(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 076 616 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
28.10.2015 Bulletin 2015/44

(21) Application number: **07803558.1**

(22) Date of filing: **20.09.2007**

(51) Int Cl.:
C22C 19/05 *(2006.01)* ***F01D 5/28*** *(2006.01)*

(86) International application number:
PCT/EP2007/059936

(87) International publication number:
WO 2008/046708 (24.04.2008 Gazette 2008/17)

(54) **NICKEL-BASE SUPERALLOYS**

NICKELBASIS-SUPERLEGIERUNGEN

SUPERALLIAGES À BASE DE NICKEL

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **17.10.2006 EP 06021724**

(43) Date of publication of application:
08.07.2009 Bulletin 2009/28

(73) Proprietor: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventors:
- **HASSELQVIST, Magnus**
  61213 Finspong (SE)
- **MCCOLVIN, Gordon**
  North Hykeham Lincoln LN6 8DP (GB)

(74) Representative: **Maier, Daniel Oliver et al**
Siemens AG
Postfach 22 16 34
80506 München (DE)

(56) References cited:
EP-A1- 0 560 296
EP-A1- 1 054 072
JP-A- 10 317 080
JP-A- 11 256 258
US-A1- 2003 041 930
US-A1- 2005 194 068

- **M.B. HENDERSON, J. HANNIS, G. MCCOLVIN, G. OGLE: "Materials issues for the design of industrial gas turbines" ADVANCED MATERIALS AND PROCESSES FOR GAS TURBINES, September 2002 (2002-09), pages 3-13, XP009079117 TMS Publications, Warrendale**

EP 2 076 616 B1

Description

[0001] The invention relates to nickel-base superalloys and to components containing these alloys.

[0002] Nickel-base superalloys are used in applications where a combination of high strength and a strong resistance to chemical attacks at high temperatures is needed. They are employed for the production of components of gas turbines such as blades and vanes. These parts are arranged in the hot section of a turbine and thus have to withstand high temperatures and an aggressive atmosphere.

[0003] Nickel-base superalloys and components of the above mentioned kind are disclosed for example in US 6,818,077, US 6,419,763, US 6,177,046, EP 0 789 087 and EP 0 637 474.

[0004] From US 2005/0194068 a Nickel-base superalloy is known, which basically consists of 4.75 to 5.25% Co, 15.5 to 16.5% Cr, 0.8 to 1.2% Mo, 3.75 to 4.25% W, 3.75 to 4.25% A1, 1.75 to 2.25% Ti, 4.75 to 5.25% Ta, the remaining part being Nickel beside other constituents in traces.

[0005] Further Nickel-base superalloys are described in EP 0 560 296 A1. To achieve high temperature strength, high temperature ductility, hot corrosion and oxidation resistance, a composition containing 7.3 to 9% Cr, 4.7 to 5.5% A1, 5 to 6.3% W, 5 to 7.5% Ta, 0.5 to 1.8% Mo, 0.5 to 1.5% Co, 1.3 to 1.8% Nb, 1.3 to 1.65% Re, not more than 0.13% Hf and the balance Ni is proposed.

[0006] It is an object of the present invention to provide a nickel-base superalloy, which combines high strength, high oxidation resistance, high corrosion resistance, microstructural stability and a large heat treatment window. It is a further object of the present invention to provide components, which comprise such a superalloy.

[0007] These objects are solved by the superalloy of claim 1 and the components of claims 22 to 25.

[0008] The nickel-base superalloy of the invention comprises in wt%:

Co + Fe + Mn	0 - 20
Al	4 - 6, especially from 4.3 to 6
Cr	>12 - 20
Ta	>7.5 - 15
Ti	0 - <0.45
V	0 - 1
Nb	0 - <0.28
Mo	0 - 2.5
Mo + W + Re + Rh	2 - 8
Ru + Os + Ir + Pt + Pd	0 - 4
Hf	0 - 1.5
C + B + Zr	0 - 0.5
Ca + Mg + Cu	0 - 0.5
Y + La + Sc + Ce + Actinides + Lanthanides	0 - 0.5
Si	0 - 0.5
Ni	balance

and unavoidable impurities.

[0009] Especially the superalloy consists of these elements.

Especially one, several or all optionally listed elements are present in the alloy. "Present" means that the amount of this element is measurable higher than the known impurity level of this element in a nickel based super alloy. That means that the amount of this element is at least twice the impurity level of this element in a nickel powder based alloy.

