **3** is not limited as long as it has properties as described above, but it is desired for the cover **3** to be formed from polyurethane-based thermoplastic elastomer as a main component in view of productivity and cost, more preferably polyurethane-based thermoplastic elastomer formed by using cycloaliphatic diisocyanate in view of yellowing resistance.

[**0043**] Examples of the cycloaliphatic diisocyanates include one or combination of two or more selected from the group consisting of 4,4'-dicyclohexylmethane diisocyanate ($H_{12}MDI$), which is hydrogenated compound of 4,4'-diphenylmethane diisocyanate (MDI); 1,3-bis (isocyanatomethyl) cyclohexane (H_6XDI), which is hydrogenated compound of xylylene diisocyanate (XDI); isophorone diisocyanate (IPDI); and trans-1,4-cyclohexane diisocyanate (CHDI). Preferred is the $H_{12}MDI$ in view of general-purpose properties and processability.

[**0044**] Concrete examples of the polyurethane-based thermoplastic elastomers include polyurethane-based thermoplastic elastomer formed by using the $H_{12}MDI$, which is commercially available from BASF Polyurethane Elastomers Co., Ltd. under the trade name "Elastollan" (such as "Elastollan XNY90A", "Elastollan XNY97A", "Elastollan XNY585" and the like) and the like.

[**0045**] As a suitable materials used in the cover **3** of the present invention, the above polyurethane-based thermoplastic elastomer may be used alone, but the polyurethane-based thermoplastic elastomer may be used in combination with at least one of the other thermoplastic elastomer, diene-based block copolymer, ionomer resin and the like. Examples of the other thermoplastic elastomers include the other polyurethane-based thermoplastic elastomer, polyamide-based thermoplastic elastomer, polyester-based thermoplastic elastomer, polystyrene-based thermoplastic elastomer, polyolefin-based thermoplastic elastomer and the like. If used, it is desired for the polyurethane-based thermoplastic elastomer to be used in combination with polyamide-based thermoplastic elastomer in view of the compatibility with the polyurethane-based thermoplastic elastomer and the rebound characteristics. In addition, it is desired that the weight ratio of the polyurethane-based thermoplastic elastomer to the polyamide-based thermoplastic elastomer be within the range of 95/5 to 70/30. The other thermoplastic elastomer may have functional group, such as carboxyl group, glycidyl group, sulfone group, epoxy group and the like.

[**0046**] Concrete examples of the other thermoplastic elastomers include polyurethane-based elastomer, which is commercially available from BASF Polyurethane Elastomers Co., Ltd. under the trade name of "Elastollan" (such as "Elastollan ET880"); polyamide-based thermoplastic elastomer, which is commercially available from Atofina Japan Co., Ltd. under the trade name of "Pebax" (such as "Pebax 2533"); polyester-based thermoplastic elastomer, which is commercially available from Toray-Du Pont Co., Ltd. under the trade name of "Hytrel" (such as "Hytrel 3548", "Hytrel 4047"); styrene-based thermoplastic elastomer available from Asahi Kasei Corporation under the trade name "Tuftec" (such as "Tuftec H1051"); olefin-based thermoplastic elastomer available from Mitsubishi Chemical Co., Ltd. under the trade name "Thermoran" (such as "Thermoran 3981N"); polyolefin-based thermoplastic elastomer, which is commercially available from Sumitomo Chemical Co., Ltd. under the trade name of "Sumitomo TPE" (such as "Sumitomo TPE3682" and "Sumitomo TPE9455"); and the like.

[**0047**] The diene-based block copolymer is a block copolymer or partially hydrogenated block copolymer having double bond derived from conjugated diene compound. The base bock copolymer is block copolymer composed of block polymer block A mainly comprising at least one aromatic vinyl compound and polymer block B mainly comprising at least one conjugated diene compound. The partially hydrogenated block copolymer is obtained by hydrogenating the block copolymer. Examples of the aromatic vinyl compounds comprising the block copolymer include styrene, α-methyl styrene, vinyl toluene, p-t-butyl styrene, 1,1-diphenyl styrene and the like, or mixtures thereof. Preferred is styrene. Examples of the conjugated diene compounds include butadiene, isoprene, 1,3-pentadiene, 2,3-dimethyl-1,3-butadiene and the like, or mixtures thereof. Preferred are butadiene, isoprene and combinations thereof. Examples of the diene block copolymers include an SBS (styrene-butadiene-styrene) block copolymer having polybutadiene block with epoxy groups or SIS (styrene-isoprene-styrene) block copolymer having polyisoprene block with epoxy groups and the like. Concrete examples of the diene block copolymers include the diene block copolymers, which are commercially available from Daicel Chemical Industries, Ltd. under the trade name of "Epofriend" (such as "Epofriend A1010"), the diene-based block copolymers, which are commercially available from Kuraray Co., Ltd. under the trade name of "Septon" (such as "Septon HG-252" and the like) and the like.

