(RELATED ART)

[0006] Patent Document 1: International Patent Publication WO2019/031577

SUMMARY

(PROBLEMS TO BE SOLVED BY THE INVENTION)

[0007] According to the technology of Patent Document 1, it is possible to obtain by additive manufacturing a member that excels in tensile strength, ductility, and corrosion resistance. However, to apply such the alloy member to more severe use environments, further improvement in corrosion resistance has been awaited.

The invention in Patent Document 1 includes an air-cooling or water-cooling process after a pseudo-solution heat treatment. Patent Document 1 describes that rapid cooling in a temperature range from 900ºC to 800ºC after the pseudo-solution heat treatment at this time results in difference of the average grain diameter of the minute precipitates, thereby enabling to improve the mechanical strength and ductility. However, no further consideration has been given to the cooling process, and there still is a place left for further consideration in improvement on the mechanical properties and corrosion resistance.

[0008] Due to above reasons, it is an object of the present invention to provide a method for producing an alloy member that is fabricated by additive manufacturing and has increased mechanical strength and ductility and higher corrosion resistance, and the alloy member.

(MEANS FOR SOLVING PROBLEMS)

[0009] A method for producing an alloy member according to an aspect of the present invention includes an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for the remainder; a heat treatment step for raising a temperature of the products through heating and holding the products at a temperature between 1080ºC and 1180ºC; and a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate from~~between~~ 110 ºC/min ~~and~~to less than 600~~2400~~ºC/min.

[0010] A method for producing an alloy member according to another aspect of the invention includes an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of Co, Cr, Fe, Ni, and Ti in a range

between 5 at%, and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for the remainder; a heat treatment step for raising a temperature of the products through heating and holding the products at a temperature between 1080ºC and 1180ºC; a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate from~~between~~ 110ºC/min ~~and~~to less than ~~2400~~600ºC/min; and an aging treatment step for applying aging treatment to the products at a temperature ranging from 500ºC to less than 900ºC after the forced cooling step.

[0010A] A method for producing an alloy member according to another aspect of the invention includes an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of cobalt (Co), chromium (Cr), iron (Fe), nickel (Ni), and titanium (Ti) in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder; a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC; and a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate more than 600ºC/min and 2400ºC/min or less wherein the forced cooling step uses any one of liquids of salt bath, quenching oil, and polymer aqueous solution.

[0010B] A method for producing an alloy member according to another aspect of the invention includes an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder; a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC; a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate more than 600ºC/min and 2400ºC/min or less; and an aging treatment step for applying aging treatment to the products at a temperature ranging from 500ºC to less than 900ºC after the forced cooling step.

[0011] Yet another aspect of the present invention is an alloy member including each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for the remainder, where a grain morphology of a parent phase is an equiaxed system, minute precipitates having an average diameter of 100 nm or less are deposited and dispersed among crystal grains of the parent phase, and deposition of hexagonal precipitates in crystal grain boundaries of

the parent phase is less than 1 vol%.

(EFFECTS OF THE INVENTION)

[0012] The present invention can provide a method for producing an alloy member that is fabricated by additive manufacturing and has increased mechanical strength and ductility and higher corrosion resistance, and the alloy member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a process drawing illustrating an example of a method for producing an alloy member according to the present invention.

FIG. 2 is a schematic view illustrating examples of a structure of an additive manufacturing device and an additive manufacturing method using a selective laser melting method.

FIG. 3 is a process drawing illustrating an example of a flow of a heat treatment step, a forced cooling step, and an aging treatment step, which follows the additive manufacturing.

FIGs. 4A and 4B show an example of a microstructure of the alloy member according to the present invention. FIG. 4A is an image view observed under a scanning electron microscope (SEM), FIG. 4B is an image view observed under a scanning transmission electron microscope (STEM).

WHAT IS CLAIMED IS:

1. A method for producing an alloy member comprising:

an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of cobalt (Co), chromium (Cr), iron (Fe), nickel (Ni), and titanium (Ti) in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder;

a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC; and

a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate from~~between~~ 110ºC/min ~~and~~to less than ~~2400~~600ºC/min.

