The present invention relates to a steel composition for bearing having improved fatigue durability and a method of manufacturing the same. The steel composition comprises: an amount of about 0.08 to 1.0 wt % of carbon (C); an amount of about 0.9 to 1.6 wt % of silicon (Si); an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P); an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S); an amount of about 0.01 to 0.1 wt % of copper (Cu); an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); one or more selected from the group consisting of: an amount of about 0.5 to 1.00 wt % of manganese (Mn), an amount of about 0.1 to 0.6 wt % of nickel (Ni), an amount of about 1.4 to 1.55 wt % of chromium (Cr), an amount of about 0.2 to 0.5 wt % of molybdenum (Mo), and an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V); and iron (Fe) constituting the balance of the weight of the steel composition, all wt % based on the total weight of the alloy steel composition.
MANUFACTURE WIRE ROD

PRIMARILY SPHEROIDIZING HEAT-TREAT WIRE ROD

WIRE DRAW ALLOY STEEL

SECONDARILY SPHEROIDIZING HEAT-TREAT ALLOY STEEL

FORGE ALLOY STEEL

QUENCH ALLOY STEEL

TEMPER ALLOY STEEL

END
BEARING STEEL HAVING IMPROVED FATIGUE DURABILITY AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS


TECHNICAL FIELD

[0002] The present invention relates to a steel composition for a bearing having improved fatigue durability, and a method of manufacturing the same. In particular, the steel composition may contain a spheroidized complex carbide to provide substantially improved hardness, strength, and toughness, and improved fatigue strength and fatigue life.

BACKGROUND

[0003] Recently, an environmental problem has been on the rise around the globe, and thus a method of reducing fuel in accordance with such problems which encompasses all industries has been sought. In particular, for reducing fuel consumption a vehicle industrial field has proposed improving fuel efficiency of a vehicle engine and reducing a weight of vehicles. By reducing the weight of vehicles, for example, fuel efficiency of the vehicle can be increased. However, when reducing the weight of vehicles, there occurs a problem in that strength and durability required in vehicles are not satisfied. Therefore, it is the greatest goal of the vehicle industry to solve this problem.

[0004] Therefore, under the environmentally-friendly trend, in the vehicle industry, various environmentally-friendly vehicles have been developed with an object of reducing a discharge amount of carbon dioxide to 95 g/km that is 27% of a current discharge amount thereof by 2021 based on European regulations. Further, vehicle makers have developed a technology to downsize and improve fuel economy in order to meet 54.5 mpg (23.2 km/l) which is a regulation value of corporate average fuel economy (CAFE) in the USA by 2025.

[0005] Generally, with increase in number of parts or an increase in weight of additional parts, a weight of a material for those parts should be reduced. In this case, as a weight reduction method, a heat-treating technology for implementing high strength of the material or hardening a material surface has been frequently used. Further, as shapes of parts being complicated, precise joining, low distortion welding, and low distortion heat-treating technologies have been used. In addition to this, as a technology for reducing noise, a technology of reducing distortion caused by heat treating, and a technology for reducing noise and removing dust have been used.

[0006] Particularly, a high performance and high efficiency technology of engines and transmissions for maximizing fuel economy of vehicles has been developed, and this technology may include an increase in the number of gears, a novel concept drive-way device, high efficiency of a two-pump system, a fusion hybrid technology, technologies relating to an automatic/manual fusion transmission and a hybrid transmission, and the like.

[0007] An alloy steel used in this technology relating to the engines and the transmissions has been used in parts of the engines, carriers of the manual or automatic transmissions, annulus gears, shafts, synchronizer hubs, or the like, and such an alloy steel used in the engine may correspond to about 32 to 40% based on the weight of the engine and the alloy steel used in the transmission may correspond about 58 to 62 wt% based on the weight of the transmission. Particularly, as the materials of the transmission parts, for example, the gear or the shaft, development of high strengthening and high durability materials has been continuously required with demand for a weight reduction and downsizing. However, a technology relating to downsizing the parts, reducing sizes of the parts, or improving fuel efficiency has problems. For instance, when a load applied to the parts of the engines is increased, a quality of the parts may be reduced and a durability life may be reduced due to burning, friction, abrasion, and the like. Moreover, due to an increase in severity of parts and a lack of durability of a material, surface damage may occur, and when the alloy steel is used without a lubricant, a surface temperature may be increased, and thus hardness may be reduced at high temperatures or under an environment requiring a lot of rotation. Therefore, durability of the bearing steel in the related art may require to be reinforced.

[0008] Generally, the gears of the transmission of the vehicle are parts performing a role of directly transferring engine power to a differential system and effectively transferring rotation or power between two or more shafts, such that engine power is attuned to a driving state of the vehicle. In addition, the gears of the transmission receive bending stress and contact stress simultaneously. In the gears, when durability of the material is insufficient, fatigue failure (tooth breakage) due to a lack of bending fatigue strength and fatigue damage (pitting) due to a lack of contact fatigue strength may frequently occur. Therefore, in the gears, physical properties such as high hardness, strength, toughness, fatigue strength, and a fatigue life are required.

[0009] In the related arts, a conventional bearing steel, such as SUJ2, including iron (Fe) as a main component, 1.00 wt % of carbon (C), 0.27 wt % of silicon (Si), 0.38 wt % of manganese (Mn), 0.012 wt % of phosphorus (P), 0.005 wt % of sulfur (S), 1.46 wt % of copper (Cu), 0.05 wt % of nickel (Ni), 1.46 wt % of chromium (Cr), 0.02 wt % of molybdenum (Mo), 0.017 wt % of aluminum (Al), and 0.0006 wt % of oxygen (O) has been typically used. However, this steel has a problem in terms of durability and thus has a problem in that surface damage (flaking) and pin abrasion of a pinion shaft are severe.

[0010] Therefore, the present inventors have tried to develop a steel composition for bearing and the bearing steel having improved physical properties such as hardness, strength, toughness, fatigue strength, and a fatigue life, and a method of manufacturing the same.

