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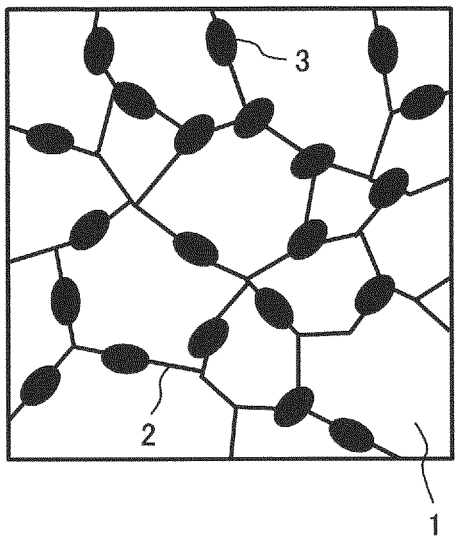
(54) SINTERED MATERIALS OF AUSTENITE STEEL POWDER AND TURBINE MEMBERS

(57) The present invention aims to provide sintered materials of austenite steel powder each having a strength which is equivalent to or in excess of the strength of a Ni-based alloy and insusceptible to oxygen and turbine members each being composed of each sintered material. There is provided the sintered material of austenite steel powder which contains 25 to 50% Ni; 12 to 25% Cr, 3 to 6% Nb; 0.001 to 0.05% B; not more than 1.6% Ti; not more than 6% W; not more than 4.8% Mo; and not more than 0.5% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

FIG. 1A



EP 3 653 322 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to sintered materials of austenite steel powder and turbine members.

BACKGROUND OF THE INVENTION

[0002] Nowadays, an increase in steam temperature is promoted aiming for efficiency enhancement of coal-fired power plants. In currently running coal-fired power plants, steam turbines which are as high as 620°C in steam temperature are currently operated as steam turbines (USC (Ultra Super Critical) pressure power generation) which are the highest in stream temperature. However, the increase in stream temperature is thought to be more promoted hereafter for suppressing CO_2 emission. Although 9Cr-type and 12Cr-type heat-resisting ferritic steels and so forth have been used so far as high-temperature members of the steam turbines, it is thought that application of these heat-resisting ferritic steels would become difficult in association with the increase in steam temperature.

[0003] An Ni-based alloy which is higher than the ferritic steels in durable temperature would become a candidate for an alloy which is applicable to the high-temperature members. The Ni-based alloy contains Al and Ti as precipitation strengthening elements and exhibits an excellent strength at high temperatures by generating a γ' phase which would become a stable phase at the high temperatures. However, although, in general, turbine valve casings, turbine discs and so forth are manufactured by casting methods, air shutoff in melting is not sufficiently attained by the casting methods and when amounts of active elements (Al and Ti) are large, these elements are oxidized.

[0004] A technology of applying austenite steel which simultaneously attains excellent strength and castability and an austenite steel casting which uses the austenite steel to turbine members in place of the Ni-based alloy is disclosed in Japanese Unexamined Patent Application Publication No. 2017-88963.

SUMMARY OF THE INVENTION

[0005] The above-described Japanese Unexamined Patent Application Publication No. 2017-88963 proposes a composition of the austenite steel which reduces macrosegregations in a large-sized casting. However, manufacturing of a metal mold which is used for the casting comparatively takes much time and labor. In particular, in a case of manufacturing a mold for a casting which is large-sized and has a complicated shape, a process cost is increased. Therefore, in a case where it becomes possible to obtain the turbine members not by casting but by sintering, it becomes possible to further increase manufacturability of the turbine members.

[0006] The present invention has been made in view of the above-described circumstances and aims to provide sintered materials of austenite steel powder each having a strength which is equivalent to or in excess of the strength of the Ni-based alloy and insusceptible to oxygen and turbine members each being composed of each sintered material of austinite steel powder.

[0007] In order to solve the above-described issues, according to a first aspect of the present invention, there is provided a sintered material of austenite steel powder which contains 25 to 50% Ni, 12 to 25% Cr, 3 to 6% Nb, 0.001 to 0.05% B, not more than 1.6% Ti, not more than 6% W, not more than 4.8% Mo, and not more than 0.5% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

[0008] In order to solve the above-described issues, according to a second aspect of the present invention, there is provided a sintered material of austenite steel powder which contains 30 to 45% Ni, 12 to 20% Cr, 3 to 5% Nb, 0.001 to 0.02% B, 0.3 to 1.3% Ti, not more than 5.5% W, not more than 2% Mo, and not more than 0.3% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

[0009] In order to solve the above-described issues, according to a third aspect of the present invention, there is provided a sintered material of austenite steel powder which contains 30 to 40% Ni, 15 to 20% Cr, 3.5 to 4.5% Nb, 0.001 to 0.02% B, 0.5 to not more than 1.1% Ti, not more than 5.5% W, and not more than 0.3% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

[0010] In order to solve the above-described issues, according to a fourth aspect of the present invention, there is provided a turbine member which uses the sintered material of austenite steel powder.

[0011] More specific configurations of the present invention are described in claims.

[0012] According to the present invention, it becomes possible to provide the sintered materials of austenite steel powder each having the strength which is equivalent to or in excess of the strength of the Ni-based alloy and insusceptible to oxygen and the turbine members each being composed of each sintered material of austinite steel powder.