[**0048**] The ionomer resin may be a copolymer of ethylene and α,β-unsaturated carboxylic acid, of which a portion of carboxylic acid groups is neutralized with metal ion; or a terpolymer of ethylene, α,β-unsaturated carboxylic acid and α,β-unsaturated carboxylic acid ester, of which a portion of carboxylic acid groups is neutralized with metal ion. Examples of the α,β-unsaturated carboxylic acid in the ionomer include acrylic acid, methacrylic acid, fumaric acid, maleic acid, crotonic acid and the like, and preferred are acrylic acid and methacrylic acid. Examples of the α,β-unsaturated carboxylic acid ester in the ionomer include methyl ester, ethyl ester, propyl ester, n-butyl ester and isobutyl ester of acrylic acid, methacrylic acid, fumaric acid, maleic acid, crotonic acid and the like. Preferred are acrylic acid esters and methacrylic acid esters. The metal ion which neutralizes a portion of carboxylic acid groups of the copolymer or terpolymer includes sodium ion, potassium ion, lithium ion, magnesium ion, calcium ion, zinc ion, barium ion, aluminum ion, tin ion, zirconium ion, cadmium ion, and the like. Preferred are sodium ions, zinc ions, magnesium ions and the like, in view of rebound characteristics, durability and the like.

[0049] The ionomer resin is not limited, but examples thereof will be shown by a trade name thereof. Examples of the ionomer resins, which are commercially available from Du Pont-Mitsui Polychemicals Co., Ltd. include Hi-milan 1555, Hi-milan 1557, Hi-milan 1605, Hi-milan 1652, Hi-milan 1702, Hi-milan 1705, Hi-milan 1706, Hi-milan 1707, Hi-milan 1855, Hi-milan 1856 and the like. Examples of the ionomer resins, which are commercially available from Du Pont Co., include Surlyn 8945, Surlyn 9945, Surlyn 6320 and the like. Examples of the ionomer resins, which are commercially available from Exxon Chemical Co., include Iotek 7010, Iotek 8000 and the like. These ionomer resins may be used alone or in combination.

[0050] The composition for the cover **3** used in the present invention may optionally contain pigments (such as titanium dioxide, etc.) and the other additives such as a dispersant, an antioxidant, a UV absorber, a photostabilizer and a fluorescent agent or a fluorescent brightener, etc., in addition to the resin component as long as the addition of the additives does not deteriorate the desired performance of the golf ball cover. If used, the amount of the pigment is preferably 0.1 to 5.0 parts by weight, based on 100 parts by weight of the base resin for the cover.

[0051] A method of covering the core **4** with the cover **3** is not specifically limited, but may be a conventional method. For example, there can be used a method comprising molding the cover composition into a semi-spherical half-shell in advance, covering the core with the two half-shells, followed by press molding at 130 to 170° C. for 1 to 5 minutes, or a method comprising injection molding the cover composition directly on the core, which is covered with the cover, to cover it.

[0052] At the time of molding the cover, many depressions called "dimples" are formed on the surface of the golf ball. Furthermore, paint finishing or marking with a stamp may be optionally provided after the cover is molded for commercial purposes.

[0053] The golf ball of the present invention is formed such that it has a diameter of not less than 42.67 mm (preferably 42.67 to 42.82 mm) and a weight of not more than 45.93 g, in accordance with the regulations for golf balls.

[0054] In the golf ball of the present invention, it is desired to have a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.0 to 3.5 mm, preferably 2.2 to 3.2 mm, more preferably 2.4 to 3.0 mm. When the deformation amount is smaller than 2.0 mm, the shot feel is hard and poor. On the other hand, when the deformation amount is larger than 3.5 mm, the golf ball is too soft, and the shot feel is heavy and poor, or the flight distance is reduced.

