1.0%, Ni: 0.05~~1.0~~% to 3.0%, and Ca: 0.0003~~1~~% to 0.0015%.

(3) A steel for a bearing part according to one aspect of the present invention includes, as a chemical composition, by mass%: C: 0.95% to 1.10%; Si: 0.10% to 0.70%; Mn: 0.20% to 1.20%; Cr: 0.90% to 1.60%; Al: 0.010% to 0.100%; N:0.003% to 0.030%; S: 0.025% or less; P: 0.025% or less; O: 0.0010% or less; and optionally one or more of the group consisting of; Mo: 0.25% or less, B: 0.0050% or less, Cu: 1.0% or less, Ni: 3.0% or less, and Ca: 0.0015% or less; and a remainder including Fe an impurities; a metallographic structure includes a spherical cementite and a ferrite; a number density of the spherical cementite having a grain size of 0.5 μm to 3.0 μm is 2.0×10^6 mm^{-2} or more in the metallographic structure.

(4) The steel for the bearing part according to (3) may include, as the chemical composition, by mass%, one or more of Mo: 0.01% to 0.25%, B: 0.0001% to 0.0050%, Cu: 0.1% to 1.0%, Ni: 0.05~~1.0~~% to 3.0%, and Ca: 0.0003~~1~~% to 0.0015%.

(5) A method for producing a steel for a bearing part according to one aspect of the present invention includes: a casting process for obtaining a steel piece having a chemical composition according to (3) or (4); a heating process of heating the steel piece to 900°C to 1300°C; a hot rolling process for obtaining a hot rolled wire rod by subjecting the steel piece to hot rolling at a finish rolling temperature of 850°C or less after the heating process; a winding process of winding the hot rolled wire rod after the hot rolling process at a winding temperature of 800°C or less; a cooling process for making a microstructure of the hot rolled wire rod a pearlite by cooling the hot rolled wire rod to 600°C at a cooling rate of 3.0 °C/second or less after the winding process; a wire drawing process of subjecting the hot rolled wire rod to wire drawing in which a total reduction of an area is 50% or more after the cooling process; and a spheroidizing annealing process for obtaining the steel for the bearing part by performing spheroidizing annealing in which the hot rolled wire rod after the wire drawing process is held at a temperature of 650°C to the lower of 750°C and A_1-5°C for 0.5 hours to 5 hours; wherein, A_1 represents a temperature at which A_1 transformation starts, and is a

A metallographic structure of a bearing part according to the present embodiment will be described. The metallographic structure of the bearing part according to the present embodiment is retained austenite, spherical cementite and martensite. FIG. 1 shows a SEM image of the microstructure of the bearing part according to the present embodiment. The SEM image of FIG. 1 shows the microstructure where the spherical cementite 2 precipitates in the martensite 1. Because retained austenite cannot be observed with SEM, retained austenite can be determined by the ratio of the diffraction intensity of martensite to the diffraction intensity of retained austenite with X-ray diffraction method (XRD).

In the metallographic structure of the bearing part according to the present embodiment, the amount of retained austenite is 18% to 25% by volume%. The sum of spherical cementite and martensite is preferably 75% to 82% by volume %, which is obtained by subtracting the amount of retained austenite from the total volume.

[0029]

A metallographic structure of steel for the bearing part according to the present embodiment will be described. The metallographic structure of the steel for the bearing part according to the present embodiment includes spherical cementite and ferrite. However, in order to obtain the rolling contact fatigue life and the hardness of the bearing part, it is preferable that microstructures other than spherical cementite and ferrite are not included in the steel for the bearing part. FIG. 2 shows a SEM image of the metallographic structure of the steel for the bearing part after the spheroidizing annealing according to the present embodiment. The SEM image of FIG. 2 shows the microstructure where the spherical cementite 5 precipitates in the ferrite 4.

[0030]

Hereinafter, regarding the chemical composition of the base elements of the bearing part, and the steel for the bearing part according to the present embodiment, the numerical limitation range and the reasons for the limitation will be described. Here, "%" in the following description represents "mass%".

The hot rolled wire rod has the same chemical composition as the bearing part. Then, it is preferable that the hot rolled wire rod has a metallographic structure consisting of pearlite and 5% or less of proeutectoid cementite by area ratio. When the hot rolled wire rod has supercooled structure such as martensite in the metallographic structure, it cannot be uniformly deformed during wire drawing. As a result, it may cause breaking wire. Therefore, it is preferable that the hot rolled wire rod does not include martensite and mainly include pearlite as the microstructure.

In addition, the size of the pearlite block has a very strong correlation with ductility. In other words, the wire drawability can be improved by refining the pearlite. Therefore, it is preferable that the average grain size of the pearlite block (circle equivalent diameter) be 15 μm or less. When the average grain size of the pearlite block is more than 15 μm, an effect of improving the wire drawability may not be obtained. On the other hand, it may be industrially difficult to control the average grain size of the pearlite block to 1 μm or less. Therefore, the average grain size of the pearlite block is preferably 1 μm to 15 μm. More preferably, the average grain size of the pearlite block is 1 μm to 10 μm.

The average grain size of the pearlite block (circle equivalent diameter) can be measured with an electron backscatter diffraction apparatus (EBSD).