[0013] Issues, configurations and effects other than the above will become apparent from the following description of practical examples of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1A is a schematic diagram illustrating one example of a structure of a sintered material of austinite steel powder according to one practical example of the present invention;
FIG. 1B is a photograph of one example of a structure of a sintered material of austinite steel powder according to one practical example of the present invention which is observed using an SEM (Scanning Electron Microscope);
FIG. 2 is a schematic diagram illustrating one example of the structure of the austinite steel cast material which is disclosed in Japanese Unexamined Patent Application Publication No. 2017-88963;
FIG. 3 is a schematic diagram illustrating one example of a structure of a related art Ni-based alloy forged material;
FIG. 4 is a schematic diagram illustrating one example of a turbine valve casing to which the sintered material of austinite steel powder according to one practical example of the present invention is applied;
FIG. 5 is a schematic diagram illustrating one example of a turbine disc to which the sintered material of austinite steel powder according to one practical example of the present invention is applied;
FIG. 6 is a graph illustrating one example of 0.2% proof stress (with a comparative example 4 being set as a standard) of practical examples 1 to 3 and comparative examples 1 to 4;
FIG. 7 is a graph illustrating one example of creep durable temperature ratios (with a comparative example 3 being set as the standard) of the practical examples 1 to 3 and the comparative examples 1 to 4; and
FIG. 8 is a graph illustrating one example of the 0.2% proof stress ratios and the creep durable temperature ratios of the practical examples 1 and 3 and the comparative examples 1, 3, and 4.

DETAILED DESCRIPTION

[0015] In the following, practical examples of the present invention will be described in detail with reference to the drawings.

[Sintered Material of Austenite Steel Powder]

[0016] FIG. 1A is a schematic diagram illustrating one example of a structure of a sintered material of austinite steel powder according to one practical example of the present invention and FIG. 1B is a photograph of one example of a structure of a sintered material of austinite steel powder according to one practical example of the present invention which is observed using an SEM (Scanning Electron Microscope). As illustrated in FIG. 1A and FIG. 1B, the sintered material of the austenite steel powder according to the practical example of the present invention has an austenite steel powder crystal 1, a crystal grain boundary 2 which is present at a boundary between mutually adjacent austenite steel powder crystal grains, and a Laves phase 3 which precipitates on the crystal grain boundary 3.

[0017] It is preferable that an average grain diameter of the austenite steel powder crystal 1 be 10 to 300 μm. In a case where the average grain diameter is smaller than 10 μm, there is a fear that a creep strength would not become sufficient. In a case where the average grain diameter is larger than 300 μm, there is a fear that tensile strength and fatigue strength would not become sufficient. In addition, a grain boundary coverage of the Laves phase 3 changes with changing the total number of the grain boundaries, and there is a fear that the strengths (the creep strength, the tensile strength, the fatigue strength and so forth) would be lowered. It is possible to measure the abovementioned "grain diameter" by using a planar image obtained in a case where the sintered material of austenite steel powder is observed using an observation unit such as an electronic microscope and so forth. In addition, it is possible to define the "average grain diameter" as a value obtained by averaging grain diameters of a predetermined number of the austenite steel powder crystals 1 which are displayed on the observed photograph of a predetermined magnification.

[0018] The cast structure which is disclosed in Japanese Unexamined Patent Application Publication No. 2017-88963 and a structure of a related art Ni-based alloy forged material (Alloy 718) will also be described in comparison with the structure of the above-described sintered material of the austenite steel power according to the practical example of the present invention. FIG. 2 is a schematic diagram illustrating one example of the structure of the cast material of austinite steel powder which is disclosed in Japanese Unexamined Patent Application Publication No. 2017-88963. As illustrated in FIG. 2, the cast material of austenite steel powder has an austenite steel powder crystal 4, a crystal grain boundary 5 which is present at a boundary between the mutually adjacent austenite steel powder crystals, and a Laves phase 6 which precipitates on the crystal grain boundary 5. In the cast structure, the number of the crystal grain boundaries is small and the grain diameters and shapes of the crystals are not homogeneous. In addition, the cast structure becomes larger than the structure of the sintered material in the micro segregation. It is thought that the micro segregation is increased as the member concerned becomes large, and there is a fear that a defect which is caused by the micro segregation would become liable to occur and the strengths would become liable to be reduced. On the other hand, since in the sintered material, a homogeneous structure is formed not depending on the size of the member concerned and therefore the micro segregation becomes difficult to occur.

[0019] FIG. 3 is a schematic diagram illustrating one example of the structure of the related art Ni-based alloy forged material (Alloy 718). As illustrate in FIG. 3, the Ni-based alloy forged material has an Ni-based alloy crystal 7, a prior particle boundary (PPB) 8 which is present at a boundary between the mutually adjacent Ni-based alloy crystals 7, and a delta phase 9 which precipitates on the prior particle boundary (PPB) 8.

[0020] As apparent from comparison among the structures in FIG. 1 to FIG. 3, the structure of the sintered material of austenite steel powder according to one practical example of the present invention is clearly distinguished from the structures of the related art austenite cast material and the Ni-based alloy forged material.

[0021] In the following, a composition of the sintered material of austenite steel powder according to one practical example of the present invention will be described. In the following description of compositions, it is supposed that "%" means "percentage by mass" unless otherwise specified.

Ni (nickel): 25 to 50%

[0022] Ni is added as an austenite phase stabilization element. In addition, Ni generates an intermetallic compound (a δ phase, Ni_3Nb) together with Nb which will be described later and contributes to intragranular strengthening by precipitating into grains. From the viewpoint of phase stabilization, an additive amount of Ni is preferably 25 to 50% (at least 25% and not more than 50%), more preferably 30 to 45%, and still more preferably 30 to 40%.