2. A method for producing an alloy member comprising:

an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder;

a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC;

a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate ~~between~~from 110ºC/min ~~and~~to less than ~~2400~~600ºC/min; and

an aging treatment step for applying aging treatment to the products at a temperature ranging from 500ºC to less than 900ºC after the forced cooling step.

~~3. The method for producing the alloy member according to claim 1 or 2, wherein~~

~~the cooling rate in the forced cooling step ranges from 110ºC/min to less than 600ºC/min.~~

~~4.~~3. The method for producing the alloy member according to claim 1 or 2~~3~~, wherein

the forced cooling step uses at least one of inert gases of nitrogen, argon, or helium, which are at the atmospheric pressure or higher.

~~5. The method for producing the alloy member according to claim 1 or 2, wherein~~

~~the cooling rate in the forced cooling step ranges between 600ºC/min and~~

~~2400ºC/min.~~

~~6. The method for producing the alloy member according to claim 5, wherein~~

~~the forced cooling step uses any one of liquids of salt bath, quenching oil, and polymer aqueous solution.~~

~~7.~~4. The method for producing the alloy member according to any one of claims 1 to ~~3~~6, wherein

a heating rate of the heating process between 800ºC and 1080ºC in the heat treatment step is 5ºC/min.

~~8.~~5. The method for producing the alloy member according to any one of claims 1 to ~~4~~7, wherein

a laser beam or an electron beam is used as a heat source for additive manufacturing in the additive manufacturing step.

6. A method for producing an alloy member comprising:

an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of cobalt (Co), chromium (Cr), iron (Fe), nickel (Ni), and titanium (Ti) in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder;

a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC; and

a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate more than 600ºC/min and 2400ºC/min or less wherein

the forced cooling step uses any one of liquids of salt bath, quenching oil, and polymer aqueous solution.

7. A method for producing an alloy member comprising:

an additive manufacturing step for forming products by additive manufacturing using an alloy powder including each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%, Mo in a range of greater than 0 at% and 8 at% or less, and unavoidable impurities for a remainder;

a heat treatment step for raising a temperature of the products through heating, and holding the products at a temperature between 1080ºC and 1180ºC;

a forced cooling step for cooling the products after the heat treatment in a temperature range from a holding temperature to 800ºC at a cooling rate more than 600ºC/min and 2400ºC/min or less; and

an aging treatment step for applying aging treatment to the products at a temperature ranging from 500ºC to less than 900ºC after the forced cooling step.

8. The method for producing the alloy member according to claim 6 or 7, wherein the cooling rate is 1000 ºC/min or more.

9. The method for producing the alloy member according to any one of claims 6 to 8, wherein

a heating rate of the heating process between 800ºC and 1080ºC in the heat treatment step is 5ºC/min.

10. The method for producing the alloy member according to any one of claims 6 to 9, wherein

a laser beam or an electron beam is used as a heat source for additive manufacturing in the additive manufacturing step.

~~9.~~11. An alloy member comprising:

~~–~~each of Co, Cr, Fe, Ni, and Ti in a range between 5 at% and 35 at%;

Mo in a range of greater than 0 at% and 8 at% or less; and

unavoidable impurities for a remainder, wherein

~~–~~a grain morphology of a parent phase is an equiaxed system;

minute precipitates having an average diameter of 100 nm or less are deposited and dispersed among crystal grains of the parent phase; and

deposition of hexagonal precipitates in crystal grain boundaries of the parent phase is less than 1 vol%.

~~10.~~12. The alloy member according to claim 11~~9~~, wherein

a~~the~~ crystal structure of the parent phase includes at least one of a face-centered-cubic structure or a simple cubic structure.

~~11.~~13. The alloy member according to claim 11~~9~~ or 12~~0~~, wherein

the alloy member has tensile strength of 1100 MPa or more, elongation at break of 10% or more, and a corrosion rate in 10% boiling sulfuric acid of 5 mm/year or less.