[0055] The diameter of golf balls is limited to not less than 42.67 mm in accordance with the regulations for golf balls as described above. Generally, when the diameter of the golf ball is large, air resistance of the golf ball on a flight is large, which reduces the flight distance. Therefore, most of golf balls commercially available are designed to have a diameter of 42.67 to 42.82 mm. The present invention is applicable to the golf balls having the diameter. There are golf balls having large diameter in order to improve the easiness of hitting. In addition, there are cases where golf balls having a diameter out of the regulations for golf balls are required depending on the demand and object of users. Therefore, it can be considered for golf balls to have a diameter of 42 to 44 mm, more widely 40 to 45 mm. The present invention is also applicable to the golf balls having the diameter. In addition, the golf ball of the present invention has a weight of 44 to 46 g, preferably 45.00 to 45.93 g.

EXAMPLES

[0056] The following Examples and Comparative Examples further illustrate the present invention in detail but are not to be construed to limit the scope of the present invention.

Examples 1 to 6 and Comparative Examples 1 to 7

[0057] (i) Production of Center

[0058] The rubber compositions for the center having the formulation shown in Table 1 (Examples) and Table 2 (Comparative Examples) were mixed, and then vulcanized by press-molding in the mold at 170° C. for 15 minutes to obtain spherical centers. The diameter, weight, deformation amount, central point hardness and surface hardness of the resulting centers were measured. The results are shown in Table 3 (Examples) and Table 4 (Comparative Examples).

[0059] (ii) Preparation of Compositions for Intermediate Layer

[0060] The formulation materials for the intermediate layer shown in Table 1 (Examples) and Table 2 (Comparative Examples) were mixed using a kneading type twin-screw extruder to obtain pelletized intermediate layer compositions. The extrusion condition was,

[0061] a screw diameter of 45 mm,

[0062] a screw speed of 200 rpm, and

[0063] a screw L/D of 35.

[0064] The formulation materials were heated at 160 to 260° C. at the die position of the extruder. The Shore D hardness were measured, using a sample of a stack of the three or more heat and press molded sheets having a thickness of about 2 mm from each intermediate layer composition, which had been stored at 23° C. for 2 weeks. The results are shown in Table 3 (Examples) and Table 4 (Comparative Examples) as the hardness of the intermediate layer.

[0065] (iii) Production of Core

[0066] The compositions for the intermediate layer obtained in the step (ii) were injection-molded to obtain semi-spherical half-shells for the intermediate layer. The center produced in the step (i) was covered with the two semi-spherical half-shells for the intermediate layer into a concentric sphere, and then press-molded in the mold at 150° C. for 2 minutes to obtain two-layer structured cores **4**. The two-layer structured core **4** was consisted of the center **1** and the intermediate layer **2** having the thickness shown in Table 3 (Examples) and Table 4 (Comparative Examples) covered on the center **1**. The diameter, weight, and deformation amount of the resulting two-layer structured core **4** were measured. The results are shown in Table 3 (Examples) and Table 4 (Comparative Examples).

[0067] (iv) Preparation of Compositions for Cover

[0068] The formulation materials for the cover shown in Table 1 (Examples) and Table 2 (Comparative Examples) were mixed using a kneading type twin-screw extruder to obtain pelletized cover compositions. The extrusion condition was,

[0069] a screw diameter of 45 mm,

[0070] a screw speed of 200 rpm, and

[0071] a screw L/D of 35.

[0072] The formulation materials were heated at 160 to 260° C. at the die position of the extruder. The Shore D hardness were measured, using a sample of a stack of the three or more heat and press molded sheets having a thickness of about 2 mm from each cover composition, which had been stored at 23° C. for 2 weeks. The results are shown in Table 3 (Examples) and Table 4 (Comparative Examples) as the cover hardness.