Cr (chromium): 12 to 25%

[0023] Cr is an element which improves oxidation resistance and steam oxidation resistance. It is possible to obtain sufficient oxidation resistance by adding Cr by 12% or more by taking an operating temperature of a steam turbine into consideration. Further, addition of Cr in excess of 25% leads to precipitation of intermetallic compounds such as a σ phase and so forth and induces reductions in high temperature ductility and toughness. When taking a balance among the abovementioned matters into consideration, an additive amount of Cr is preferably 12 to 25%, more preferably 12 to 20%, and still more preferably 15 to 20%.

Nb (niobium): 3 to 6%

[0024] Nb is added for stabilization of a Laves phase (Fe_2Nb) and the δ phase (Ni_3Nb). As illustrated in FIG. 1, the Laves phase 6 precipitates mainly on the grain boundary 2 and contributes to grain boundary strengthening. The δ phase precipitates mainly into the grains and contributes to the intragranular strengthening. It is possible to obtain a sufficient high temperature creep strength by adding Nb by 3% or more. When adding Nb in excess of 6%, there is the possibility that harmful phases such as the δ phase and so forth would become liable to precipitate. For obtaining the more sufficient high temperature creep strength, an additive amount of Nb is preferably 3 to 6%, more preferably 3 to 5%, and still more preferably 3.5 to 4.5%.

B (boron): 0.001 to 0.05%

[0025] B contributes to precipitation of the Laves phase on the grain boundary. In a case where B is not added, precipitation of the Laves phase on the grain boundary becomes difficult and the creep strength and creep ductility are reduced. The effect of grain boundary precipitation is obtained by addition of 0.001% or more of boron. On the other hand, when an additive amount of B is too large, a melting point is locally lowered and, for example, weldability would be reduced. When taking this matter into consideration, the additive amount of B is preferably 0.001 to 0.05% and more preferably 0.001 to 0.02%.

Ti (titanium): 0 to 1.6%

[0026] Ti is an element which contributes to intragranular precipitation strengthening of phases such as a γ" phase, the δ phase and so forth. It becomes possible to greatly reduce initial-stage creep deformation by appropriately adding Ti. However, excessive addition of Ti adversely affects mechanical properties of the member concerned under the influence of oxidation in manufacturing. When taking this matter into consideration, an additive amount of Ti is preferably not more than 1.6%, more preferably 0.3 to 1.3%, and still more preferably 0.5 to 1.1%.

W (tungsten): 0 to 6%

[0027] W contributes to stabilization of the Laves phase in addition to contribution to solid solution strengthening. A precipitation amount of the Laves phase which precipitates on the grain boundary is increased owing to addition of W, and W is able to contribute to improvement of breaking strength and ductility in long-term creep properties. When adding W in excess of 6%, there is the possibility that the harmful phases such as the δ phase and so forth would become liable to precipitate. When taking this matter into consideration, an additive amount of W is preferably not more than 6%, more preferably 5.3 to 6%, and still more preferably about 5.5%.

Mo (molybdenum): 0 to 4.8%

[0028] Mo contributes to stabilization of the Laves phase in addition to contribution to the solid solution strengthening. The precipitation amount of the Laves phase which precipitates on the grain boundary is increased owing to addition of Mo, and Mo is able to contribute to improvement of the breaking strength and the ductility in the long-term creep properties. When taking this matter into consideration, an additive amount of Mo is preferably 0 to 4.8% and more preferably 0 to not more than 2%.

Zr (zirconium): 0 to 0.5%

[0029] Zr contributes to precipitation of the γ'' phase (Ni_3Nb) in addition to contribution to precipitation of the Laves phase on the grain boundary similarly to B. Addition of Zr is particularly effective in a short time or at a low temperature (less than 750°C, desirably not more than 700°C). However, the γ'' phase is a metastable phase and therefore changes to the δ phase when maintained at a high temperature (in particular, 750°C or more) for a long time. Accordingly, Zr may not be added. When an additive amount of Zr is too large, the stability of the δ phase is improved and the γ'' phase changes to the δ phase early. In addition, weldability is worsened. When taking these matters into consideration, an additive amount of Zr is preferably 0 to 0.5% and more preferably 0 to not more than 0.3%.

[0030] As described above, the sintered material of austenite steel powder according to the practical example of the present invention contains Nb and Ti as main strengthening elements and does not contain Al as the strengthening element. Therefore, the sintered material of austinite steel powder is insusceptible to oxidation and so forth with oxygen and is able to improve the strengths (the creep strength, the tensile strength, the fatigue strength and so forth).

[0031] In addition, the sintered material has the forged structure, and it is possible to control with ease strength properties of the sintered material coping with a required strength of a product concerned by controlling the crystal grain diameter by heat treatment and so forth.

[0032] Further, since manufacturing of the die of the sintered material is easier than manufacturing of the mold of the cast material, the sintered material makes it possible to manufacture even complicated shape products at a high yield.

[Method of Manufacturing the Sintered Material of Austenite Steel Powder]

[0033] Next, a method of manufacturing the sintered material of austenite steel powder according to one practical example of the present invention will be described. It is possible to manufacture the sintered material of austenite steel powder according to one practical example of the present invention by, for example, the following processes.

(1) Raw material powder or a raw material alloy having the above-described composition is made into alloy powder which is not more than 250 μm in average grain diameter by using a gas atomizing method, a water atomizing method, and so forth.