SUMMARY OF THE INVENTION

[0011] In preferred aspects, the present invention provides a steel composition for bearing and a method of manufacturing the same. The steel composition may comprise iron (Fe) as a main component, carbon (C), silicon (Si), manganese (Mn), phosphorus (P), sulfur (S), copper (Cu), nickel (Ni), chromium (Cr), molybdenum (Mo), aluminum (Al), nitrogen (N), oxygen (O), and vanadium (V) to improve
physical properties such as hardness, strength, and toughness and thus improve durability, fatigue strength, and a fatigue life.

An exemplary embodiment of the present invention provides a steel composition for bearing that comprises: an amount of about 0.08 to 1.0 wt % of carbon (C), an amount of about 0.9 to 1.6 wt % of silicon (Si), an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P), an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S), an amount of about 0.01 to 0.1 wt % of copper (Cu), an amount of about 0.01 to 0.06 wt % of aluminum (Al), an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N), an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and iron (Fe) being the balance of the weight of the steel composition, all wt % based on a total weight of the steel composition.

It would be understood that all the weight % (wt %) referred to herein is based on the total weight of the steel or alloy steel composition, unless otherwise indicated.

Additionally, the steel composition of the present invention may further comprise manganese (Mn), and preferably, a content of manganese (Mn) may be an amount of about 0.5 to 1.00 wt %.

The steel composition of the present invention may further comprise nickel (Ni), and preferably, a content of nickel (Ni) may be an amount of about 0.1 to 0.6 wt %.

The steel composition of the present invention may further comprise chromium (Cr), and preferably, a content of chromium (Cr) may be an amount of about 1.4 to 1.55 wt %.

The steel composition of the present invention may further comprise molybdenum (Mo), and preferably, a content of molybdenum (Mo) may be an amount of about 0.2 to 0.5 wt %.

The steel composition of the present invention may further comprise vanadium (V), and preferably, a content of vanadium (V) may be an amount greater than 0 wt % and of about 0.4 wt % or less.

Alternatively, the steel composition of the present invention may further include one or more of selected from the group consisting of manganese (Mn), nickel (Ni), chromium (Cr), molybdenum (Mo), or vanadium (V), and preferably, a content of manganese (Mn) may be an amount of about 0.5 to 1.00 wt %, a content of nickel (Ni) may be an amount of about 0.1 to 0.6 wt %, a content of chromium (Cr) may be an amount of about 1.4 to 1.55 wt %, a content of molybdenum (Mo) may be an amount of about 0.2 to 0.5 wt %, and a content of vanadium (V) may be an amount greater than 0 wt % and of about 0.4 wt % or less.

Also provided is the steel composition or steel alloy composition of the invention that may consist of, essentially consist of, or consist essentially of the components above. For example, the steel composition for bearing may consist of, essentially consist of, or consist essentially of: an amount of about 0.08 to 1.0 wt % of carbon (C); an amount of about 0.9 to 1.6 wt % of silicon (Si); an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P); an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S); an amount of about 0.01 to 0.1 wt % of copper (Cu); an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and iron (Fe) constituting the balance of the weight of the steel composition, all wt % based on the total weight of the alloy steel composition. Further, the steel composition for bearing may consist of, essentially consist of, or consist essentially of: an amount of about 0.08 to 1.0 wt % of carbon (C); an amount of about 0.9 to 1.6 wt % of silicon (Si); an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P); an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S); an amount of about 0.01 to 0.1 wt % of copper (Cu); an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and iron (Fe) constituting the balance of the weight of the steel composition, all wt % based on the total weight of the alloy steel composition.

Another exemplary embodiment of the present invention provides a method of manufacturing a bearing steel. The method may comprise: manufacturing a wire rod comprising an alloy steel composition; heat-treating the wire rod for primary spheroidizing; wire drawing the heat-treated wire rod; secondary heat-treating the wire-drawn wire rod for secondary spheroidizing; forging the secondary heat-treated wire rod; quenching the forged wire rod; and tempering the quenched wire rod.

In particular, the alloy steel composition may comprise: an amount of about 0.08 to 1.0 wt % of carbon (C); an amount of about 0.9 to 1.6 wt % of silicon (Si); an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P); an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S); an amount of about 0.01 to 0.1 wt % of copper (Cu); an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); and iron (Fe) constituting the balance of the weight of the alloy steel composition, all wt % based on the total weight of the alloy steel composition. Further, the alloy steel composition may comprise: an amount of about 0.08 to 1.0 wt % of carbon (C); an amount of about 0.9 to 1.6 wt % of silicon (Si); an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P); an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S); an amount of about 0.01 to 0.1 wt % of copper (Cu); an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and iron (Fe) constituting the balance of the weight of the alloy steel composition, all wt % based on the total weight of the alloy steel composition.

The term “spheroidizing” or “spheroidize”, as used herein, refers to a heat-treating process, particularly used for iron based alloy steel or a composition thereof. Particularly, the spheroidizing may refer to a heat-treating process that changes the shape or crystalline shape of carbons of carbide or carbide complex contained in the iron based steel into, for example, globular form, spheroid, or elliptical form, to provide desirable physical properties, such as mechanical strength, high temperature resistance, ductility, machinability and the like. During the spheroidizing, the temperature may be increased up to an iron based alloy steel.

The heat-treating for the primary spheroidizing may be performed at a temperature of about 720 to 850° C. for about 4 to 8 hours.
The secondary heat-treating for the secondary spheroidizing may be performed at a temperature of about 720 to 850° C. for about 4 to 8 hours.

The quenching may be performed at a temperature of about 840 to 860° C. for about 0.5 to 2 hours.

The tempering may be performed at a temperature of about 150 to 190° C. for about 0.5 to 2 hours.

Preferably, thus manufactured bearing steel may contain a carbide complex which may include one or more selected from the group consisting of M₁₅C₇, M₁₇C₇, and M₁₉C₈ carbides, and MC carbides.