[0010] The alloy contains significant levels of Al, Cr and Ta to provide a combination of high strength, high oxidation resistance and high corrosion resistance.

[0011] Along Ta, other strengtheners of the gamma prime particles like Ti, Nb and V can be added to the superalloy, but since they are detrimental to the oxidation resistance, they should at most be added in limited quantities.

The amount of Ti should not exceed 0.45, the amount of Nb should not exceed 0.28, and the amount of V should not exceed 1 wt% respectively.

[0012] The amount of matrix strengthening elements Mo, W, Re and Rh is between 2 and 8 wt%.

[0013] Other elements like Hf, C, B, Zr, Ca, Mg, Cu, Y, La, Sc, Ce, actinides and lanthanides, and Si can be present in the superalloy in order to adapt its properties to special needs such as grain boundary strengthening, oxide scale fortification, and compatibility with specific coating systems.

[0014] The content of Ti can be in the range (in wt%) of 0-0.40. Preferably it can be 0-0.35, more preferably 0-0.30 and most preferably 0-0.20.

[0015] It was also found that the content of Nb (in wt%) can be in the range of 0-0.25, preferably 0-0.20, more preferably 0-0.15 and most preferably 0-0.10.

[0016] According to another embodiment of the invention the content of C (in wt%) can be in the range of 0-0.15, preferably 0-0.08, more preferably 0.01-0.06 and most preferably 0.02-0.04.

[0017] The superalloy of the invention can also contain B in the range (in wt%) of 0-0.02, preferably 0-0.01, more preferably 0.001-0.008 and most preferably 0.003-0.007.

[0018] According to one aspect of the invention a conventional cast component, directionally solidified component and a single crystal component, which comprise the super alloy are provided.

[0019] According to another aspect of the invention, a conventional cast or a single crystal component consisting of a superalloy, which comprises in wt%:

Co + Fe + Mn	0 - 20
Al	4 - 6
Cr	>12 - 20
Ta	>7.5 - 15
Ti	0 - 1.5
V	0 - 1
Ti + Nb + V	0-2
Mo	0 - 2.5
Mo + W + Re + Rh	2 - 8
Ru + Os + Ir + Pt + Pd	0-4
Hf	0 - 1.5
C + B + Zr	0 - 0.5
Ca + Mg + Cu	0 - 0.5
Y + La + Sc + Ce + Actinides + Lanthanides	0 - 0.5
Si	0 - 0.5
Ni	balance

and unavoidable impurities.

[0020] Especially the superalloy consists of these elements.

[0021] The components of the invention can especially be part of a gas turbine, for example a turbine blade or vane, or as filler material, for example for laser welding of gas turbine components.

[0022] In the following one preferred embodiment of the invention is described. A superalloy was cast which has the composition given in table 1.

Table 1

Element	wt%
Co	4.12
Cr	14.2
Mo	0.96
W	2.51
Al	5.47
Ta	10.1
Hf	0.41
C	0.04
B	0.005
Ni	balance

[0023] Especially the superalloy comprises the elements Ni, Co, Cr, Mo, W, Al, Ta, Hf, C and B and very especially consists only of these elements.

[0024] In order to characterize the properties of the cast superalloy in Table 1 different experiments were conducted.

[0025] Solutioning experiments for 4h at 1220, 1250, 1260, 1270 and 1300°C followed by water quenching were done. At 1220°C residual particles were seen and at 1250, 1260, 1270 and 1300°C full solutioning without incipient melting was observed.

[0026] Further a heat treatment at 1250°C for 8h, 1100°C for 4h and 850°C for 24h was applied. SEM and TEM analysis showed a very regular microstructure with primary particles of ~0.35 μm side length and a significant amount of secondary particles.

[0027] No trace of TCP phases was found. The particle content was measured to be ~60 vol%.

At this relatively high particle content it is usually difficult to obtain such a large heat treatment window, or, to include as much as 14%Cr without precipitation of brittle phases.

Accordingly it was shown that this emphasis on Cr, Ta and Al with at most moderate levels of other alloy elements provides a large heat treatment window and a good microstructural stability. Since Al is regarded as highly beneficial, Cr and Ta as beneficial, Mo and W as mildly detrimental (and Ti, Nb and V as detrimental) to oxidation resistance the composition in Table 1 will have a high oxidation resistance. With 14%Cr and a low level of the detrimental element Mo it will also have a high corrosion resistance.