(2) The alloy powder which is obtained by the above process (1) is sintered by a hot isotropic pressure pressing method (HIP). As sintering conditions, for example, a sintering temperature is set to 1100 to 1300°C and an isotropic pressure is set to at least 50 MPa.

[0034] Sintering may be performed by a hot-pressing method under an anisotropic pressure or a metal-powder injection molding method (MIM), in place of the HIP. In addition, solution heat treatment (a heat treatment temperature: 1100 to 1300°C) and/or aging heat treatment (the heat treatment temperature: not more than 1000°C) may be performed after sintered.

[Turbine Member Using Sintered Material of Austenite Steel Powder]

[0035] FIG. 4 is a schematic diagram illustrating one example of a turbine valve casing to which the sintered material of austinite steel powder according to one practical example of the present invention is applied. FIG. 5 is a schematic diagram illustrating one example of a turbine disc to which the sintered material of austinite steel powder according to one practical example of the present invention is applied. As illustrated in FIG. 4, the sintered material of the austenite steel power according to one practical example of the present invention has the excellent strengths and therefore is preferable for a turbine valve casing 10 and a turbine disc 11.

[Practical Examples]

[0036] In the following, the present invention will be described in more detail on the basis of practical examples.

[Production and Evaluation of Sintered Materials of Austenite Steel Powder]

[0037] Sintered materials according to practical examples 1 to 3 and comparative examples 1 and 2 are produced and evaluated. Compositions of the practical examples 1 to 3 and the comparative examples 1 and 2 are indicated on Table 1 which will be described later. Master ingots or raw materials having the compositions which are indicated in Table 1 are prepared, and alloy powder which is not more than 250 μm in grain diameter is produced by the gas atomizing method. The obtained alloy powder is sintered by the HIP (the sintering temperature: 1160 C, the isotropic pressure: 100 MPa) and the sintered materials of the practical examples 1 to 3 and the comparative examples 1 and 2 are produced. The comparative example 1 has a composition which is out of range of the present invention in the amount of Cr and the comparative example 2 has a composition which is out of range of the present invention in the amount of Ni.

[0038] Also, Alloy (INCONEL) 718 (the forged material) which is the Ni-based alloy is prepared as a comparative example 3 and Alloy (INCONEL) 625 (the cast material) which is the Ni-based alloy is prepared as a comparative example 4 and these alloys are evaluated. Compositions of the comparative example 3 and the comparative example 4 are also indicated on Table 1 together with other examples. "INCONEL" is a registered trademark of Huntington Alloys Corporation.

[Table 1]

[0039]

Table 1

	Fe	Ni	Cr	Nb	B	Ti	W	Mo	Zr	C		Manufacturing Method
Practical Example 1	Bal.	35.4	18.3	4.2	0.006	0.76	-	-	0.014	-	-	HIP
Practical Example 2	Bal.	38.0	15.9	4.0	0.008	0.93	-	-	0.016	-	-	HIP
Practical Example 3	Bal.	36.1	18.3	4.1	0.006	0.84	5.0	-	0.016	-	-	HIP
Comparative Example 1	Bal.	35.6	10.8	3.8	0.006	0.78	-	-	0.018	-	-	HIP
Comparative Example 2	Bal.	24.4	19.2	4.3	0.006	0.81	-	-	0.015	-	-	HIP
Comparative Example 3	Bal.	52.3	19.0	5.1	0.004	0.97	-	3.1	-	0.03	0.59	Forging
Comparative Example 4	4.0	Bal.	21.8	3.5	-	0.22	-	8.9	-	0.03	0.26	Casting

[0040] 0.2% proof stress and creep durable temperature ratios of the practical examples 1 to 3 and the comparative examples 1 to 4 are evaluated. The 0.2% proof stress are evaluated on the basis of JIS G 0567 and creep tests are performed on the basis of JIS Z 22761.

[0041] FIG. 6 is a graph illustrating one example of the 0.2% proof stress (with the comparative example 4 being set as the standard) of the practical examples 1 to 3 and the comparative examples 1 to 4. As illustrated in FIG. 6, both the sintered materials of the practical examples 1 and 3 indicate values which are higher than values of the comparative examples 1, 2, and 4 and indicate the 0.2% proof stress which are equivalent to or in excess of the 0.2% proof stress of the related art comparative example 3 (Alloy 718).

[0042] FIG. 7 is a graph illustrating one example of the creep durable temperature ratios (with the comparative example 3 being set as the standard) of the practical examples 1 to 3 and the comparative examples 1 to 4. As illustrated in FIG. 7, both the sintered materials of the practical examples 1 and 2 indicate values which are higher than values of the comparative examples 1 to 3 and indicate the 0.2% proof stress which are equivalent to or in excess of the 0.2% proof stress of the related art comparative example 4 (Alloy 625).

[0043] Judging from the graphs in FIG. 6 and FIG. 7, although the 0.2% proof stress of the practical example 2 is slightly lower than the 0.2% proof stress of the comparative examples 2 to 4, the creep durable temperature ratio of the practical example 2 is larger than the creep durable temperature ratios of the comparative examples 2 to 4, and it may be said that the practical example 2 is superior to the comparative examples 2 to 4 when making a decision by comprehensively taking both the 0.2% proof stress and the creep durable temperature ratio into account.