The term “carbide complex”, as used herein, refers to a compound comprising at least carbon and other elements that is less electronegative to be positive or partially positive when combined with carbon. The carbide complex may be suitably formed with at least carbon and metal, and the metal may be an alkali metal, an alkali earth metal or a transition metal, a post-transition metal, a lanthanide, or an actinide, without limitation. In particular, the M₁₅C₇, M₁₇C₇, and M₁₉C₈ carbides may be one or more selected from the group consisting of vanadium (V) and molybdenum (Mo).

The bearing or bearing steel of the steel composition comprising iron (Fe) as a main component, carbon (C), silicon (Si), manganese (Mn), phosphorus (P), sulfur (S), copper (Cu), nickel (Ni), chromium (Cr), molybdenum (Mo), aluminum (Al), nitrogen (N), oxygen (O), and vanadium (V) may contain the complex carbide such as M₁₅C₇, M₁₇C₇, M₁₉C₈ (Me: Cr, Fe, Mn) that is finely formed through adjustment of alloy components of the bearing steel and control of a process condition. As such, physical properties of the bearing steel, such as hardness, strength, and toughness of a bearing and thus improve durability, fatigue strength, and a fatigue life, may be substantially improved. Moreover, high strengthening of the bearing steel may be obtained, and thus through a thickness reduction thereof, a weight reduction of about 20%, and the like, may secure the degree of freedom in design of a vehicle and reduce manufacturing costs.

Further provided is a vehicle part that can be manufactured by the bearing steel of the alloy composition as described above. For example, a transmission and an engine for a vehicle can be manufactured by using the bearing comprising the steel or alloy steel composition as described above, such that it is possible to improve durability of the vehicle and reduce weight of the vehicle, thereby improving fuel efficiency and prevent environmental pollution.

Other aspects of the invention are disclosed infra.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a flowchart of an exemplary method of manufacturing a bearing steel according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, preferable exemplary embodiments of the present invention will be described in detail. Prior to this, terms or words used in the present specification and claims should not be interpreted as having meanings and concepts which comply with the technical spirit of the present invention, based on the principle that an inventor can appropriately define the concept of the term to describe his/her own invention in the best manner. Accordingly, the embodiment described in the present specification is just the most preferred embodiment of the present invention but does not represent all technical spirits of the present invention. Therefore, it should be understood that there are various equivalents and modifications replacing the embodiments at the time of filing of the present application.

It would be understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

Unless specifically stated or obvious from context, as used herein, the term “about” is understood as within a range of normal tolerance in the art, for example within 2 standard deviations of the mean. “About” can be understood as within 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, 0.1%, 0.05%, or 0.01% of the stated value. Unless otherwise clear from the context, all numerical values provided herein are modified by the term “about.”

It would be also understood that the term “vehicle” or “vehicular” or other similar term as used herein is inclusive of motor vehicles in general such as passenger automobiles including sports utility vehicles (SUV), buses, trucks, various commercial vehicles, watercraft including a variety of boats and ships, aircraft, and the like, and includes hybrid vehicles, electric vehicles, plug-in hybrid electric vehicles, hydrogen-powered vehicles and other alternative fuel vehicles (e.g. fuels derived from resources other than petroleum). As referred to herein, a hybrid vehicle is a vehicle that has two or more sources of power, for example both gasoline-powered and electric-powered vehicles.

Hereinafter, the present invention will be described in detail. The present invention relates to a bearing steel having improved fatigue durability and a method of manufacturing the same, and in one aspect, the present invention relates to a bearing steel having improved fatigue durability.

The steel composition for bearing may have improved durability. The steel composition may comprise: an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P), an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S), an amount of about 0.01 to 0.1 wt % of copper (Cu), an amount of about 0.01 to 0.06 wt % of aluminum (Al), an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N), an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O), and iron (Fe) constituting the balance of the weight of the steel composition. All the weight % (wt %) are based on the total weight of the steel composition.

In particular, according to a necessity of the invention, the steel composition for bearing may suitably comprise one or more of an amount of about 0.8 to 1.0 wt % of carbon (C), an amount of about 0.9 to 1.6 wt % of silicon (Si), an amount of about 0.5 to 1.00 wt % of manganese (Mn), an amount of about 0.1 to 0.6 wt % of nickel (Ni), an amount of about 1.4 to 1.55 wt % of chromium (Cr), an
amount of about 0.2 to 0.5 wt % of molybdenum (Mo), and an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V).

[0041] Hereinafter, each component of the steel composition and content thereof will be described in detail

[0042] (1) Carbon (C)

[0043] Carbon (C), as used herein, may be important to secure strength of the bearing steel, and stabilize residual austenite.

[0044] Preferably, the content of carbon (C) may be an amount of about 0.8 to 1.0 wt % based on the total weight of the alloy steel composition. When the content of carbon (C) is less than about 0.8 wt %, strength of the steel used as bearing steel may not be sufficiently obtained and a reduction in fatigue strength and the like may be caused. On the other hand, when the content of carbon (C) is greater than about 1.0 wt %, an undissolved large carbide may remain in the steel, and thus fatigue strength, a durability life, and the like may be reduced and processability before quenching and the like may be reduced.

[0045] (2) Silicon (Si)

[0046] Silicon (Si), as used herein, may serve as a deoxidizer, and suppress formation of a pin hole of the alloy steel, thereby increasing strength of the alloy steel by a solid-solution strengthening effect as being solid-solved in a matrix, and increasing activity of carbon (C) and the like.

[0047] Preferably, the content of silicon (Si) may be an amount of about 0.9 to 1.6 wt % based on the total weight of the alloy steel composition. When the content of silicon (Si) is less than about 0.9 wt %, oxide by oxygen may not be sufficiently removed and remain in the alloy steel, and thus strength of the alloy steel may be reduced and a sufficient solid-solution strengthening effect may not be obtained. When the content of silicon (Si) is greater than about 2.0 wt %, decarbonization may occur by an interpenetration reaction in a mixture, such as a site competition reaction with carbon (C) by the excessive content of silicon (Si), and processability may be rapidly reduced due to an increase in hardness before quenching.