[0028] With as much as 10% Ta supported by moderate levels of Mo and W is will also have a high strength, as Ta is a very potent strengthening element. Consequently it satisfies our requirements on high strength, high oxidation resistance, high corrosion resistance, microstructural stability and a large heat treatment window.

[0029] Table 2 shows a further preferred embodiment of the invention.

Table 2

Element	wt%
Ni	balance
Co	3
Cr	16
Mo	1.7
W	2.3
Al	4.5
Ta	10
Hf	0.1
Zr	0.02
C	0.06
B	0.01

[0030] Especially the superalloy comprises the elements Ni, Co, Cr, Mo, W, Al, Ta, Hf, Zr, C and B and very especially consists only of these elements.

[0031] Most highly oxidation resistant alloys like e.g. CMSX-4 contain >5% Al and are cast with production processes to obtain <5ppm S, and recently to levels as low as <0.5ppm S.

[0032] The composition in Table 2 had an average content of sulphur (S) estimated to be ~30ppm, at which it should be severely detrimental, and the Al content is a comparatively moderate 4.5%.

[0033] Cyclic oxidation tests on the superalloy in Table 2 nevertheless showed a stable response for 300h under the severe test conditions of 1h cycle time and 1100C test temperature, which indicates an ability to form stable alumina, i.e. a high oxidation resistance. Accordingly it was shown that this emphasis on Cr, Ta and Al with at most moderate levels of other alloy elements provides a high oxidation resistance.

[0034] The composition in Table 2 has a lower particle content than the composition in Table 1, about 45 vol% rather than about 60vol%, and should therefore have a larger heat treatment window, and be at least as stable. With 16%Cr and a low level of the detrimental element Mo it will also have a high corrosion resistance.

With as much as 10% Ta supported by moderate levels of Mo and W it will also have a high strength, as Ta is a very potent strengthening element.

Consequently it satisfies our requirements on high strength, high oxidation resistance, high corrosion resistance, micro-

structural stability and a large heat treatment window.

Claims

1. A nickel-base superalloy comprising (in wt%):

Co + Fe + Mn	0 - 20
Al	4 - 6, especially from 4.3 to 6,
Cr	>12 - 20
Ta	>7.5 - 15
Ti	0 - <0.45
V	0 - 1
Nb	0 - <0.28
Mo	0 - 2.5
Mo + W + Re + Rh	2 - 8
Ru + Os + Ir + Pt + Pd	0 - 4
Hf	0 - 1.5
C + B + Zr	0 - 0.5
Ca + Mg + Cu	0 - 0.5
Y + La + Sc + Ce + Actinides + Lanthanides	0 - 0.5
Si	0 - 0.5
Ni	balance

and unavoidable impurities.

2. The nickel-base superalloy as claimed in claim 1,
wherein titanium (Ti) is in the range (in wt%) of 0 - 0.40, preferably 0 - 0.35,
more preferably 0 - 0.30 and
most preferably 0 - 0.20.

3. The nickel-base superalloy as claimed in any of the preceding claims,
wherein niobium (Nb) is in the range (in wt%) of 0 - 0.25,
preferably 0 - 0.20,
more preferably 0 - 0.15 and
most preferably 0 - 0.10.

4. The nickel-base superalloy as claimed in any of the preceding claims,
wherein carbon (C) is in the range (in wt%) of 0 - 0.15,
preferably 0 - 0.08,
more preferably 0.01 - 0.06 and
most preferably 0.02 - 0.04.

5. The nickel-base superalloy as claimed in any of the preceding claims,
wherein boron (B) is in the range (in wt%) of 0 - 0.02,
preferably 0 - 0.01,
more preferably 0.001 - 0.008 and most preferably 0.003 - 0.007.

6. The nickel-base superalloy as claimed in any of the preceding claims,
wherein molybdenum (Mo) is present in the alloy with 1.0wt% to 2.4 wt%,
preferably 1.7wt% to Mo.

7. The nickel-base superalloy as claimed in any of the preceding claims,
wherein the element hafnium (Hf) is present in the alloy higher than 0.1wt%.

8. The nickel-base superalloy as claimed in any of the preceding claims, wherein the maximum amount of Hf is 0.5wt%.

9. The nickel-base superalloy as claimed in any of the preceding claims, wherein Co is present in the alloy with 2wt% to 4wt%, preferably with 3wt%.