[0044] Judging from the graphs in FIG. 6 and FIG. 7, although the creep durable temperature ratio of the practical example 3 is slightly lower than the creep durable temperature ratio of the comparative example 4, the 0.2% proof stress of the practical example 3 is greatly larger than the 0.2% proof stress of the comparative example 4, and it may be said that the practical example 3 is superior to the comparative example 4 when making a decision by comprehensively taking both the 0.2% proof stress and the creep durable temperature ratio into account.

[0045] FIG. 8 is a graph illustrating one example of the 0.2% proof stress and the creep durable temperature ratios of the practical examples 1 and 3 and the comparative examples 1, 3, and 4. As illustrated in FIG. 8, the practical examples 1 and 3 indicate values which are greatly lager than values of the comparative example 1 in both the 0.2% proof stress and the creep durable temperature ratio. In addition, the values of the practical examples 1 and 3 are larger than a value of the comparative example 4 (Alloy 625) in the 0.2% proof stress and reach the level which is equivalent to the level of the comparative example 3 (Alloy 718). Further, the values of the practical examples 1 and 3 are larger than the value of the comparative example 3 (Alloy 718) in the creep durable temperature ratio. In particular, the practical example 1 attains the level which is equivale to the level of the comparative example 4 (Alloy 625).

[0046] In general, the 0.2% proof stress and the creep durable temperature are in a trade-off relation, that is, exhibit a behavior that when the 0.2% proof stress is increased, the creep durable temperature is deceased and when the creep durable temperature is increased, the 0.2% proof stress is decreased. Since both the practical example 1 and the practical example 3 are located at upper right positions above a straight line connecting the comparative example 3 with the comparative example 4, it may be said that the practical examples 1 and 3 are superior to the comparative example 3 and the comparative example 4 when making a decision by comprehensively taking both the 0.2% proof stress and the creep durable temperature ratio into account.

[0047] As described above, according to the present invention, it is proved that it becomes possible to provide the sintered materials of the austenite steel powder each having the strength which is equivalent to or in excess of the strength of the Ni-based alloy and insusceptible to oxygen and the turbine members each being composed of each of the above-described sintered materials.

[0048] Incidentally, the present invention is not limited to the aforementioned practical examples and various modified examples are included. For example, the aforementioned practical examples have been described in detail in order to comprehensibly describe the present invention and are not necessarily limited to those which possess all the above-described configurations. In addition, it is possible to replace part of a configuration of one practical example with a configuration of another practical example, and it is also possible to add the configuration of another practical example to the configuration of one practical example. In addition, it is also possible to add, delete and replace another configuration to, from and with part of one configuration of each practical example.

LIST OF REFERENCE SIGNS

[0049] 1, 4 ... austenite steel powder crystal, 2, 5 ... grain boundary, 3, 6 ... Laves phase, 7 ...Ni-based alloy crystal, 8 ... prior particle boundary (PPB), 9 ... delta phase, 10 ... turbine valve casing, 11 ... turbine disc.

Claims

1. A sintered material of austenite steel powder containing:
25 to 50% Ni; 12 to 25% Cr; 3 to 6% Nb; 0.001 to 0.05% B; not more than 1.6% Ti; not more than 6% W; not more than 4.8% Mo; and not more than 0.5% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

2. The sintered material of austenite steel powder according to claim 1, wherein an average particle diameter of the sintered material of austenite steel powder is 10 to 300 μm.

3. The sintered material of austenite steel powder according to claim 1 or 2, wherein a Laves phase precipitates on a crystal grain boundary of the sintered material of austenite steel powder.

4. The sintered material of austenite steel powder according to claim 3, wherein the Laves phase is made up of Fe_2Nb.

5. A turbine member comprising the sintered material of austenite steel powder according to any one of claims 1 to 4.

6. The turbine member according to claim 5, wherein the turbine member is a turbine valve casing or a turbine disc.

7. Austenite steel powder containing 25 to 50% Ni; 12 to 25% Cr; 3 to 6% Nb; 0.001 to 0.05% B; not more than 1.6% Ti; not more than 6% W; not more than 4.8% Mo; and not more than 0.5% Zr in percentage by mass, with a balance made up of Fe and unavoidable impurities.

8. The austenite steel powder according to claim 7, wherein an average particle dimeter of the austenite steel powder is not more than 250 μm.

