




30/03/16

Number of documents: 10

| | |
|-------------------------------|--|
| GB200215563 | A method of heat treating titanium aluminide ROLLS ROYCE |
| GB200319061 | A method of heat treating titanium aluminide ROLLS ROYCE |
| GB9915394 | A method of adding boron to a heavy metal containing titanium aluminide alloy and a heavy metal containing titanium aluminide alloy ROLLS ROYCE |
| GB200601662 | A method of heat treating titanium aluminide ROLLS ROYCE |
| GB9714391 | Titanium aluminide alloys ROLLS ROYCE UNIVERSITY OF BIRMINGHAM |
| GB200616566 | An alloy and method of treating titanium aluminide ROLLS ROYCE |
| US5296056 | Titanium aluminide alloys AEC ACQUISTION ALLISON ENGINE CHEMICAL BANK ROLLS ROYCE |
| US20030051780 | Method of adding boron to a heavy metal containing titanium aluminide alloy and a heavy metal containing titanium aluminide alloy ROLLS ROYCE |
| WO200248420 | Method for producing components with a high load capacity from tial alloys LEISTRITZ LEISTRITZ TURBINENKOMPONENTEN REMSCHEID LEISTRITZ TURBINENKOMPONENTEN RENSCHIED ROLLS ROYCE THYSSENKRUPP AUTOMOTIVE THYSSENKRUPP TURBINENKOMPO NENTEN |
| WO2014204534 | Titanium-aluminide components ROLLS ROYCE NORTH AMERICAN TECHNOLOGIES |

A method of heat treating titanium aluminide GB200215563

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|------------|-----------------|------------|---------------|---------------------------|----|------------|-------------|-------------------------------|----|------------|-----------------|---------------------------|----|------------|-------------|------------|----|------------|--------------|------------|----|------------|--------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE • Inventor HU DAWEI • International Patent Classification C22F-001/04 C22F-001/18 • US Patent Classification PCLO=148669000 • CPC Code C22F-001/04; C22F-001/18/3 | <ul style="list-style-type: none"> • Publication Information GB0215563 D0 2002-08-14 [GB200215563]    • Priority Details 2002GB-0015563 2002-07-05 | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;">GB0215563</td> <td style="width: 33%;">D0</td> <td style="width: 33%;">2002-08-14</td> <td style="width: 33%;">[GB200215563]</td> </tr> <tr> <td>EP1378582</td> <td>A1</td> <td>2004-01-07</td> <td>[EP1378582]</td> </tr> <tr> <td>US20040003877</td> <td>A1</td> <td>2004-01-08</td> <td>[US20040003877]</td> </tr> <tr> <td>EP1378582</td> <td>B1</td> <td>2004-10-20</td> <td>[EP1378582]</td> </tr> <tr> <td>DE60300101</td> <td>D1</td> <td>2004-11-25</td> <td>[DE60300101]</td> </tr> <tr> <td>DE60300101</td> <td>T2</td> <td>2005-03-03</td> <td>[DE60300101]</td> </tr> </table> | | GB0215563 | D0 | 2002-08-14 | [GB200215563] | EP1378582 | A1 | 2004-01-07 | [EP1378582] | US20040003877 | A1 | 2004-01-08 | [US20040003877] | EP1378582 | B1 | 2004-10-20 | [EP1378582] | DE60300101 | D1 | 2004-11-25 | [DE60300101] | DE60300101 | T2 | 2005-03-03 | [DE60300101] |
| GB0215563 | D0 | 2002-08-14 | [GB200215563] | | | | | | | | | | | | | | | | | | | | | | |
| EP1378582 | A1 | 2004-01-07 | [EP1378582] | | | | | | | | | | | | | | | | | | | | | | |
| US20040003877 | A1 | 2004-01-08 | [US20040003877] | | | | | | | | | | | | | | | | | | | | | | |
| EP1378582 | B1 | 2004-10-20 | [EP1378582] | | | | | | | | | | | | | | | | | | | | | | |
| DE60300101 | D1 | 2004-11-25 | [DE60300101] | | | | | | | | | | | | | | | | | | | | | | |
| DE60300101 | T2 | 2005-03-03 | [DE60300101] | | | | | | | | | | | | | | | | | | | | | | |

- **Abstract:**

(EP1378582)




A gamma titanium aluminide alloy consisting of 48at% aluminium, 2at% chromium, 2at% niobium and the balance titanium plus incidental impurities was heat treated according to the present invention. The gamma titanium aluminide alloy has an alpha transus temperature $T_{\alpha} = 1360 \text{ DEG.C}$. The gamma titanium aluminide alloy was heated to a temperature $T_1 = 1380 \text{ DEG.C}$ and was held at $T_1 = 1380 \text{ DEG.C}$ for 1 hour. The gamma titanium aluminide alloy was oil cooled. The gamma titanium aluminide alloy was heated to a temperature $T_2 = 1320 \text{ DEG.C}$ and was held at $T_2 = 1320 \text{ DEG.C}$ for 2 hours. The gamma titanium aluminide alloy was air cooled to ambient temperature. The gamma titanium aluminide alloy has a fine duplex microstructure comprising differently orientated alpha plates in a massively transformed gamma matrix.