TABLE 1

	(parts by weight) Example No.					
Composition	1	2	3	4	5	6
(Center composition)						
BR11 *1	100	100	100	100	100	100
Zinc acrylate	35	35	35	30	35	35
Zinc oxide	6.0	6.0	6.0	8.3	4.0	18
Dicumyl peroxide	0.8	0.8	0.8	0.8	0.8	0.8
Diphenyl disulfide	0.5	0.5	0.5	0.5	0.5	0.5
(Intermediate layer composition)						
Hytrel 7247 *2	100	100	100	100	100	—
Surlyn 8945 *3	—	—	—	—	—	—
Pebax 7233 *4	—	—	—	—	—	100
(Cover composition)						
Elastollan XNY90A *5	—	—	100	—	—	100
Elastollan XNY97A *6	100	80	—	100	100	—
Pebax 5533 *7	—	20	—	—	—	—
Surlyn 8945 *3	—	—	—	—	—	—
Surlyn 9945 *8	—	—	—	—	—	—
Titanium dioxide	4	4	4	4	4	4

[0073]

TABLE 2

	(parts by weight) Comparative Example No.						
Composition	1	2	3	4	5	6	7
(Center composition)							
BR11 *1	100	100	100	100	100	100	100
Zinc acrylate	33	35	35	35	43	25	33
Zinc oxide	3.0	5.0	16.0	8.0	3.0	10.5	12.0
Dicumyl peroxide	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Diphenyl disulfide	0.5	0.5	0.5	0.5	0.5	0.5	0.5
(Intermediate layer composition)							
Hytrel 7247 *2	100	100	—	100	100	100	—
Surlyn 8945 *3	—	—	100	—	—	—	
Pebax 7233 *4	—	—	—	—	—	—	

TABLE 2-continued

	(parts by weight) Comparative Example No.						
Composition	1	2	3	4	5	6	7
(Cover composition)							
Elastollan XNY90A *5	—	—	—	—	—	—	—
Elastollan XNY97A *6	100	100	100	—	100	100	100
Pebax 5533 *7	—	—	—	—	—	—	—
Surlyn 8945 *3	—	—	—	50	—	—	—
Surlyn 9945 *8	—	—	—	50	—	—	—
Titanium dioxide	4	4	4	4	4	4	4

*1: BR-11 (trade name), high-cis polybutadiene commercially available from JSR Co., Ltd. (Content of 1,4-cis-polybutadiene: 96%)
*2: Hytrel 7247 (trade name), polyester-based thermoplastic elastomer, which is commercially available from Toray-Du Pont Co., Ltd.
*3: Surlyn 8945 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with sodium ion, manufactured by Du Pont Co.
*4: Pebax 7233 (trade name), polyamide-based thermoplastic elastomer, which is commercially available from Atofina Japan Co., Ltd.
*5: Elastollan XNY90A (trade name), polyurethane-based thermoplastic elastomer formed by using 4,4'-dicyclohexylmethane diisocyanate ($H_{12}MDI$), commercially available from BASF Polyurethane Elastomers Co., Ltd.; Shore A (JIS-A) hardness = 90
*6: Elastollan XNY97A (trade name), polyurethane-based thermoplastic elastomer formed by using 4,4'-dicyclohexylmethane diisocyanate ($H_{12}MDI$), commercially available from BASF Polyurethane Elastomers Co., Ltd.; Shore A (JIS-A) hardness = 97
*7: Pebax 5533 (trade name), polyamide-based thermoplastic elastomer, which is commercially available from Atofina Japan Co., Ltd.
*8: Surlyn 9945 (trade name), ethylene-methacrylic acid copolymer ionomer resin obtained by neutralizing with zinc ion, manufactured by Du Pont Co.

[0074] (v) Production of Golf Ball

[0075] The cover composition obtained in the step (iv) was injection molded to obtain semi-spherical half-shell for the cover. The two-layer structured core **4** produced in the step (iii) was covered with the two semi-spherical half-shells for the cover into a concentric sphere, and then press-molded in the mold at 150° C. for 2 minutes to form a cover layer **3** having a thickness shown in Table 3 (Examples) and Table 4 (Comparative Examples). Then, clear paint was applied on the surface to produce golf ball having a diameter of 42.7 mm and a weight of 45.3 g. With respect to the resulting golf balls, the deformation amount, coefficient of restitution, flight performance (spin amount and flight distance), shot feel and controllability were measured or evaluated. The results are shown in Table 5 (Examples) and Table 6 (Comparative Examples). The test methods are as follows.

[0076] (Test Method)

[0077] (1) Hardness of Center

[0078] The surface hardness of the center is determined by measuring a Shore D hardness at the surface of the center prepared. The central point hardness of the center is determined by measuring a Shore D hardness at the central point of the center in section, after the center is cut into two equal parts. Shore D hardness is measured with a Shore D hardness meter according to ASTM-D 2240.