[0048] (3) Manganese (Mn)

[0049] Manganese (Mn), as used herein, may improve a quenching property of the alloy steel and improve the strength of the alloy steel and the like.

[0050] Preferably, the content of manganese (Mn) may be an amount of about 0.5 to 1.0 wt %. When the content of manganese (Mn) is less than about 0.5 wt %, an improvement effect of the quenching property of the alloy steel may be reduced. On the other hand, when the content of manganese (Mn) is greater than about 1.0 wt %, processability before quenching may be reduced and MnS reducing center segregation and a fatigue life may be precipitated.

[0051] (4) Nickel (Ni)

[0052] Nickel (Ni), as used herein, may micronize crystal grains of the alloy steel and may be solid-solved in austenite and ferrite to strengthen a matrix. Moreover, nickel may improve toughness to an impact at low temperatures and a hardening ability, and reduce a temperature of an AI transformation point to expand austenite. Further, nickel may increase activity of carbon.

[0053] Preferably, the content of nickel (Ni) may be an amount of about 0.1 to 0.6 wt %. When the content of nickel (Ni) is less than about 0.1 wt %, an effect of micronization of the crystal grains and improvement effect such as solid-solution strengthening and matrix strengthening may not be sufficiently obtained. On the other hand, when the content of nickel (Ni) is greater than about 0.6 wt %, red shortness and like may be caused in the alloy steel.

[0054] (5) Chromium (Cr)

[0055] Chromium (Cr), as used herein, may improve a quenching property of the alloy steel, provide hardenability, and simultaneously, micronize a tissue of the alloy steel and spheroidize the tissue by heat-treating. Further, chromium may harden a lamella in cementite.

[0056] Preferably, the content of chromium (Cr) may be an amount of about 1.5 to 3.0 wt %. When the content of chromium (Cr) is less than about 1.5 wt %, the quenching property and hardenability may be limited and sufficient micronization and spheroidizing of the tissue may not be obtained. On the other hand, when the content of chromium (Cr) is greater than about 3.0 wt %, an increase effect of the content may not be sufficient, and thus manufacturing costs may be increased.

[0057] (6) Molybdenum (Mo)

[0058] Molybdenum (Mo), as used herein, increase a quenching property of the alloy steel thereby improving hardenability, toughness, and the like of the alloy steel after tempering and providing brittleness resistance. Further, molybdenum may reduce activity of carbon.

[0059] Preferably, the content of molybdenum (Mo) may be an amount of about 0.2 to 0.5 wt %. When the content of molybdenum (Mo) is less than about 0.2 wt %, hardenability and toughness of the alloy steel, and the like may not be sufficiently secured. On the other hand, when the content of molybdenum (Mo) is greater than about 0.5 wt %, processability (machinability) and productivity of the alloy steel, and the like may be reduced and an increase effect of the content may not be sufficient and thus manufacturing costs may be increased.

[0060] (7) Vanadium (V)

[0061] Vanadium (V), as used herein, may form precipitates such as carbides, strengthen a matrix tissue and thus improve strength and wear resistance through a precipitation strengthening effect. In addition, vanadium may reduce activity of carbon, and further, at the same cooling rate, strength of the alloy steel may be increased by addition of vanadium.

[0062] Preferably, the content of vanadium (V) may be an amount greater than 0 wt % and of 0.8 wt % or less. When the content of vanadium (V) is greater than about 0.4 wt %, toughness and hardness of the alloy steel and the like may be reduced.

[0063] (8) Aluminum (Al)

[0064] Aluminum (Al), as used herein, may be an element serving as a strong deoxidizer and serving to improve cleanliness of the alloy steel and be reacted with nitrogen (N) in the alloy steel to form nitride and thus micronize the crystal grains.

[0065] Preferably, the content of aluminum (Al) may be an amount of about 0.01 to 0.06 wt %. When the content of aluminum (Al) is less than about 0.01 wt %, sufficient effects relating to the deoxidizer, cleanliness, and micronization of the crystal grains may not be obtained. On the other hand, when the content of aluminum (Al) is greater than about 0.06 wt %, coarse oxide inclusions and the like may be formed to reduce a fatigue life of the steel and the like.

[0066] (9) Nitrogen (N)

[0067] Nitrogen (N), as used herein, may stabilize austenite, micronizing crystal grains, and improve tensile strength,
yield strength, and elongation of the alloy steel and the like. However, an impurity or AlN (aluminum nitride) may be formed to reduce a durability life when excessive amount of nitrogen is included.

**0068** Preferably, the content of nitrogen (N) may be greater than 0 wt% and of about 0.006 wt% or less. When the content of nitrogen (N) is greater than 0.006 wt%, brittleness may be caused and the durability life and the like may be reduced.

**0069** (10) Oxygen (O)
**0070** Oxygen (O), as used herein, may increase generation of the impurity of the alloy steel to reduce cleanliness and degrade the alloy steel through contact fatigue.

**0071** Preferably, the content of oxygen (O) may be an amount of about 0.001 wt% or less. When the content of oxygen (O) is greater than 0.001 wt%, the impurity of the alloy steel may be increased to degrade the alloy steel due to contact fatigue.

**0072** (11) Phosphorus (P)
**0073** Phosphorus (P), as used herein, may induce crystal grain boundary segregation to reduce toughness of the alloy steel.

**0074** Preferably, the content of phosphorus (P) may be an amount greater than 0.001 wt% and of about 0.03 wt% or less. When the content of phosphorus (P) is greater than about 0.03 wt%, toughness of the alloy steel may be reduced.

**0075** (12) Sulfur (S)
**0076** Sulfur (S), as used herein, may increase machinability of the alloy steel to facilitate processing, and also reduce toughness of the alloy steel due to grain boundary segregation and reduce a fatigue life of the alloy steel by being reacted with manganese (Mn) to form MnS.

**0077** Preferably, the content of sulfur (S) may be an amount greater than 0 wt% and of about 0.01 wt% or less. When the content of sulfur (S) is greater than about 0.01 wt%, toughness of the alloy steel may be reduced thereby reducing a fatigue life of the steel.