Claims

(EP1378582)

1. A method of heat-treating a titanium aluminide alloy, the titanium aluminide alloy having a single alpha phase field and being capable of producing a massively transformed gamma microstructure the method comprising the steps of
 - (a) heating a titanium aluminide alloy to a temperature above the alpha transus temperature,
 - (b) maintaining the titanium aluminide alloy at the temperature above the alpha transus temperature in the single alpha phase field for a predetermined time period,
 - (c) cooling the titanium aluminide alloy from the single alpha phase field to produce a massively transformed gamma microstructure,
 - (d) heating the titanium aluminide alloy to a temperature below the alpha transus temperature in the alpha and gamma phase field,
 - (e) maintaining the titanium aluminide alloy at the temperature below the alpha transus temperature for a predetermined time period to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy,
 - (f) cooling the titanium aluminide alloy to ambient temperature.
2. A method as claimed in claim 1 wherein in step (b) the predetermined time period is up to 2 hours.
3. A method as claimed in claim 1 or claim 2 wherein in step (e) the predetermined time period is up to 4 hours.
4. A method as claimed in claim 1, claim 2 or claim 3 wherein step (d) comprises heating the titanium aluminide alloy to a temperature about 30 DEG.C to 60 DEG.C below the alpha transus temperature.
5. A method as claimed in any of claims 1 to 4 wherein step (a) comprises heating the titanium aluminide alloy to a temperature of about 20 DEG.C to 30 DEG.C above the alpha transus temperature.
6. A method as claimed in any of claims 1 to 5 wherein step (f) comprises air-cooling or furnace cooling.
7. A method as claimed in any of claims 1 to 6 wherein step (c) comprises air-cooling or oil cooling.
8. A method as claimed in any of claims 1 to 7 wherein the titanium aluminide alloy consists of at least 46at% aluminium.
9. A method as claimed in any of claims 1 to 8 wherein the titanium aluminide alloy comprises 48at% aluminium, 2at% chromium, 2at% niobium and the balance titanium and incidental impurities.
10. A method as claimed in claim 9 wherein the alpha transus temperature is about 1360 DEG.C, step (a) comprises heating to a temperature of 1380 DEG.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1380 DEG.C for about 1 hour, step (c) comprises oil cooling the titanium aluminide alloy from a temperature of 1380 DEG.C to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of about 1320 DEG.C for about 2 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
11. A method as claimed in any of claims 1 to 8 wherein the titanium aluminide alloy comprises 46at% aluminium, 8at% niobium, up to 0.07at% carbon and the balance titanium and incidental impurities.
12. A method as claimed in claim 11 wherein the alpha transus temperature is about 1335 DEG.C, step (a) comprises heating to a temperature of 1360 DEG.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1360 DEG.C for about 1 hour, step (c) comprises oil cooling, or air cooling, the titanium aluminide alloy from a temperature of 1360 DEG.C to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of about 1300 DEG.C for about 4 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
13. A method as claimed in any of claims 1 to 7 wherein the titanium aluminide alloy consists of 45-46at% aluminium, 8at% niobium, up to 0.07at% carbon and the balance titanium and incidental impurities.
14. A method as claimed in any of claims 1 to 7 wherein the titanium aluminide alloy consists of 45-46at% aluminium, 2-6at% niobium, 2-6at% hafnium and the balance titanium and incidental impurities.
15. A method as claimed in claim 14 wherein the titanium aluminide alloy consists of 46at% aluminium, 4at% niobium, 4at% hafnium and the balance titanium and incidental impurities.
16. A method as claimed in any of claims 1 to 15 wherein the titanium aluminide alloy is a cast titanium aluminide alloy component.
17. A method as claimed in claim 16 comprising hot isostatic pressing of the cast titanium aluminide alloy component.
18. A method as claimed in claim 17 wherein the hot isostatic pressing of the cast titanium aluminide alloy component is concurrent with step (e).
19. A method as claimed in claim 17 or claim 18 wherein the hot isostatic pressing comprises applying a pressure of about 150MPa for about 4 hours.
20. A method as claimed in any of claims 1 to 19 wherein the titanium aluminide alloy is a compressor blade or a compressor vane.