FIG. 1A

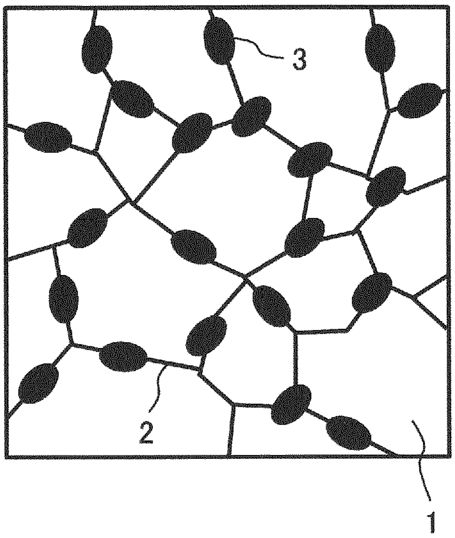


FIG. 1B

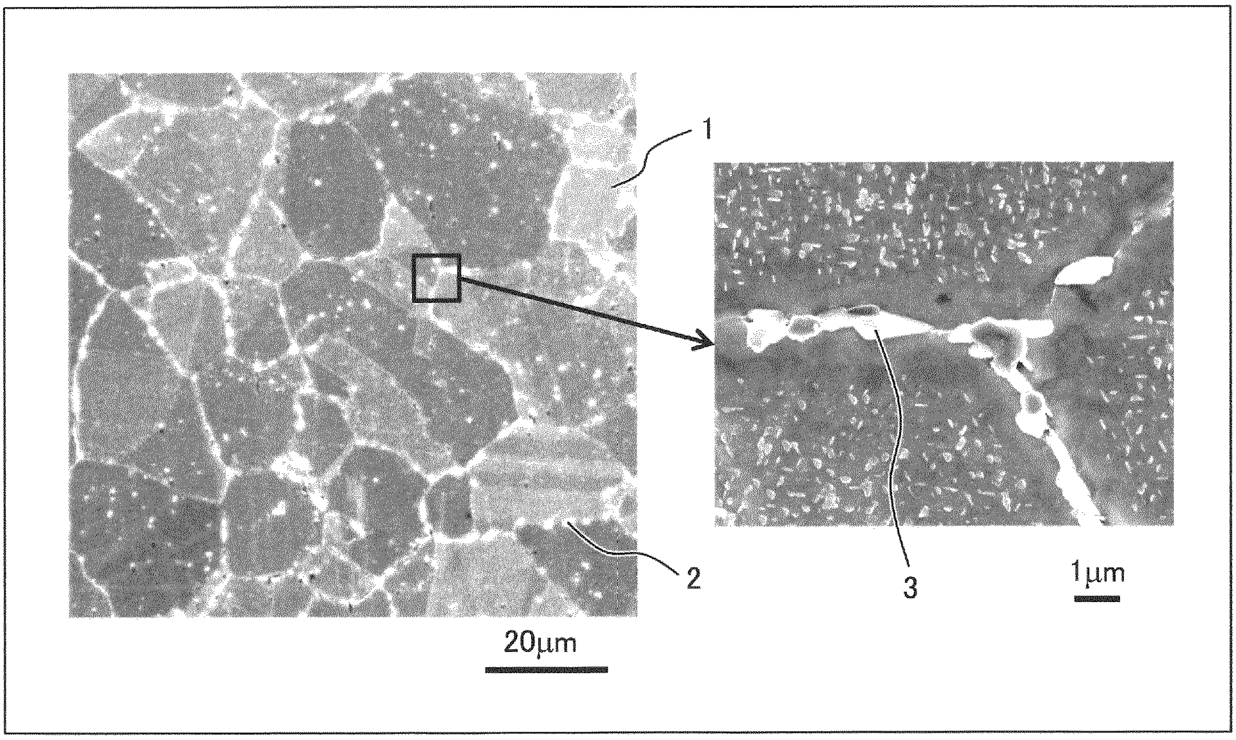


FIG. 2

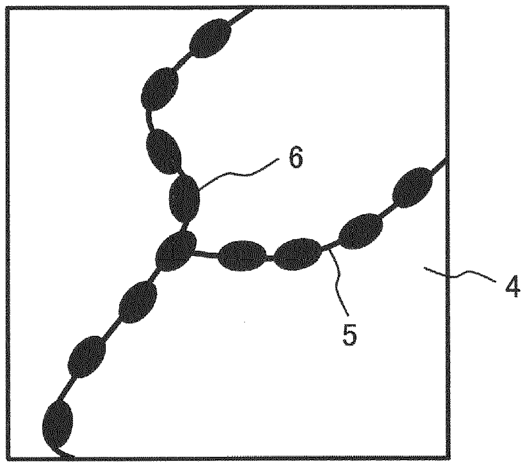


FIG. 3

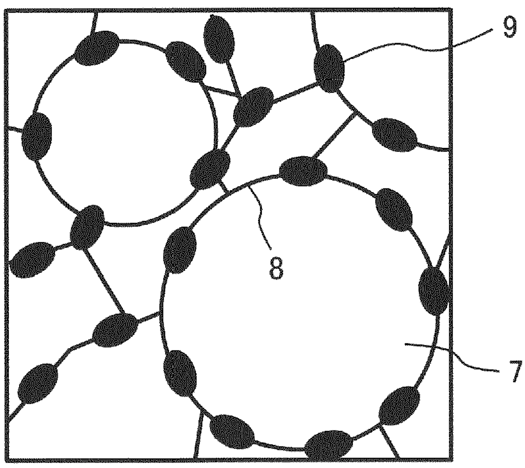


FIG. 4

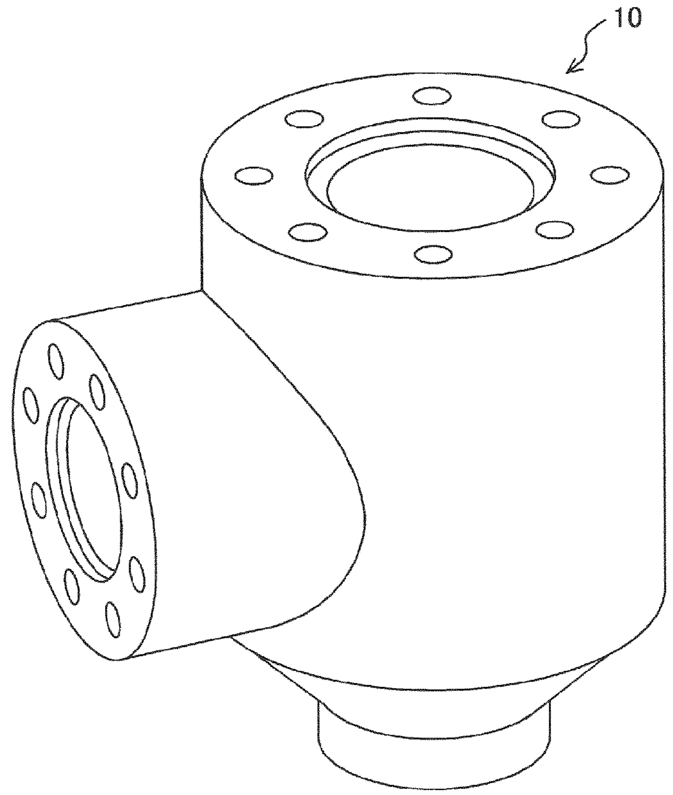


FIG. 5