**0078** (13) Copper (Cu)
**0079** Copper (Cu), as used herein, may improve hardenability of the alloy steel and the like.

**0080** Preferably, the content of copper (Cu) may be an amount of about 0.01 to 0.1 wt%. When the content of copper (Cu) is less than about 0.01 wt%, sufficient hardenability improvement effect may not be obtained. Meanwhile, when the content of copper (Cu) is greater than about 0.1 wt%, since a solid-solution limitation may be exceeded, a strength improvement effect of the steel may be saturated, and thus manufacturing costs may be increased and red shortness may be caused.

**0081** Since the steel composition for bearing including the aforementioned components may have superior hardness, strength, toughness, fatigue strength, and a fatigue life. Accordingly, the steel composition may be applied to vehicle parts and the like. For example, the steel composition for bearing may be applied to automatic or manual transmissions and the like of vehicles, and among the transmission parts, the bearing steel may be applied to carriers, annulus gears, gears, shafts, synchronizer hubs, or the like.

**0082** Hereinafter, in another aspect, the present invention relates to a method of manufacturing a bearing steel having improved fatigue durability.

**0083** The bearing steel having improved fatigue durability according to the present invention may be suitably manufactured by a person with ordinary skill in the art with reference to a publicly known technology.

**0084** The method of manufacturing a bearing steel having improved fatigue durability according to the present invention may comprise:

**0085** For example, as shown in FIG. 1, the method may comprise: mixing components of the alloy steel for a bearing (S10); heat-treating the alloy steel for primary spheroidizing at a temperature of about 720 to 850°C for about 4 to 8 hours (S20); wire drawing the heat-treated alloy steel (S30); secondary heat-treating the wire-drawn alloy steel for secondary spheroidizing at a temperature of about 720 to 850°C for about 4 to 8 hours (S40); forging the secondary heat-treated alloy steel (S50); quenching the forged alloy steel at a temperature of about 840 to 860°C for about 0.5 to 2 hours (S60); and tempering the quenched alloy steel at a temperature of about 150 to 190°C for about 0.5 to 2 hours (S70).

**0086** In the method of manufacturing the bearing steel, the complex carbide may be formed and spheroidized in the steel. Particularly, the complex carbide may include one or more selected from the group consisting of M₁₂C, M₁₇C₇, and M₁₇C₉ carbides, and MC carbides that are precipitates. M may be a metal or a transition metal without limitation.

**0087** Preferably, M of the M₁₂C and M₁₇C₇ carbides, and the M₁₇C₉ carbides may be one or more selected from the group consisting of vanadium (V) and molybdenum (Mo). When the aforementioned complex carbide is formed, strength and hardness of the bearing steel, and the like may be improved, and a durability life and the like may be prolonged.

**0088** The method may comprise manufacturing a wire rod using the alloy steel for bearing, as described above. For example, the wire rod comprising the alloy component as described above may be manufactured by adding and mixing one or more components selected from carbon (C), silicon (Si), manganese (Mn), nickel (Ni), chromium (Cr), molybdenum (Mo), or vanadium (V) to iron (Fe) as the main component, phosphorus (P), sulfur (S), copper (Cu), aluminum (Al), nitrogen (N), and oxygen (O). Thus manufactured wire rod may be further heat treated for primary spheroidizing, for example, at a temperature of about 720 to 850°C for about 4 to 8 hours (S20); wire drawn (S30); secondary heat-treated for second spheroidizing, for example, at a temperature of about 720 to 850°C for about 4 to 8 hours (S40); forged (S50); quenched, for example, at a temperature of about 840 to 860°C for about 0.5 to 2 hours (S60); and tempered, for example, at a temperature of about 150 to 190°C for about 0.5 to 2 hours (S70).

**0089** The quenching of the manufacturing method may be performed at a temperature of about a temperature of about 840 to 860°C for about 0.5 to 2 hours, and the tempering may be performed at a temperature of about 150 to 190°C for about 0.5 to 2 hours.

**0090** When the quenching temperature is less than about 840°C or the quenching time is less than about 0.5 hours, a rapidly cooled tissue may be formed nonuniformly thereby causing material deviation. On the other hand, when the quenching temperature is greater than about 860°C or the quenching time is greater than about 2 hours, the spheroidized complex carbide formed by the primary and secondary spheroidizing heat-treating may be dissolved.
When the tempering temperature is less than about 150°C or the tempering time is less than about 0.5 hours, physical properties such as toughness of the bearing steel may not be secured. On the other hand, when the tempering temperature is greater than about 190°C or the tempering time is greater than about 2 hours, hardness of the bearing steel and the like may be rapidly reduced, and thus it may be difficult to improve a durability life.

Meanwhile, when temperatures in the primary and secondary spheroidizing heat-treating of the manufacturing method are each less than about 720°C or the spheroidizing heat-treating time is less than about 4 hours, a lot of spheroidizing time of the complex carbide may be required, and thus manufacturing costs may be rapidly increased. On the other hand, when temperatures in the primary and secondary spheroidizing heat-treating are greater than about 850°C, since the formed complex carbide is dissolved, a possibility of forming a lamella-type complex carbide instead of a spherical complex carbide during a cooling process may be significantly increased. Further, when times in the primary and secondary spheroidizing heat-treating are greater than about 8 hours, a spheroidizing rate of the complex carbide may be slowed thereby rapidly increasing manufacturing costs.

Example

Hereinafter, the present invention will be described in more detail through the Examples. These Examples are only for illustrating the present invention, and it will be obvious to those skilled in the art that the scope of the present invention is not interpreted to be limited by these Examples.

In order to compare physical properties of the bearing steel having improved fatigue durability according to exemplary embodiments of the present invention, Comparative Examples and Examples having the components as described in the following Table 1 were manufactured. The conditions of the primary and secondary spheroidizing heat-treating temperatures, the quenching temperature and time, and the tempering temperature and time applied are described in the following Table 2.