A method of heat treating titanium aluminide GB200319061

| | | | | | | | | | | | | | |
|---|---|------------|-----------------|------------|---------------|-----------|----|------------|-------------|--------------|----|------------|-----------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE • Inventor HU DAWEI WU XINHUA LORETTO MICHAEL • International Patent Classification C22F-001/18 • US Patent Classification PCLO=148669000 • CPC Code C22F-001/18/3 | <ul style="list-style-type: none"> • Publication Information GB0319061 D0 2003-09-17 [GB200319061]    • Priority Details 2003GB-0019061 2003-08-14 | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;">GB0319061</td> <td style="width: 33%;">D0</td> <td style="width: 33%;">2003-09-17</td> <td style="width: 33%;">[GB200319061]</td> </tr> <tr> <td style="color: blue;">EP1507017</td> <td>A1</td> <td>2005-02-16</td> <td>[EP1507017]</td> </tr> <tr> <td style="color: blue;">US2005081967</td> <td>A1</td> <td>2005-04-21</td> <td>[US20050081967]</td> </tr> </table> | | GB0319061 | D0 | 2003-09-17 | [GB200319061] | EP1507017 | A1 | 2005-02-16 | [EP1507017] | US2005081967 | A1 | 2005-04-21 | [US20050081967] |
| GB0319061 | D0 | 2003-09-17 | [GB200319061] | | | | | | | | | | |
| EP1507017 | A1 | 2005-02-16 | [EP1507017] | | | | | | | | | | |
| US2005081967 | A1 | 2005-04-21 | [US20050081967] | | | | | | | | | | |

- **Abstract:**

(EP1507017)

A gamma titanium aluminide alloy consisting of 46at% aluminium, 8at% niobium, up to 0.07at% carbon and the balance titanium plus incidental impurities has an alpha transus temperature $T_{\alpha} = 1335 \text{ DEG.C}$. The gamma titanium aluminide alloy was heated to a temperature $T_1 = 1360 \text{ DEG.C}$ and was held at $T_1 = 1360 \text{ DEG.C}$ for 1 hour or longer. The gamma titanium aluminide alloy was fluidised bed, or salt bath, quenched to a temperature T_2 , where $900 \text{ DEG.C} < T_2 < 1200 \text{ DEG.C}$, and was held at temperature T_2 for a sufficient time to allow the massive transformation to go to completion. The gamma titanium aluminide alloy was heated to a temperature $T_3 = 1300 \text{ DEG.C}$ or 1320 DEG.C and was held at T_2 for 4 hours. The gamma titanium aluminide alloy was air cooled to ambient temperature. The gamma titanium aluminide alloy has a fine duplex microstructure comprising differently orientated alpha plates in a massively transformed gamma matrix. The heat treatment reduces quenching stresses, allows larger castings and a broader range of titanium aluminide alloys to be grain refined.


Claims

(EP1507017)