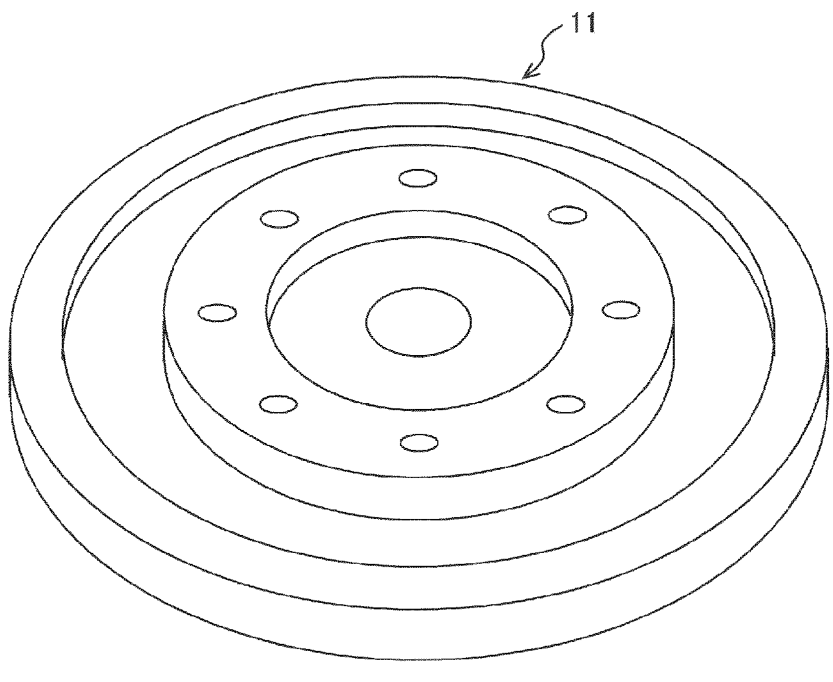


FIG. 6

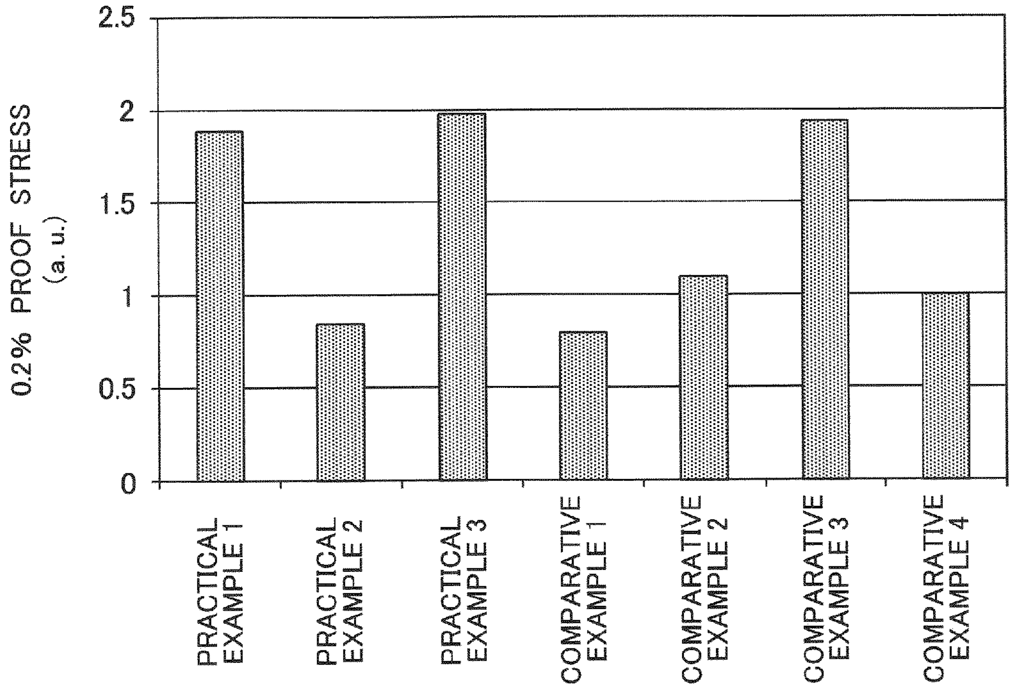

2.5
2
1.5
1
0.5
0
0.2% PROOF STRESS (a. u.)
PRACTICAL EXAMPLE 1
PRACTICAL EXAMPLE 2
PRACTICAL EXAMPLE 3
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
COMPARATIVE EXAMPLE 3
COMPARATIVE EXAMPLE 4