### Table 1

<table>
<thead>
<tr>
<th>Comparative Example</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cu</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>Al</th>
<th>N</th>
<th>O</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>1.00</td>
<td>0.27</td>
<td>0.38</td>
<td>0.012</td>
<td>0.005</td>
<td>0.05</td>
<td>0.05</td>
<td>1.46</td>
<td>0.02</td>
<td>0.017</td>
<td>0.0035</td>
<td>0.0006</td>
<td>—</td>
</tr>
<tr>
<td>Example 2</td>
<td>0.75</td>
<td>0.85</td>
<td>0.63</td>
<td>0.012</td>
<td>0.004</td>
<td>0.049</td>
<td>0.049</td>
<td>1.55</td>
<td>0.24</td>
<td>0.024</td>
<td>0.0049</td>
<td>0.0004</td>
<td>0.26</td>
</tr>
<tr>
<td>Example 3</td>
<td>0.95</td>
<td>1.02</td>
<td>0.62</td>
<td>0.010</td>
<td>0.005</td>
<td>0.047</td>
<td>0.047</td>
<td>1.42</td>
<td>0.23</td>
<td>0.023</td>
<td>0.0044</td>
<td>0.0003</td>
<td>0.43</td>
</tr>
<tr>
<td>Example 4</td>
<td>0.99</td>
<td>1.53</td>
<td>0.60</td>
<td>0.011</td>
<td>0.004</td>
<td>0.048</td>
<td>0.048</td>
<td>1.32</td>
<td>0.54</td>
<td>0.026</td>
<td>0.0052</td>
<td>0.0004</td>
<td>0.47</td>
</tr>
<tr>
<td>Example 5</td>
<td>0.92</td>
<td>1.72</td>
<td>0.70</td>
<td>0.014</td>
<td>0.004</td>
<td>0.049</td>
<td>0.049</td>
<td>1.47</td>
<td>0.048</td>
<td>0.017</td>
<td>0.0049</td>
<td>0.0003</td>
<td>—</td>
</tr>
<tr>
<td>Example 6</td>
<td>0.91</td>
<td>1.05</td>
<td>0.72</td>
<td>0.013</td>
<td>0.005</td>
<td>0.047</td>
<td>0.047</td>
<td>1.48</td>
<td>0.49</td>
<td>0.018</td>
<td>0.0042</td>
<td>0.0004</td>
<td>0.42</td>
</tr>
<tr>
<td>Example 7</td>
<td>0.88</td>
<td>1.45</td>
<td>0.73</td>
<td>0.011</td>
<td>0.004</td>
<td>0.048</td>
<td>0.048</td>
<td>1.13</td>
<td>0.62</td>
<td>0.015</td>
<td>0.0049</td>
<td>0.0005</td>
<td>—</td>
</tr>
<tr>
<td>Example 8</td>
<td>1.05</td>
<td>0.79</td>
<td>0.69</td>
<td>0.007</td>
<td>0.006</td>
<td>0.049</td>
<td>0.049</td>
<td>1.43</td>
<td>0.15</td>
<td>0.018</td>
<td>0.0052</td>
<td>0.0004</td>
<td>0.16</td>
</tr>
<tr>
<td>Example 9</td>
<td>0.83</td>
<td>1.24</td>
<td>0.68</td>
<td>0.012</td>
<td>0.005</td>
<td>0.047</td>
<td>0.047</td>
<td>1.45</td>
<td>0.13</td>
<td>0.015</td>
<td>0.0042</td>
<td>0.0005</td>
<td>0.43</td>
</tr>
<tr>
<td>Example 10</td>
<td>0.81</td>
<td>1.57</td>
<td>0.89</td>
<td>0.014</td>
<td>0.004</td>
<td>0.042</td>
<td>0.042</td>
<td>1.59</td>
<td>0.35</td>
<td>0.018</td>
<td>0.0047</td>
<td>0.0003</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Table 1 shows the constitutional components and the contents of Comparative Examples 1 to 10 according to the bearing steel in the related art and the constitutional components and the contents of Examples 1 to 3 according to the present invention.

### Table 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature in primary spheroidizing heat-treating (°C)</th>
<th>Temperature in secondary spheroidizing heat-treating (°C)</th>
<th>Quenching temperature (°C)</th>
<th>Tempering temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>720</td>
<td>850/1</td>
<td>150/1</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows, among the manufacturing conditions of Comparative Examples 1 to 10 and Examples 1 to 3 having the constitutional components and the contents of Table 1, temperatures in the primary and secondary spheroidizing heat-treating, the quenching temperature and time, and the tempering temperature and time. Herein, all of Comparative Examples 1 to 10 and Examples 1 to 3 satisfied temperatures in the primary and secondary spheroidizing heat-treating, the quenching temperature and time, and the tempering temperature and time according to the present invention.
TABLE 3

<table>
<thead>
<tr>
<th>Classification</th>
<th>Hardness at room temperature (HV)</th>
<th>Hardness at 300°C (HV)</th>
<th>Rotation number of rotation bending fatigue tester under surface pressure of 6.2 GPa at 150°C (L10 life, times)</th>
<th>Comparison of durability lives (based on Comparative Example 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative Example 1</td>
<td>720</td>
<td>698</td>
<td>8,400,000</td>
<td>100%</td>
</tr>
<tr>
<td>Comparative Example 2</td>
<td>764</td>
<td>725</td>
<td>9,320,000</td>
<td>111%</td>
</tr>
<tr>
<td>Comparative Example 3</td>
<td>753</td>
<td>723</td>
<td>9,290,000</td>
<td>111%</td>
</tr>
<tr>
<td>Comparative Example 4</td>
<td>768</td>
<td>715</td>
<td>9,410,000</td>
<td>112%</td>
</tr>
<tr>
<td>Comparative Example 5</td>
<td>751</td>
<td>717</td>
<td>8,620,000</td>
<td>103%</td>
</tr>
<tr>
<td>Comparative Example 6</td>
<td>765</td>
<td>724</td>
<td>8,690,000</td>
<td>103%</td>
</tr>
<tr>
<td>Comparative Example 7</td>
<td>741</td>
<td>718</td>
<td>8,750,000</td>
<td>104%</td>
</tr>
<tr>
<td>Comparative Example 8</td>
<td>759</td>
<td>712</td>
<td>9,540,000</td>
<td>114%</td>
</tr>
<tr>
<td>Comparative Example 9</td>
<td>773</td>
<td>726</td>
<td>9,140,000</td>
<td>109%</td>
</tr>
<tr>
<td>Comparative Example 10</td>
<td>748</td>
<td>718</td>
<td>9,390,000</td>
<td>112%</td>
</tr>
<tr>
<td>Example 1</td>
<td>842</td>
<td>829</td>
<td>18,579,000</td>
<td>22.1%</td>
</tr>
<tr>
<td>Example 2</td>
<td>843</td>
<td>831</td>
<td>18,347,000</td>
<td>21.8%</td>
</tr>
<tr>
<td>Example 3</td>
<td>847</td>
<td>834</td>
<td>18,482,000</td>
<td>22.0%</td>
</tr>
</tbody>
</table>