1. A method of heat-treating titanium aluminide alloy, the titanium aluminide alloy having a single alpha phase field and being capable of producing a massively transformed gamma microstructure, the method comprising the steps of :-
 - (a) heating a titanium aluminide alloy to a temperature (T1) above the alpha transus temperature (Tvaries),
 - (b) maintaining the titanium aluminide alloy at a temperature (T1) above the alpha transus temperature in the single alpha phase field for a predetermined time period (t1),
 - (c) cooling the titanium aluminide alloy from the single alpha phase field to a temperature (T2) in the range of 900 DEG.C to 1200 DEG.C,
 - (d) maintaining the titanium aluminide alloy at the temperature (T2) in the range of 900 DEG.C to 1200 DEG.C for a predetermined time period (t2) to produce a massively transformed gamma microstructure,
 - (e) heating the titanium aluminide alloy to a temperature (T3) below the alpha transus temperature in the alpha and gamma phase field,
 - (f) maintaining the titanium aluminide alloy at the temperature (T3) below the alpha transus temperature for a predetermined time period (t3) to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy,
 - (g) cooling the titanium aluminide alloy to ambient temperature.
2. A method as claimed in claim 1 wherein in step (b) the predetermined time period (t1) is up to 2 hours.
3. A method as claimed in claim 1 or claim 2 wherein in step (f) the predetermined time period (t3) is up to 4 hours.
4. A method as claimed in claim 1, claim 2 or claim 3 wherein step (e) comprises heating the titanium aluminide alloy to a temperature (T3) about 30 DEG.C to 60 DEG.C below the alpha transus temperature.
5. A method as claimed in any of claims 1 to 4 wherein step (a) comprises heating the titanium aluminide alloy to a temperature (T1) of about 20 DEG.C to 30 DEG.C above the alpha transus temperature.
6. A method as claimed in any of claims 1 to 5 wherein step (g) comprises air-cooling or furnace cooling.
7. A method as claimed in any of claims 1 to 6 wherein step (c) comprises fluidised bed (FB) cooling or salt bath (SB) cooling.
8. A method as claimed in any of claims 1 to 7 comprising cooling the titanium aluminide to ambient temperature after step (d) and before step (e).
9. A method as claimed in claim 8 wherein the titanium aluminide is cooled to ambient temperature by air-cooling (AC) or oil cooling (OC).
10. A method as claimed in any of claims 1 to 9 wherein the titanium aluminide alloy comprises 48at% aluminium, 2at% chromium, 2at% niobium and the balance titanium and incidental impurities.
11. A method as claimed in claim 10 wherein the alpha transus temperature (Tvaries) is about 1360 DEG.C, step (a) comprises heating to a temperature (T1) of 1380 DEG.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature (T1) of about 1380 DEG.C for about 1 hour, step (c) and (d) comprise salt bath (SB), or fluidised bed (FB), cooling the titanium aluminide alloy from a temperature (T1) of 1380 DEG.C to a temperature (T2) between 900 DEG.C and 1200 DEG.C and maintaining the titanium aluminide alloy at the temperature (T2) in the range of 900 DEG.C to 1200 DEG.C for a predetermined time period (t2) to produce a massively transformed gamma microstructure, steps (e) and (f) comprise heating the titanium aluminide alloy to a temperature (T3) of about 1320 DEG.C for about 2 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (g) comprises air cooling the titanium aluminide alloy to ambient temperature.
12. A method as claimed in any of claims 1 to 9 wherein the titanium aluminide alloy comprises 46at% aluminium, 8at% niobium, up to 0.07at% carbon and the balance titanium and incidental impurities.
13. A method as claimed in claim 12 wherein the alpha transus temperature (Tvaries) is about 1335 DEG.C, step (a) comprises heating to a temperature (T1) of 1360 DEG.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature (T1) of about 1360 DEG.C for about 1 hour, steps (c) and (d) comprise salt bath (SB) cooling, or fluidised bed (FB) cooling, the titanium aluminide alloy from a temperature (T1) of 1360 DEG.C to a temperature (T2) between 900 DEG.C and 1200 DEG.C and maintaining the titanium aluminide alloy at the temperature (T2) in the range of 900 DEG.C to 1200 DEG.C for a predetermined time period (t2) to produce a massively transformed gamma microstructure, steps (e) and (f) comprise heating the titanium aluminide alloy to a temperature (T3) of about 1300 DEG.C to about 1320 DEG.C for about 4 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
14. A method as claimed in any of claims 1 to 9 wherein the titanium aluminide alloy consists of 45-46at% aluminium, 8at% niobium, up to 0.07at% carbon and the balance is titanium and incidental impurities.
15. A method as claimed in any of claims 1 to 9 wherein the titanium aluminide alloy consists of 45-46at% aluminium, 2-6at% niobium, 2-6at% hafnium and the balance is titanium plus incidental impurities.
16. A method as claimed in any of claims 1 to 15 wherein the titanium aluminide alloy is a cast titanium aluminide component.
17. A method as claimed in any of claims 1 to 16 wherein comprising hot isostatic pressing of the cast titanium aluminide alloy component.
18. A method as claimed in claim 17 wherein the hot isostatic pressing of the cast titanium aluminide alloy component is concurrent with step (f).
19. A method as claimed in claim 17 or claim 18 wherein the hot isostatic pressing comprises applying a pressure of about 150MPa for about 4 hours.
20. A method as claimed in any of claims 1 to 19 wherein the titanium aluminide alloy is a compressor blade (10) or a compressor vane.

A method of adding boron to a heavy metal containing titanium aluminide alloy and a heavy metal containing titanium aluminide alloy