[0050]

The proeutectoid cementite generally has little plastic deformability. Therefore, the proeutectoid cementite is divided by wire drawing, and it results in formation of voids. However, when the area ratio of the proeutectoid cementite is low and the thickness of the proeutectoid cementite is small, wire drawability is not inhibited. Accordingly, it is preferable that the proeutectoid cementite be 5% or less by area ratio and the thickness of the proeutectoid cementite be 1.0 μm or less. More preferably, the proeutectoid cementite is 3% or less by area ratio and the thickness of the proeutectoid cementite is 0.8 μm or less.

The area ratio of the proeutectoid cementite and the thickness of the proeutectoid

[0073]

The evaluation results of the microstructures of the materials, the producing method, the microstructures of the bearing parts and the rolling contact fatigue life are shown in Table 2-1 and Table 2-2. A1 to A19 are within the appropriate range of the present invention in the Table 1-1 and Table 2-1; ~~the ratio of the~~ normal rolling contact fatigue life is 1.5 times or more of the B1, the rolling contact fatigue life in a contaminated environment is 2 times or more of the B1, and thus, A1 to A19 have an excellent rolling contact fatigue life.

All of the metallographic structures of the steels for the bearing part consisted of spherical cementite and ferrite in examples of the present invention. In addition, all of the metallographic structures of the bearing parts consisted of retained austenite, spherical cementite and martensite.

On the other hand, A20 to A38, B1 and B2 are Comparative Examples. Since Comparative Examples of A20 to A38, B1 and B2 failed to satisfy one or both of the chemical composition and microstructures of the bearing parts, which are defined by the present invention, the rolling contact fatigue life was equivalent to a conventional bearing part, or inferior to a conventional bearing part.

[0074]

The chemical compositions of A20 to A31 were out of the scope of the present invention. Since the content of C was small in A20, the number density of spherical cementite in the steel for the bearing part was lowered. Therefore, since the average grain size of austenite was coarsened during quenching and the amount of retained austenite was insufficient, the rolling contact fatigue life of the bearing part in the contaminated environment was lowered. In addition, since the content of C was small, the number density of the spherical cementite in the bearing part was also insufficient. When the content of C was small, the strength during quenching was also low, and thus, the rolling contact fatigue life even under the normal conditions was lowered. On the other hand, the content of C was excessive in A21. Therefore, since the amount of retained austenite and the average grain size of the spherical cementite were excessive, the normal rolling contact fatigue life was not improved.

[0075]

The content of Mn was excessive in A23. Therefore, since cracks occurred during wire drawing due to martensite of the steel for the bearing part, both the normal rolling contact fatigue life and the rolling contact fatigue life in the contaminated environment were lowered in the bearing part. Furthermore, since wire drawability was lowered, enough amount of wire drawing could not be secured. Therefore, the

The bearing part according to claim 1 comprising, as the chemical composition, by mass%, one or more of

Mo: 0.01% to 0.25%,

B: 0.0001% to 0.0050%,

Cu: 0.1% to 1.0%,

Ni: ~~1.00~~0.05% to 3.0%, and

Ca: 0.0003~~1~~% to 0.0015%.

[Claim 3]

A steel for a bearing part comprising, as a chemical composition, by mass%,

C: 0.95% to 1.10%;

Si: 0.10% to 0.70%;

Mn: 0.20% to 1.20%;

Cr: 0.90% to 1.60%;

Al: 0.010% to 0.100%;

N: 0.003% to 0.030%;

S: 0.025% or less;

P: 0.025% or less;

O: 0.0010% or less;

optionally one or more of the group consisting of:

Mo: 0.25% or less,

B: 0.0050% or less,

Cu: 1.0% or less,

Ni: 3.0% or less, and

Ca: 0.0015% or less; and

a remainder including Fe and impurities;

wherein a metallographic structure includes a spherical cementite and a ferrite;

wherein a number density of the spherical cementite having a grain size of 0.5

μm to 3.0 μm is 2.0×10^6 mm^{-2} or more in the metallographic structure.

[Claim 4]

The steel for the bearing part according to claim 3 comprising, as the chemical composition, by mass%, one or more of

Mo: 0.01% to 0.25%,

B: 0.0001% to 0.0050%,

Cu: 0.1% to 1.0%,

Ni: ~~1.0~~0.05% to 3.0%, and

Ca: 0.0003~~1~~% to 0.0015%.

[Claim 5]

A method for producing a steel for a bearing part comprising,

a casting process for obtaining a steel piece having a chemical composition according to claim 3 or 4;

a heating process of heating the steel piece to 900°C to 1300°C;

a hot rolling process for obtaining a hot rolled wire rod by subjecting the steel piece to hot rolling at a finish rolling temperature of 850°C or less after the heating process;

a winding process of winding the hot rolled wire rod after the hot rolling process at a winding temperature of 800°C or less;

a cooling process for making a metallographic structure of the hot rolled wire rod a pearlite by cooling the hot rolled wire rod to 600°C at a cooling rate of 3.0 °C/second or less after the winding process;

a wire drawing process of subjecting the hot rolled wire rod to wire drawing in which a total reduction of an area is 50% or more after the cooling process; and

a spheroidizing annealing process for obtaining the steel for the bearing part by performing a spheroidizing annealing in which the hot rolled wire rod after the wire