10. The nickel-base superalloy as claimed in any of the preceding claims, wherein cobalt (Co) and iron (Fe) are present in the alloy and wherein the amount of Fe is smaller than the amount of Co.

11. The nickel-base superalloy as claimed in any of the preceding claims, wherein cobalt (Co) and manganese (Mn) are present in the alloy and wherein the amount of Mn is smaller than the amount of Co.

12. The nickel-base superalloy as claimed in any of the preceding claims, wherein cobalt (Co), manganese (Mn) and iron (Fe) are present in the alloy and wherein the amount of Fe and Mn is smaller than the amount of Co.

13. The nickel-base superalloy as claimed in any of the preceding claims, wherein the chromium (Cr) content is higher than 14wt%.

14. The nickel-base superalloy as claimed in any of the preceding claims, wherein the chromium (Cr) content is higher than 16wt%.

15. The nickel-base superalloy as claimed in any of the claims 1 to 13, wherein the amount of chromium (Cr) is between 14wt% to 18wt% Cr, preferably 16wt%.

16. The nickel-base superalloy as claimed in any of the preceding claims, wherein the amount of tungsten (W) is between 1.7wt% and 2.8wt%, especially is 2.3wt%.

17. The nickel-base superalloy as claimed in any of the preceding claims, wherein the amount of aluminium (Al) is equal or higher than 4.5wt%.

18. The nickel-base superalloy as claimed in any of the claims 1 to 16, wherein the amount of aluminium (Al) is between 4.0wt% to 4.3wt%.

19. The nickel-base superalloy as claimed in any of the preceding claims, wherein the amount of tantalum (Ta) is between 9wt% to 11wt%, preferably the amount of Ta is 10 wt%.

20. The nickel-base superalloy as claimed in any of the claims 1 to 18, wherein the amount of tantalum (Ta) is higher than 10wt%.

21. The nickel-base superalloy as claimed in any of the preceding claims, wherein the amount of zirconium (Zr) is higher or equal than 0.02 Zr, especially is 0.02 wt%.

22. The nickel-base superalloy as claimed in any of the preceding claims, wherein the superalloy consists of Ni, Co, Cr, Mo, W, Al, Ta, Hf, Zr, C and B.

23. A conventional cast component comprising a superalloy according to any of the claims 1 to 22.

24. A directionally solidified component comprising a superalloy according to any of the claims 1 to 22.

25. A single crystal component comprising a superalloy according to any of the claims 1 to 22.

26. The component according to any of the claims 23 to 25, wherein the component is a part of a gas turbine.

Patentansprüche

1. Nickelbasis-Superlegierung, umfassend (in Gew.-%):

Co + Fe + Mn	0 - 20
Al	4 - 6, insbesondere von 4,3 bis 6,
Cr	>12 - 20
Ta	>7,5 - 15
Ti	0 - <0,45
V	0 - 1
Nb	0 - <0,28
Mo	0 - 2,5
Mo + W + Re + Rh	2 - 8
Ru + Os + Ir + Pt + Pd	0 - 4
Hf	0 - 1,5
C + B + Zr	0 - 0,5
Ca + Mg + Cu	0 - 0,5
Y + La + Sc + Ce + Actinoide + Lanthanoide	0 - 0,5
Si	0 - 0,5
Ni	Rest

und unvermeidbare Verunreinigungen.

2. Nickelbasis-Superlegierung nach Anspruch 1, wobei Titan (Ti) im Bereich (in Gew.-%) von
0 - 0,40, vorzugsweise 0 - 0,35,
noch mehr bevorzugt 0 - 0,30 und
am meisten bevorzugt 0 - 0,20 vorhanden ist.

3. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Niob (Nb) im Bereich (in Gew.-%) von
0 - 0,25,
vorzugsweise 0 - 0,20,
noch mehr bevorzugt 0 - 0,15 und
am meisten bevorzugt 0 - 0,10 vorhanden ist.

4. Nickelbasis-Superlegierung nach einem der
vorhergehenden Ansprüche,
wobei Kohlenstoff (C) im Bereich (in Gew.-%) von 0 - 0,15,
vorzugsweise 0 - 0,08,
noch mehr bevorzugt 0,01 - 0,06 und
am meisten bevorzugt 0,02 - 0,04 vorhanden ist.

5. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Bor (B) im Bereich (in Gew.-%) von
0 - 0,02,
vorzugsweise 0 - 0,01,
noch mehr bevorzugt 0,001 - 0,008 und am meisten bevorzugt 0,003 - 0,007 vorhanden ist.

6. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,

wobei Molybdän (Mo) in der Legierung mit
1,0 Gew.-% bis 2,4 Gew.-%,
vorzugsweise 1,7 Gew.-% bis Mo vorhanden ist.

7. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei das Element Hafnium (Hf) mit mehr als 0,1 Gew.-% in der Legierung vorhanden ist.

8. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die maximale Menge an Hf 0,5 Gew.-% beträgt.

9. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Co in der Legierung mit 2 Gew.-% bis 4 Gew.-%, vorzugsweise mit 3 Gew.-% vorhanden ist.

10. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Kobalt (Co) und Eisen (Fe) in der Legierung vorhanden sind und
wobei die Menge an Fe kleiner als die Menge an Co ist.

11. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Kobalt (Co) und Mangan (Mn) in der Legierung vorhanden sind und
wobei die Menge an Mn kleiner als die Menge an Co ist.

12. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei Kobalt (Co), Mangan (Mn) und Eisen (Fe) in der Legierung vorhanden sind und
wobei die Menge an Fe und Mn kleiner als die Menge an Co ist.

13. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei der Gehalt an Chrom (Cr) höher als 14 Gew.-% ist.

14. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei der Gehalt an Chrom (Cr) höher als 16 Gew.-% ist.

15. Nickelbasis-Superlegierung nach einem der Ansprüche 1 bis 13,
wobei die Menge an Chrom (Cr) zwischen
14 Gew.-% und 18 Gew.-% Cr,
vorzugsweise bei 16 Gew.-% liegt.

16. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die Menge an Wolfram (W) zwischen
1,7 Gew.-% und 2,8 Gew.-%,
insbesondere bei 2,3 Gew.-% liegt.

17. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die Menge an Aluminium (Al) gleich oder höher als 4,5 Gew.-% ist.

18. Nickelbasis-Superlegierung nach einem der Ansprüche 1 bis 16,
wobei die Menge an Aluminium (Al) zwischen 4,0 Gew.-% und
4,3 Gew.-% liegt.

19. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die Menge an Tantal (Ta) zwischen 9 Gew.-% und 11 Gew.-% liegt,
die Menge an Ta vorzugsweise 10 Gew.-% beträgt.

20. Nickelbasis-Superlegierung nach einem der Ansprüche 1 bis 18,
wobei die Menge an Tantal (Ta) höher als 10 Gew.-% ist.

21. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die Menge an Zirconium (Zr) höher oder gleich 0,02 Zr, insbesondere 0,02 Gew.-% ist.

22. Nickelbasis-Superlegierung nach einem der vorhergehenden Ansprüche,
wobei die Superlegierung aus
Ni, Co, Cr, Mo, W, Al, Ta, Hf, Zr, C und B besteht.

23. Im konventionellen Gießverfahren hergestellte Komponente, umfassend eine Superlegierung nach einem der Ansprüche 1 bis 22.

24. Gerichtet erstarrte Komponente, umfassend eine Superlegierung nach einem der Ansprüche 1 bis 22.

25. Einkristallkomponente, umfassend eine Superlegierung nach einem der Ansprüche 1 bis 22.

26. Komponente nach einem der Ansprüche 23 bis 25, wobei die Komponente Bestandteil einer Gasturbine ist.

Revendications

1. Superalliage à base de nickel comprenant (en % en poids) :

Co + Fe + Mn	0 - 20 ;
Al	4 - 6, en particulier de 4,3 à 6 ;
Cr	>12 - 20 ;
Ta	>7,5 - 15 ;
Ti	0 - <0,45 ;
V	0 - 1 ;
Nb	0 - <0,28 ;
Mo	0 - 2,5 ;
Mo + W + Re + Rh	2 - 8 ;
Ru + Os + Ir + Pt + Pd	0 - 4 ;
Hf	0 - 1,5 ;
C + B + Zr	0 - 0,5 ;
Ca + Mg + Cu	0 - 0,5 ;
Actinides + lanthanides	0 - 0,5 ;
Si	0 - 0,5 ;
Ni	le solde, et

des impuretés inévitables.

2. Superalliage à base de nickel selon la revendication 1, dans lequel le titane (Ti) se situe dans la fourchette (en % en poids) de 0 à 0,40, de préférence de 0 à 0,35, de manière particulièrement préférée de 0 à 0,30, et de manière tout particulièrement préférée de 0 à 0,20.