GB9915394

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|------------|--------------|------------|-------------|---------------------------|----|------------|-------------|---------------------------|----|------------|-------------|---------------------------|----|------------|-------------|--------------------------|---|------------|-------------|------------|----|------------|--------------|------------|----|------------|--------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE • Inventor BLENKINSOP PAUL ADDYMAN GODFREY ALASTAIR BRYAN • International Patent Classification B22F-003/10 C22C-014/00 C22C-032/00 • US Patent Classification PCLO=164057100 PCLX=164097000 • CPC Code B22F-003/10/03; B22F-2998/00; C22C-014/00 C22C-032/00/73; | <ul style="list-style-type: none"> • Publication Information GB9915394 D0 1999-09-01 [GB9915394]  <ul style="list-style-type: none"> • Priority Details 1999GB-0015394 1999-07-02 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">GB9915394</td> <td style="width: 33%;">D0</td> <td style="width: 33%;">1999-09-01</td> <td style="width: 33%;">[GB9915394]</td> </tr> <tr> <td>EP1065289</td> <td>A1</td> <td>2001-01-03</td> <td>[EP1065289]</td> </tr> <tr> <td>US6488073</td> <td>B1</td> <td>2002-12-03</td> <td>[US6488073]</td> </tr> <tr> <td>EP1065289</td> <td>B1</td> <td>2004-10-27</td> <td>[EP1065289]</td> </tr> <tr> <td>AT280842</td> <td>T</td> <td>2004-11-15</td> <td>[ATE280842]</td> </tr> <tr> <td>DE60015240</td> <td>D1</td> <td>2004-12-02</td> <td>[DE60015240]</td> </tr> <tr> <td>DE60015240</td> <td>T2</td> <td>2005-03-10</td> <td>[DE60015240]</td> </tr> </table> | | GB9915394 | D0 | 1999-09-01 | [GB9915394] | EP1065289 | A1 | 2001-01-03 | [EP1065289] | US6488073 | B1 | 2002-12-03 | [US6488073] | EP1065289 | B1 | 2004-10-27 | [EP1065289] | AT280842 | T | 2004-11-15 | [ATE280842] | DE60015240 | D1 | 2004-12-02 | [DE60015240] | DE60015240 | T2 | 2005-03-10 | [DE60015240] |
| GB9915394 | D0 | 1999-09-01 | [GB9915394] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EP1065289 | A1 | 2001-01-03 | [EP1065289] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| US6488073 | B1 | 2002-12-03 | [US6488073] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EP1065289 | B1 | 2004-10-27 | [EP1065289] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AT280842 | T | 2004-11-15 | [ATE280842] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DE60015240 | D1 | 2004-12-02 | [DE60015240] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DE60015240 | T2 | 2005-03-10 | [DE60015240] | | | | | | | | | | | | | | | | | | | | | | | | | | |

- **Abstract:**

(EP1065289)


A method of adding boron to a tungsten, or tantalum, containing titanium aluminide alloy to form a boride dispersion in the tungsten, or tantalum, containing titanium aluminide. A molten tungsten, or tantalum, containing titanium aluminide alloy is formed and tungsten, or tantalum, boride is added to the molten tungsten, or tantalum, containing titanium aluminide alloy to form a molten mixture. The molten mixture is cooled and solidified to form a tungsten, or tantalum, containing titanium aluminide alloy having a uniform dispersion of tungsten, or tantalum, boride particles substantially without the formation of clusters of tungsten, or tantalum, boride. The titanium aluminide alloy comprises between 0.5at% and 2.0at% boron.

Claims

(EP1065289)