[0097] Table 3 shows hardness at room temperature, hardness at 300°C, and hardness at 150°C when surface pressure is 6.2 GPa, and the durability life considering Comparative Examples 1 to 10 and Examples 1 to 3 having the constitutitional components and the contents of Table 1 were manufactured according to the condition of Table 2.

[0098] Hardness at room temperature, hardness at 300°C, and hardness at 150°C when surface pressure was 6.2 GPa were measured at 300 gF according to the KS B 0811 measurement method by using the Micro Vickers Hardness tester. For the rotation number of the rotation bending fatigue tester, the L10 life was measured according to the KS B ISO 1143 measurement method under the condition of the maximum friction moment of about 20 kgf, the rotation number of about 200 to 3000 RPM, the maximum load of about 100 kg, and electric power of three phases, 220 V, and 7 kW by using the standard line diameter of the diameter of about 4 mm through the rotation bending fatigue tester. The L10 life is the durability life of the specimen, and means the total rotation number of the rotation bending fatigue tester until about 10% of the specimen is damaged.

[0099] Accordingly, reviewing hardness at room temperature (about 25°C), it can be confirmed from Table 3 that in Examples 1 to 3, as compared to Comparative Examples 1 to 10, hardness at room temperature was improved by 8.9% to 17.5%. Additionally, reviewing hardness at 300°C, it can be confirmed from Table 3 that in Examples 1 to 3, as compared to Comparative Examples 1 to 10, hardness at room temperature was improved by 14.4% to 19.4%.

[0100] It can be confirmed that when surface pressure was 6.2 GPa, of the rotation number of the rotation bending fatigue tester to the L10 life at 150°C, the average value of Examples 1 to 3 was 18,469,333 and was about two times higher than 9,055,000 which was the average value of Comparative Examples 1 to 10. That is, it can be confirmed from Table 3 that the bearing steels of the present invention were improved by 192.3% to 221.1% as compared to the related art.

[0101] In order to compare the durability lives of Comparative Examples 1 to 10 and Examples 1 to 3 based on the rotation number of the rotation bending fatigue tester, rotation number of the rotation bending fatigue tester of Comparative Example 1, 8,400,000, was set as the basis of the durability life of 100%. As compared to the rotation number of the rotation bending fatigue tester of Comparative Example 1 as the basis, the difference showing the degree of increase or decrease in rotation number of the rotation bending fatigue tester of Comparative Examples 2 to 10 and Examples 1 to 3 was represented as the percentage. That is, the percentage for comparing the durability lives of Comparative Examples 1 to 10 and Examples 1 to 3 is a value representing the degree of relative increase and decrease of the rotation numbers of the rotation bending fatigue tester of the residual Comparative Examples 2 to 10 and Examples 1 to 3 based on Comparative Example 1.

[0102] Herein, through comparison of the durability lives of the Comparative Examples and the Examples, it could be seen from Table 3 that like the rotation number of the rotation bending fatigue tester, the durability life of Examples 1 to 3 was about two times greater than the durability life of Comparative Examples 1 to 10.

[0103] As described above, in order to check the reason why hardness and the durability life of the Examples were better than those of the Comparative Examples, the types and vol % of the complex carbides included in Comparative Example 1 and Examples 1 to 3 are described in the following Table 4.

TABLE 4

<table>
<thead>
<tr>
<th>Classification</th>
<th>MoC</th>
<th>Fe-C</th>
<th>VC + NbC</th>
<th>MoC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative Example 1</td>
<td>---</td>
<td>---</td>
<td>12.7</td>
<td>---</td>
</tr>
<tr>
<td>Example 1</td>
<td>---</td>
<td>8.14</td>
<td>---</td>
<td>0.23</td>
</tr>
<tr>
<td>Example 2</td>
<td>7.58</td>
<td>1.06</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Example 3</td>
<td>9.19</td>
<td>---</td>
<td>1.19</td>
<td></td>
</tr>
</tbody>
</table>

Unit: vol %
Mo: One or more selected from the group consisting of chromium (Cr), iron (Fe), and manganese (Mn)

[0104] Table 4 shows the contents of the complex carbides included in Comparative Example 1 and Examples 1 to 3. As shown in Table 4, the complex carbide of Comparative Example 1 mainly included MoC with a small amount of MoC, but Examples 1 to 3 relatively uniformly included VC and NbC as well as MoC and MoC. This difference in constitution of the complex carbides may be considered as one of reasons why the Examples have hardness and the durability life that are better than those of the Comparative Examples.

[0105] Therefore, it could be experimentally confirmed that Examples 1 to 3 satisfying the components and the content range according to the present invention and manufactured through the heat-treating process according to the present invention included various complex carbides and the like, and thus had strength and the durability life that were better than those of Comparative Examples 1 to 10.
As described above, the present invention has been described in relation to specific embodiments of the present invention, but the embodiments are only illustration and the present invention is not limited thereto. Embodiments described may be changed or modified by those skilled in the art to which the present invention pertains without departing from the scope of the present invention, and various alterations and modifications are possible within the technical spirit of the present invention and the equivalent scope of the claims which will be described below.