[0079] (2) Hardness of Intermediate Layer and Cover

[0080] The hardness of the intermediate layer and the hardness of the cover are determined by measuring a hardness, using a sample of a stack of the three or more heat and press molded sheets having a thickness of about 2 mm from each intermediate layer composition and each cover composition, which had been stored at 23° C. for 2 weeks, with a Shore D hardness meter according to ASTM D-2240.

[0081] (3) Deformation Amount

[0082] The deformation amount of was determined by measuring a deformation amount when applying from an initial load of 98 N to a final load of 1275 N on the center, core or golf ball.

[0083] (4) Coefficient of Restitution

[0084] An aluminum cylinder having a weight of 200 g was struck at a speed of 45 m/sec against a golf ball, and the velocity of the cylinder and the golf ball after the strike were measured. The coefficient of restitution of the golf ball was calculated from the velocity and the weight of both the cylinder and golf ball before and after strike.

[0085] (5) Flight Performance

[0086] After a No. 1 wood club (a driver, W#1; "XXIO" loft angle=10 degrees, S shaft, manufactured by Sumitomo Rubber Industries, Ltd.) having metal head was mounted to a swing robot manufactured by Golf Laboratory Co. and each golf ball was hit at head speed of 45 m/sec, the spin amount (backspin amount) immediately after hitting, and flight distance were measured. As the flight distance, total that is a distance to the stop point of the hit golf ball was measured. The measurement was conducted 12 times for each golf ball (n=12), and the average is shown as the result of the golf ball.

[0087] (6) Shot Feel

[0088] The shot feel of the golf ball is evaluated by 10 golfers according to a practical hitting test using a No. 1 wood club (W#1, a driver) having a metal head. The evaluation criteria are as follows. The results shown in the Tables below are based on the fact that the most golfers evaluated with the same criterion about shot feel.

[0089] Evaluation Criteria

[0090] ○: The golfers felt that the golf ball has good shot feel such that the impact force is small and the rebound characteristics are good.

[0091] Δ: The golfers felt that the golf ball has fairly good shot feel.

[0092] x: The golfers felt that the golf ball has hard and poor shot feel such that the impact force is large, or heavy and poor shot feel such that the rebound characteristics are poor.

[0093] (7) Controllability

[0094] The resulting golf balls were evaluated by 10 golfers according to practical hitting test using a pitching wedge (PW). The results shown in the Tables below are based on the fact that the most golfers evaluated with the same criterion about shot feel. The evaluation criteria are as follows.

[0095] Evaluation Criteria

[0096] ○: The golfers felt that it is easy to apply spin on the golf ball, and the golf ball has good controllability.

[0097] Δ: The golfers felt that the golf ball has fairly good controllability.

[0098] x: The golfers felt that it is difficult to apply spin on the golf ball such that the golf ball slips on the face of golf club, and the golf ball has poor controllability.

[0099] (Test Results)

TABLE 3

Test item	Example No. 1	2	3	4	5	6
(Center)						
Diameter (mm)	38.5	38.5	38.5	38.5	36.7	38.5
Weight (g)	32.6	32.6	32.6	32.6	27.8	34.2
Deformation amount (mm)	3.2	3.2	3.2	3.8	3.25	3.2
Hardness (Shore D)						
Central point hardness	34	34	34	31	33	33
Surface hardness	56	56	56	52	55	55
(Intermediate layer)						
Thickness (mm)	1.3	1.3	1.3	1.3	1.6	1.3
Hardness (Shore D)	72	72	72	72	72	72
(Core)						
Diameter (mm)	41.1	41.1	41.1	41.1	39.9	41.1
Weight (g)	40.6	40.6	40.6	40.6	37.3	40.6
Deformation amount (mm)	2.8	2.8	2.8	3.2	2.7	2.9
(Cover)						
Thickness (mm)	0.8	0.8	0.8	0.8	1.4	0.8
Hardness (Shore D)	47	47	42	47	47	42

[0100]