1. A method of adding boron to a heavy metal containing titanium aluminide alloy to form a boride dispersion in the heavy metal containing titanium aluminide, comprising:-
 - (a) forming molten heavy metal containing titanium aluminide alloy,
 - (b) adding heavy metal boride particles to the molten heavy metal containing titanium aluminide alloy to form a molten mixture,
 - (c) cooling and solidifying the molten mixture to form a heavy metal element containing titanium aluminide alloy having metal boride particles,characterised by adding the metal boride particles to the heavy metal containing titanium aluminide alloy as heavy metal boride particles, the heavy metal boride particles having the same form as undesirable heavy metal boride precipitate clusters whereby the heavy metal containing titanium aluminide alloy has a uniform dispersion of heavy metal boride particles substantially without the formation of heavy metal boride precipitate clusters.
2. A method as claimed in claim 1 wherein step (a) comprises forming molten tungsten containing titanium aluminide alloy, (b) adding tungsten boride to the molten tungsten containing titanium aluminide alloy to form a molten mixture, the tungsten boride particles having the same form as undesirable tungsten boride precipitate clusters, (c) cooling and solidifying the molten mixture to form a tungsten containing titanium aluminide alloy having a dispersion of tungsten boride particles substantially without the formation of tungsten boride precipitate clusters.
3. A method as claimed in claim 1 wherein step (a) comprises forming molten tantalum containing titanium aluminide alloy, (b) adding tantalum boride to the molten tantalum containing titanium aluminide alloy to form a molten mixture, the tantalum boride particles having the same form as undesirable tantalum boride precipitate clusters, (c) cooling and solidifying the molten mixture to form a tantalum containing titanium aluminide alloy having a dispersion of tantalum boride particles substantially without the formation of tantalum boride precipitate clusters.
4. A method as claimed in claim 1, claim 2 or claim 3 wherein the titanium aluminide alloy comprises up to 2.0at% boron.
5. A method as claimed in claim 4 wherein the titanium aluminide alloy comprises up to 1.0at% boron.
6. A method as claimed in any of claims 1 to 5 wherein the titanium aluminide alloy comprises more than 0.5at% boron.
7. A method as claimed in any of claims 1 to 6 wherein the heavy metal boride particles added have a size of 1 to 5 μ m.
8. A method as claimed in any of claims 1 to 7 wherein the titanium aluminide alloy comprises a gamma titanium aluminide.
9. A method as claimed in claim 8 wherein the gamma titanium aluminide alloy preferably comprises 44 to 52at% aluminium, one or more of tungsten and tantalum each in an amount of 0.05 to 8.0at%, up to 2.0at% boron and balance titanium plus incidental impurities.
10. A method as claimed in claim 9 wherein the gamma titanium aluminide additionally comprises up to 3at% chromium, up to 6at% niobium, up to 2at% manganese.
11. A method as claimed in claim 9 wherein the gamma titanium aluminide alloy comprises 45 to 47at% aluminium, 2 to 6at% niobium, 0.25 to 2at% tungsten and the balance titanium plus incidental impurities.
12. A method as claimed in claim 11 wherein the gamma titanium aluminide comprises 45at% aluminium, 5at% niobium and 1at% tungsten.
13. A method as claimed in claim 11 or claim 12 wherein the gamma titanium aluminide alloy comprises 1 to 2at% chromium and/or 1 to 2at% manganese.
14. A method as claimed in any of claims 1 to 13 wherein the method comprises forming the titanium aluminide alloy into a turbine blade, a turbine vane, a compressor blade, or a compressor vane.
15. A method as claimed in claim 14 wherein the titanium aluminide alloy is cast or forged.
16. A heavy metal containing titanium aluminide alloy, the titanium aluminide containing heavy metal boride particles substantially without heavy metal boride precipitate clusters, the heavy metal boride particles having the same form as the undesirable heavy metal boride precipitate clusters, and the titanium aluminide alloy comprises up to 2.0at% boron.
17. A heavy metal containing titanium aluminide alloy as claimed in claim 16 wherein the heavy metal is tungsten and the heavy metal boride is tungsten boride.
18. A heavy metal containing titanium aluminide alloy as claimed in claim 16 or claim 17 wherein the heavy metal is tantalum and the heavy metal boride is tantalum boride.
19. A heavy metal containing titanium aluminide alloy as claimed in any of claims 16 to 18 wherein the titanium aluminide alloy comprises a gamma titanium aluminide.
20. A heavy metal containing titanium aluminide as claimed in claim 19 wherein the gamma titanium aluminide alloy preferably comprises 44 to 52at% aluminium, one or more of tungsten and tantalum each in an amount of 0.05 to 8.0at%, up to 2.0at% boron and balance titanium plus incidental impurities.
21. A heavy metal containing titanium aluminide as claimed in claim 20 wherein the gamma titanium aluminide additionally comprises up to 3at% chromium, up to 6at% niobium, up to 2at% manganese.
22. A heavy metal containing titanium aluminide as claimed in claim 21 wherein the gamma titanium aluminide alloy comprises 45 to 47at% aluminium, 2 to 6at% niobium, 0.25 to 2at% tungsten and the balance titanium plus incidental impurities.
23. A heavy metal containing titanium aluminide as claimed in claim 22 wherein the gamma titanium aluminide comprises 45at% aluminium, 5at% niobium and 1at% tungsten.
24. A heavy metal containing titanium aluminide as claimed in claim 21 or claim 22 wherein the gamma titanium aluminide alloy comprises 1 to 2at% chromium and/or 1 to 2at% manganese.
25. A heavy metal containing titanium aluminide alloy as claimed in any of claims 16 to 24 wherein the titanium aluminide alloy is in the shape of a turbine blade, a turbine vane, a compressor blade, or a compressor vane.

A method of heat treating titanium aluminide GB200601662

| | | | | | | | | | | | | | | | | | |
|---|---|------------|-----------------|------------|---------------|---------------------------|----|------------|-------------|------------------------------|----|------------|-----------------|---------------------------|----|------------|-------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE • Inventor VOICE WAYNE ERIC HU DAWEI WU XINHUA LORETTO MICHAEL • International Patent Classification C22C-014/00 C22F-001/18 • US Patent Classification PCLO=148669000 PCLX=148421000 PCLX=420418000 • CPC Code C22C-014/00; C22C-030/00 C22F-001/18/3; | <ul style="list-style-type: none"> • Publication Information GB0601662 D0 2006-03-08 [GB200601662]  • Priority Details 2006GB-0001662 2006-01-27 | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">GB0601662</td> <td style="width: 20%;">D0</td> <td style="width: 20%;">2006-03-08</td> <td style="width: 30%;">[GB200601662]</td> </tr> <tr> <td>EP1813691</td> <td>A1</td> <td>2007-08-01</td> <td>[EP1813691]</td> </tr> <tr> <td>US2007175551</td> <td>A1</td> <td>2007-08-02</td> <td>[US20070175551]</td> </tr> <tr> <td>US7704339</td> <td>B2</td> <td>2010-04-27</td> <td>[US7704339]</td> </tr> </table> | | GB0601662 | D0 | 2006-03-08 | [GB200601662] | EP1813691 | A1 | 2007-08-01 | [EP1813691] | US2007175551 | A1 | 2007-08-02 | [US20070175551] | US7704339 | B2 | 2010-04-27 | [US7704339] |
| GB0601662 | D0 | 2006-03-08 | [GB200601662] | | | | | | | | | | | | | | |
| EP1813691 | A1 | 2007-08-01 | [EP1813691] | | | | | | | | | | | | | | |
| US2007175551 | A1 | 2007-08-02 | [US20070175551] | | | | | | | | | | | | | | |
| US7704339 | B2 | 2010-04-27 | [US7704339] | | | | | | | | | | | | | | |