FIG. 7

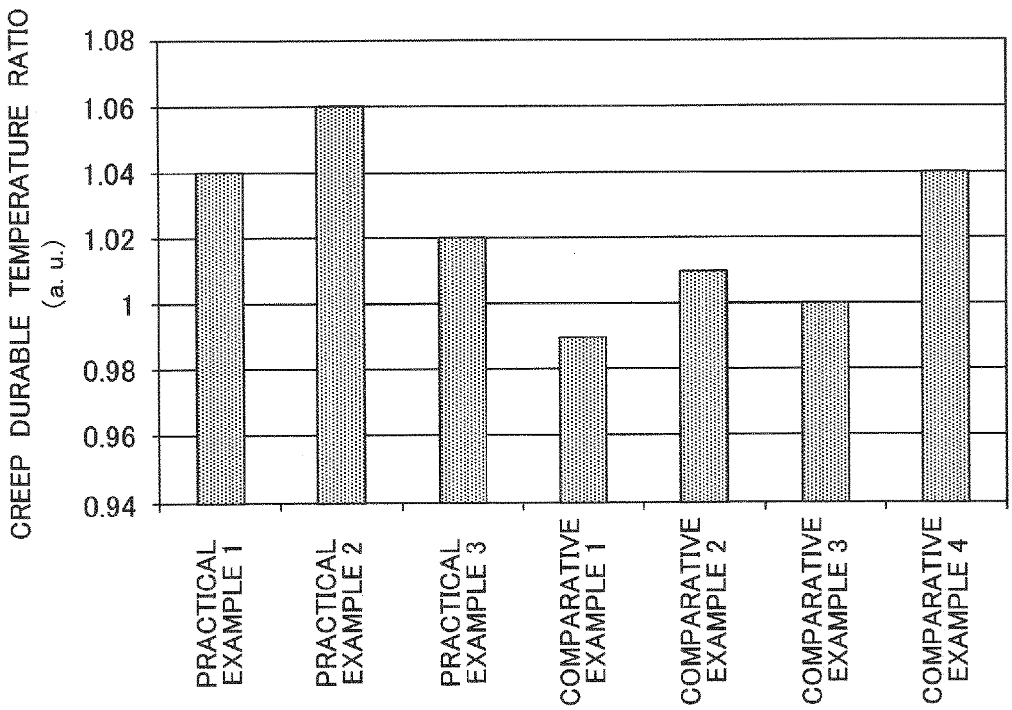
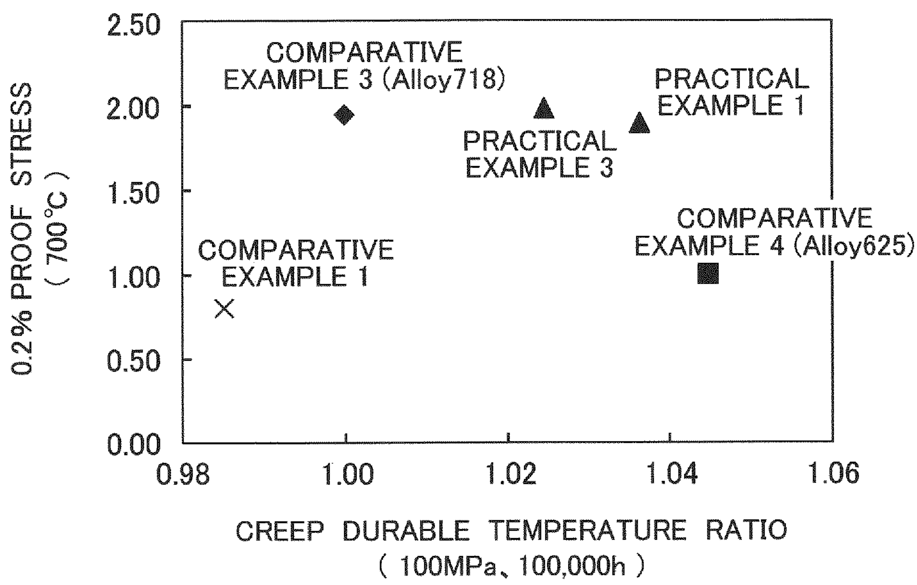

1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
CREEP DURABLE TEMPERATURE RATIO (a. u.)
PRACTICAL EXAMPLE 1
PRACTICAL EXAMPLE 2
PRACTICAL EXAMPLE 3
COMPARATIVE EXAMPLE 1
COMPARATIVE EXAMPLE 2
COMPARATIVE EXAMPLE 3
COMPARATIVE EXAMPLE 4

FIG. 8


2.50
2.00
1.50
1.00
0.50
0.00
0.98
1.00
1.02
1.04
1.06
0.2% PROOF STRESS
(700°C)
CREEP DURABLE TEMPERATURE RATIO
(100MPa、100,000h)
COMPARATIVE
EXAMPLE 3 (Alloy718)
PRACTICAL
EXAMPLE 1
PRACTICAL
EXAMPLE 3
COMPARATIVE
EXAMPLE 4 (Alloy625)
COMPARATIVE
EXAMPLE 1

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Application Number
EP 19 20 9339

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	4 December 2019	Momeni, Mohammad

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X	N. ERGIN ET AL: "Synthesis of Inconel 718 Superalloy by Electric Current Activated Sintering", ACTA PHYSICA POLONICA: SERIES A, vol. 127, no. 4, 24 April 2015 (2015-04-24), pages 1100-1102, XP055649005, PL ISSN: 0587-4246, DOI: 10.12693/APhysPolA.127.1100 * figure 1; table 1 * * page 1100; "introduction" * -----	1-8	TECHNICAL FIELDS SEARCHED (IPC)
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