TABLE 4

Test item	Comparative Example No. 1	2	3	4	5	6	7
(Center)							
Diameter (mm)	36.4	36.4	38.5	38.5	38.5	38.5	41.1
Weight (g)	26.4	29.1	34.5	33.0	32.6	32.6	40.6
Deformation amount (mm)	3.4	3.3	3.2	3.2	2.4	5.1	3.1
Hardness (Shore D)							
Central point hardness	32	34	35	34	40	26	33
Surface hardness	54	55	56	56	63	47	57
(Intermediate layer)							
Thickness (mm)	2.4	1.3	1.3	1.3	1.3	1.3	—
Hardness (Shore D)	72	72	61	72	72	72	
(Core)							
Diameter (mm)	41.1	39.0	41.1	41.1	41.1	41.1	—
Weight (g)	40.6	34.6	40.6	41.2	40.6	40.6	
Deformation amount (mm)	2.7	2.9	2.95	2.8	2.0	4.3	
(Cover)							
Thickness (mm)	0.8	1.9	0.8	0.8	0.8	0.8	0.8
Hardness (Shore D)	47	47	42	47	47	42	47

[0101]

TABLE 5

	Example No.					
Test item	1	2	3	4	5	6
Deformation amount (mm)	2.7	2.7	2.75	3.05	2.6	2.8
Coefficient of restitution	0.765	0.766	0.764	0.759	0.761	0.763
Flight performance (W#1; 45 m/sec)						
Spin amount (rpm)	2850	2820	2900	2770	2950	2870
Total (m)	232.5	233.3	231.0	232.1	229.9	231.5
Shot feel	○	○	○	○	Δ	○
Controllability	○	○	○	○	○	○

[0102]

TABLE 6

	Comparative Example No.						
Test item	1	2	3	4	5	6	7
Deformation amount (mm)	2.6	2.7	2.8	2.5	1.95	4.1	2.9
Coefficient of restitution	0.769	0.748	0.746	0.771	0.776	0.739	0.757
Flight performance (W#1; 45 m/sec)							
Spin amount (rpm)	2800	3230	3180	2700	2720	2800	3300
Total (m)	233.5	224.9	223.5	235.1	236.0	224.0	223.0
Shot feel	x	x	Δ	x	x	x	Δ
Controllability	○	○	○	x	Δ	○	○

[0103] As is apparent from the results of Tables 5 and 6, the golf balls of the present invention of Examples 1 to 6, when compared with the golf balls of Comparative Examples 1 to 7, are superior in flight distance, shot feel and controllability.

[0104] On the other hand, in the golf balls of Comparative Example 1, since the thickness of the intermediate layer having high hardness is large, the shot feel is poor. In the golf ball of Comparative Example 2, since the thickness of the cover is too large, the coefficient of restitution is small and the spin amount at the time of hitting is large, which reduces the flight distance. In addition, the shot feel is poor.

[0105] In the golf balls of Comparative Example 3, since the intermediate layer is formed from ionomer resin and has low hardness, and the coefficient of restitution is small, which reduces the flight distance. In the golf balls of Comparative Example 4, since the cover hardness is high, the spin amount is small, and controllability is poor, or the shot feel is poor.

[0106] In the golf balls of Comparative Example 5, since the deformation amount of the center is small, the center is too hard, and the shot feel of the resulting golf ball is poor. In the golf balls of Comparative Example 6, since the deformation amount of the center is large, the center is too soft, and the coefficient of restitution is small, which reduces the flight distance. In addition, the shot feel is heavy and poor. In the golf balls of Comparative Example 7, since the intermediate layer having high hardness is not present, the spin amount is large, which reduces the flight distance.

What is claimed is:

1. A multi-piece solid golf ball comprising a core consisting of a center and an intermediate layer formed on the center, and a cover covering the core, wherein

the center has a deformation amount when applying from an initial load of 98 N to a final load of 1275 N of 2.7 to 4.5 mm,

the intermediate layer has a thickness of 0.5 to 2.0 mm and a hardness in Shore D hardness of 65 to 85, and

the cover has a thickness of 0.3 to 1.5 mm and a hardness in Shore D hardness of 30 to 55.

2. The multi-piece solid golf ball according to claim 1, wherein the intermediate layer is formed from thermoplastic resin other than ionomer resin as a main component.

3. The multi-piece solid golf ball according to claim 1, wherein the cover is formed from polyurethane-based thermoplastic elastomer as a main component.

4. The multi-piece solid golf ball according to claim 1, wherein the polyurethane-based thermoplastic elastomer is formed by using cycloaliphatic diisocyanate.

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