Ca: 0 to 0.05%

Calcium (Ca) is an optional element and may not be contained. When contained, Ca immobilizes S as a sulfide, thereby improving hot workability. On the other hand, when the Ca content is too high, toughness, ductility and cleanliness deteriorate. Therefore, the Ca content is 0 to 0.05%. A lower limit of Ca is preferably 0.0005%. An upper limit of the Ca content is preferably 0.01%.

[0053]

Mg: 0 to 0.05%

Magnesium (Mg) is an optional element and may not be contained. When contained, Mg immobilizes S as a sulfide, thereby improving hot workability of a heat resistant alloy. On the other hand, when the Mg content is too high, toughness, ductility and cleanliness deteriorate. Therefore, the Mg content is 0 to 0.05%. A lower limit of Mg is preferably 0.0005%. An upper limit of the Mg content is preferably 0.01%.

[0054]

[Total volume ratio of precipitates (coarse precipitates) having a circle equivalent diameter of not less than 6 μm: not more than 5%]

As described so far, in the austenitic heat resistant alloy of the present embodiment, fine precipitates are caused to precipitate during use in a high temperature environment, and thus creep strength and maintaining toughness are increased. Examples of the precipitate include carbides, nitrides, NiAl, and α-Cr. When the precipitate is coarse, creep strength and toughness deteriorate. Therefore, coarse precipitates are preferably as small in amount as possible in a heat resistant alloy before use. Provided that the total volume ratio of precipitates having a circle equivalent diameter of not less than 6 μm (coarse precipitates) is not more than 5% in the structure of the heat resistant alloy, fine precipitates are caused to precipitate during use in a high temperature environment, and thus creep strength and toughness are increased. An upper limit of the total volume ratio of coarse precipitates is preferably 4%, and more preferably 3%. Here, the circle equivalent diameter of a precipitate means a diameter (μm) of a circle which has the same area as that of the precipitate.

[0055]

CLAIMS

1. An austenitic heat resistant alloy comprising a chemical composition, consisting of: in mass%,

C: 0.03 to less than 0.25%,

Si: 0.01 to 2.0%,

Mn: not more than 2.0%,

Cr: 10 to less than 30%,

Ni: more than 25 to 45%,

Al: more than 2.5 to less than 4.5%,

Nb: 0.2 to 3.5%,

N: not more than 0.025%,

Ti: 0 to less than 0.2%,

W: 0 to 6%,

Mo: 0 to 4%,

Zr: 0 to 0.1%,

B: 0 to 0.01%,

Cu: 0 to 5%,

rare earth metals: 0 to 0.1%,

Ca: 0 to 0.05%, and

Mg: 0 to 0.05%, with the balance being Fe and impurities, wherein P and S in the impurities are respectively, P: not more than 0.04% and S: not more than 0.01%, and wherein

in a structure, a total volume ratio of precipitates having a circle equivalent diameter of not less than 6 μm is not more than 5%.

2. The austenitic heat resistant alloy according to claim 1, wherein

the chemical composition contains one or more kinds selected from the group consisting of, in mass%,

Ti: 0.005 to less than 0.2%,

W: 0.005 to 6%,

Mo: 0.005 to 4%,

Zr: 0.0005 to 0.1%, and

B: 0.0005 to 0.01%.

3. The austenitic heat resistant alloy according to claim 1 or 2, wherein

the chemical composition contains one or more kinds selected from the group consisting of, in mass%,

Cu: 0.05 to 5%, and

rare earth metals: 0.0005 to 0.1%.

4. The austenitic heat resistant alloy according to any one of claims 1 to 3, wherein

the chemical composition contains one or more kinds selected from the group consisting of, in mass%,

Ca: 0.0005 to 0.05%, and

Mg: 0.0005 to 0.05%.

5. A method for producing an austenitic heat resistant alloy comprising steps of:

performing hot forging at a reduction of area of not less than 30% on a starting material having the chemical composition according to any one of claims 1 to 4;

producing an intermediate material by performing hot working on the starting material after hot forging; and

performing solution treatment at 1100 to 1250°C on the intermediate material to produce the austenitic heat resistant alloy having a total volume ratio of precipitates having a circle equivalent diameter of not less than 6 μm is not more than 5% in a structure.