- **Abstract:**

(EP1813691)

A gamma titanium aluminide alloy consisting of 46at% aluminium, 8at% tantalum and the balance titanium plus incidental impurities has an alpha transus temperature $T \pm$ between 1310°C and 1320°C. The gamma titanium aluminide alloy was heated to a temperature $T_1 = 1330^\circ\text{C}$ and was held at $T_1 = 1330^\circ\text{C}$ for 1 hour or longer. The gamma titanium aluminide alloy was air cooled to ambient temperature to allow the massive transformation to go to completion. The gamma titanium aluminide alloy was heated to a temperature $T_2 = 1250^\circ\text{C}$ to 1290°C and was held at T_2 for 4 hours. The gamma titanium aluminide alloy was air cooled to ambient temperature. The gamma titanium aluminide alloy has a fine duplex microstructure comprising differently orientated alpha plates in a massively transformed gamma matrix. The heat treatment reduces quenching stresses and allows larger castings to be grain refined.

Claims

(EP1813691)

1. A method of heat-treating titanium aluminide alloy, the titanium aluminide alloy having a single alpha phase field and being capable of producing a massively transformed gamma microstructure, the titanium aluminide alloy comprises at least 45at% aluminium, 0-6at% niobium, 4-10at% tantalum, niobium plus tantalum is less than or equal to 10at% and the balance titanium and incidental impurities, the method comprising the steps of :- (a) heating a titanium aluminide alloy to a temperature above the alpha transus temperature, (b) maintaining the titanium aluminide alloy at a temperature above the alpha transus temperature in the single alpha phase field for a predetermined time period, (c) cooling the titanium aluminide alloy from the single alpha phase field to produce a massively transformed gamma microstructure, (d) heating the titanium aluminide to a temperature below the alpha transus temperature in the alpha and gamma phase field, (e) maintaining the titanium aluminide at the temperature below the alpha transus temperature for a predetermined time period to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced, (f) cooling the titanium aluminide to ambient temperature.
2. A method as claimed in claim 1 wherein the titanium aluminide alloy comprising at least 45at% aluminium, 0-4at% niobium, 4-8at% tantalum, niobium plus tantalum is less than or equal to 8at% and the balance titanium and incidental impurities.
3. A method as claimed in claim 1 or claim 2 wherein step (c) comprises cooling the titanium aluminide alloy from the single alpha phase field to a temperature in the range of 900 deg.C to 1200 deg.C and maintaining the titanium aluminide alloy at the temperature in the range of 900 deg.C to 1200 deg.C for a predetermined time period to produce a massively transformed gamma microstructure.
4. A method as claimed in claim 1 or claim 2 wherein step (c) comprises cooling the titanium aluminide to ambient temperature.
5. A method as claimed in claim 1, claim 2, claim 3 or claim 4 wherein in step (b) the predetermined time period is up to 2 hours.
6. A method as claimed in claim 1, claim 2 or claim 3 wherein in step (e) the predetermined time period is up to 4 hours.
7. A method as claimed in any of claims 1 to 6 wherein step (d) comprises heating the titanium aluminide alloy to a temperature about 30 deg.C to 60 deg.C below the alpha transus temperature.
8. A method as claimed in any of claims 1 to 7 wherein step (a) comprises heating the titanium aluminide alloy to a temperature of about 20 deg.C to 30 deg.C above the alpha transus temperature.
9. A method as claimed in any of claims 1 to 8 wherein step (f) comprises air-cooling or furnace cooling.
10. A method as claimed in claim 3 wherein step (c) comprises fluidised bed cooling or salt bath cooling.
11. A method as claimed in claim 10 comprising cooling the titanium aluminide to ambient temperature after step (c) and before step (d).
12. A method as claimed in claim 1 or claim 11 wherein the titanium aluminide is cooled to ambient temperature by air-cooling or oil cooling.
13. A method as claimed in any of claims 1 to 12 wherein the titanium aluminide alloy comprises 46at% aluminium, 4at% tantalum, 4at% niobium and the balance titanium and incidental impurities.
14. A method as claimed in claim 13 wherein the alpha transus temperature is about 1340 deg.C, step (a) comprises heating to a temperature of 1360 deg.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1360 deg.C for about 1 hour, step (c) comprises salt bath, or fluidised bed, cooling the titanium aluminide alloy from a temperature of 1360 deg.C to a temperature between 900 deg.C and 1200 deg.C and maintaining the titanium aluminide alloy at the temperature in the range of 900 deg.C to 1200 deg.C for a predetermined time period to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of 1280 deg.C to 1310 deg.C for about 2 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
15. A method as claimed in claim 13 wherein the alpha transus temperature is about 1340 deg.C, step (a) comprises heating to a temperature of 1360 deg.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1360 deg.C for about 1 hour, step (c) comprises air cooling the titanium aluminide alloy from a temperature of 1360 deg.C to ambient temperature to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of 1280 deg.C to 1310 deg.C for about 2 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
16. A method as claimed in any of claims 1 to 12 wherein the titanium aluminide alloy comprises 46at% aluminium, 8at% tantalum and the balance titanium and incidental impurities.
17. A method as claimed in claim 16 wherein the alpha transus temperature is between 1310 deg.C and 1320 deg.C, step (a) comprises heating to a temperature of 1330 deg.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1330 deg.C for about 1 hour, step (c) comprise salt bath cooling, or fluidised bed cooling, the titanium aluminide alloy from a temperature of 1330 deg.C to a temperature between 900 deg.C and 1200 deg.C and maintaining the titanium aluminide alloy at the temperature in the range of 900 deg.C to 1200 deg.C for a predetermined time period to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of about 1250 deg.C to about 1290 deg.C for about 4 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.
18. A method as claimed in claim 16 wherein the alpha transus temperature is between 1310 deg.C and 1320 deg.C, step (a) comprises heating to a temperature of 1330 deg.C, step (b) comprises maintaining the titanium aluminide alloy at a temperature of about 1330 deg.C for about 1 hour, step (c) comprise air cooling the titanium aluminide alloy from a temperature of 1330 deg.C to ambient temperature to produce a massively transformed gamma microstructure, steps (d) and (e) comprise heating the titanium aluminide alloy to a temperature of about 1250 deg.C to about 1290 deg.C for about 4 hours to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced in the titanium aluminide alloy, and