3. Superalliage à base de nickel selon l'une quelconque des revendications précédentes,
dans lequel le niobium (Nb) se situe dans la fourchette (en % en poids) de
0 à 0,25,
de préférence de 0 à 0,20,
de manière particulièrement préférée de 0 à 0,15, et
de manière tout particulièrement préférée de 0 à 0,10.

4. Superalliage à base de nickel selon l'une quelconque des revendications précédentes,
dans lequel le carbone (C) se situe dans la fourchette (en % en poids) de
0 à 0,15,
de préférence de 0 à 0,08,
de manière particulièrement préférée de 0,01 à 0,06, et de manière tout particulièrement préférée de 0,02 à 0,04.

5. Superalliage à base de nickel selon l'une quelconque des revendications précédentes,
dans lequel le bore (B) se situe dans la fourchette (en % en poids) de

0 à 0,02,
de préférence de 0 à 0,01,
de manière particulièrement préférée de 0,001 à 0,008, et de manière tout particulièrement préférée de 0,003 à 0,007.

6. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel le molybdène (Mo) est présent dans l'alliage à raison de 1,0 % en poids à 2,4 % en poids, de préférence de 1,7 % en poids à Mo.

7. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel l'élément hafnium (Hf) est présent dans l'alliage à raison de plus de 0,1 % en poids.

8. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la quantité maximale de Hf est de 0,5 % en poids.

9. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel Co est présent dans l'alliage à raison de 2 % en poids à 4 % en poids, de préférence de 3 % en poids.

10. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel le cobalt (Co) et le fer (Fe) sont présents dans l'alliage, et dans lequel la quantité de Fe est plus petite que la quantité de Co.

11. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel le cobalt (Co) et le manganèse (Mn) sont présents dans l'alliage, et dans lequel la quantité de Mn est plus petite que la quantité de Co.

12. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel le cobalt (Co), le manganèse (Mn) et le fer (Fe) sont présents dans l'alliage, et dans lequel la quantité de Fe et de Mn est plus petite que la quantité de Co.

13. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la teneur en chrome (Cr) est supérieure à 14 % en poids.

14. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la teneur en chrome (Cr) est supérieure à 16 % en poids.

15. Superalliage à base de nickel selon l'une quelconque des revendications 1 à 13, dans lequel la quantité de chrome (Cr) est comprise entre 14 % en poids et 18 % en poids Cr, et est de préférence de 16 % en poids.

16. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la quantité de tungstène (W) est comprise entre 1,7 % en poids et 2,8 % en poids, et est en particulier de 2,3 % en poids.

17. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la quantité d'aluminium (Al) est supérieure ou égale à 4,5 % en poids.

18. Superalliage à base de nickel selon l'une quelconque des revendications 1 à 16, dans lequel la quantité d'aluminium (Al) est comprise entre 4,0 % en poids et 4,3 % en poids.

19. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel la quantité de tantale (Ta) est comprise entre 9 % en poids et 11 % en poids, la quantité de tantale étant de préférence de 10 % en poids.

20. Superalliage à base de nickel selon l'une quelconque des revendications 1 à 18, dans lequel la quantité de tantale (Ta) est supérieure à 10 % en poids.

21. Superalliage à base de nickel selon l'une quelconque des revendications précédentes,

dans lequel la quantité de zirconium (Zr) est supérieure ou égale à 0,02 Zr, et est de préférence de 0,02 % en poids.

22. Superalliage à base de nickel selon l'une quelconque des revendications précédentes, dans lequel le superalliage consiste en Ni, Co, Cr, Mo, W, Al, Ta, Hf, Zr, C et B.

23. Composant coulé traditionnel comprenant un superalliage selon l'une quelconque des revendications 1 à 22.

24. Composant à solidification dirigée comprenant un superalliage selon l'une quelconque des revendications 1 à 22.

25. Composant monocristallin comprenant un superalliage selon l'une quelconque des revendications 1 à 22.

26. Composant selon l'une quelconque des revendications 23 à 25, étant entendu que le composant est une pièce de turbine à gaz.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6818077 B **[0003]**
- US 6419763 B **[0003]**
- US 6177046 B **[0003]**
- EP 0789087 A **[0003]**
- EP 0637474 A **[0003]**
- US 20050194068 A **[0004]**
- EP 0560296 A1 **[0005]**