What is claimed is:

1. A steel composition for bearing, comprising:
an amount of about 0.8 to 1.0 wt % of carbon (C);
an amount of about 0.9 to 1.6 wt % of silicon (Si);
an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P);
an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S);
an amount of about 0.01 to 0.1 wt % of copper (Cu);
an amount of about 0.01 to 0.06 wt % of aluminum (Al);
an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N);
an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and
iron (Fe) constituting the balance of the weight of the steel composition,
all wt % based on the total weight of the steel composition.

2. The steel composition of claim 1, further comprising:
an amount of about 0.5 to 1.00 wt % of manganese (Mn), based on the total weight of the steel composition.

3. The steel composition of claim 1, further comprising:
an amount of about 0.1 to 0.6 wt % of nickel (Ni), based on the total weight of the steel composition.

4. The steel composition of claim 1, further comprising:
an amount of about 1.4 to 1.55 wt % of chromium (Cr), based on the total weight of the steel composition.

5. The steel composition of claim 1, further comprising:
an amount of about 0.2 to 0.5 wt % of molybdenum (Mo), based on the total weight of the steel composition.

6. The steel composition of claim 1, further comprising:
an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V), based on the total weight of the steel composition.

7. The steel composition of claim 1, further comprising:
one or more selected from the group consisting of:
an amount of about 0.5 to 1.00 wt % of manganese (Mn),
an amount of about 0.1 to 0.6 wt % of nickel (Ni),
an amount of about 1.4 to 1.55 wt % of chromium (Cr),
an amount of about 0.2 to 0.5 wt % of molybdenum (Mo), and
an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V), all wt % based on the total weight of the steel composition.

8. The steel composition of claim 1, consisting essentially of:
an amount of about 0.08 to 1.0 wt % of carbon (C);
an amount of about 0.9 to 1.6 wt % of silicon (Si);
an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P);
an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S);
an amount of about 0.01 to 0.1 wt % of copper (Cu);
an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and
iron (Fe) constituting the balance of the weight of the steel composition,
all wt % based on the total weight of the steel composition.

9. The steel composition of claim 1, consisting essentially of:
an amount of about 0.08 to 1.0 wt % of carbon (C);
an amount of about 0.9 to 1.6 wt % of silicon (Si);
an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P);
an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S);
an amount of about 0.01 to 0.1 wt % of copper (Cu);
an amount of about 0.01 to 0.06 wt % of aluminum (Al);
an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N);
an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O);
one or more selected from the group consisting of:
an amount of about 0.5 to 1.00 wt % of manganese (Mn),
an amount of about 0.1 to 0.6 wt % of nickel (Ni),
an amount of about 1.4 to 1.55 wt % of chromium (Cr),
an amount of about 0.2 to 0.5 wt % of molybdenum (Mo),
and an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V); and
iron (Fe) constituting the balance of the weight of the steel composition,
all wt % based on the total weight of the steel composition.

10. A method of manufacturing a bearing steel, the method comprising:
manufacturing a wire rod comprising an alloy steel composition;
heat-treating the wire rod for primary spheroidizing;
wire drawing the heat-treated wire rod;
secondary heat-treating the wire-drawn wire rod for secondary spheroidizing;
forging the secondary heat-treated wire rod;
quenching the forged wire rod; and
tempering the quenched wire rod,
wherein the alloy steel composition comprises:
an amount of about 0.08 to 1.0 wt % of carbon (C);
an amount of about 0.9 to 1.6 wt % of silicon (Si);
an amount greater than 0 wt % and of about 0.03 wt % or less of phosphorus (P);
an amount greater than 0 wt % and of about 0.01 wt % or less of sulfur (S);
an amount of about 0.01 to 0.1 wt % of copper (Cu);
an amount of about 0.01 to 0.06 wt % of aluminum (Al); an amount greater than 0 wt % and of about 0.006 wt % or less of nitrogen (N); an amount greater than 0 wt % and of about 0.001 wt % or less of oxygen (O); and
iron (Fe) constituting the balance of the weight of the steel composition,
all wt % based on the total weight of the alloy steel composition.

11. The method of claim 10, wherein the alloy steel composition further comprises one or more selected from the group consisting of:
an amount of about 0.5 to 1.00 wt % of manganese (Mn),
an amount of about 0.1 to 0.6 wt % of nickel (Ni),
an amount of about 1.4 to 1.55 wt % of chromium (Cr),
an amount of about 0.2 to 0.5 wt % of molybdenum (Mo),
and an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V), all wt % based on the total weight of the alloy steel composition.
molybdenum (Mo), and an amount greater than 0 wt % and of about 0.4 wt % or less of vanadium (V), all wt % based on the total weight of the alloy steel composition.

12. The method of claim 10, wherein the heat-treating for the primary spheroidizing is performed at a temperature of about 720 to 850°C. for about 4 to 8 hours.

13. The method of claim 10, wherein the secondary heat-treating for the secondary spheroidizing is performed at a temperature of about 720 to 850°C. for about 4 to 8 hours.

14. The method of claim 10, wherein the quenching is performed at a temperature of about 840 to 860°C. for about 0.5 to 2 hours.

15. The method of claim 10, wherein the tempering is performed at a temperature of about 150 to 190°C. for about 0.5 to 2 hours.

16. The method of claim 10, wherein the bearing steel contains a complex carbide.

17. The method of claim 16, wherein the complex carbide comprises one or more selected from the group consisting of M₆C, M₂₃C₆, and M₂₃C₆ carbides, and MC carbides, wherein M is a metal or a transition metal.

18. The method of claim 16, wherein the M of the M₆C, M₂₃C₆, and M₂₃C₆ carbides is one or more selected from the group consisting of chromium (Cr), iron (Fe), and manganese (Mn) and the M of the MC carbide is one or more selected from the group consisting of vanadium (V) and molybdenum (Mo).

19. A vehicle part that comprises a steel composition of claim 1.

20. The vehicle part of claim 19, wherein the vehicle part is a bearing of an engine or a transmission.

* * * * *