step (f) comprises air cooling the titanium aluminide alloy to ambient temperature.

19. A method as claimed in any of claims 16 to 18 wherein step (c) comprises cooling the titanium aluminide at a cooling rate of 4 deg.CS **-1 to 150 deg.CS **-1.

20. A method as claimed in any of claims 13 to 15 wherein step (c) comprises cooling the titanium aluminide at a cooling rate of 15 deg.CS **-1 to 150 deg.CS **-1.

21. A method as claimed in any of claims 1 to 20 wherein the titanium aluminide alloy is a cast titanium aluminide component.

22. A method as claimed in any of claims 1 to 21 wherein comprising hot isostatic pressing of the cast titanium aluminide alloy component.


23. A method as claimed in claim 22 wherein the hot isostatic pressing of the cast titanium aluminide alloy component is concurrent with step (e).

24. A method as claimed in claim 22 or claim 23 wherein the hot isostatic pressing comprises applying a pressure of about 150MPa for about 4 hours.

25. A method as claimed in any of claims 1 to 24 wherein the titanium aluminide alloy is a compressor blade or a compressor vane.

Titanium aluminide alloys

GB9714391

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|------------|--------------|------------|-------------|---------------------------|----|------------|-------------|---------------------------|---|------------|-------------|---------------------------|----|------------|-------------|------------|----|------------|--------------|------------|----|------------|--------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE UNIVERSITY OF BIRMINGHAM • Inventor CHENG TAI-TSUI JONES IAN PHILIP • International Patent Classification C22C-014/00 • US Patent Classification PCLO=420418000 PCLX=148421000 PCLX=420552000 • CPC Code C22C-014/00 | <ul style="list-style-type: none"> • Publication Information GB9714391 D0 1997-09-10 [GB9714391] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1997GB-0014391 1997-07-05 | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;">GB9714391</td> <td style="width: 33%;">D0</td> <td style="width: 33%;">1997-09-10</td> <td style="width: 33%;">[GB9714391]</td> </tr> <tr> <td>EP0889143</td> <td>A1</td> <td>1999-01-07</td> <td>[EP-889143]</td> </tr> <tr> <td>US5997808</td> <td>A</td> <td>1999-12-07</td> <td>[US5997808]</td> </tr> <tr> <td>EP0889143</td> <td>B1</td> <td>2002-05-08</td> <td>[EP-889143]</td> </tr> <tr> <td>DE69805242</td> <td>D1</td> <td>2002-06-13</td> <td>[DE69805242]</td> </tr> <tr> <td>DE69805242</td> <td>T2</td> <td>2003-03-13</td> <td>[DE69805242]</td> </tr> </table> | | GB9714391 | D0 | 1997-09-10 | [GB9714391] | EP0889143 | A1 | 1999-01-07 | [EP-889143] | US5997808 | A | 1999-12-07 | [US5997808] | EP0889143 | B1 | 2002-05-08 | [EP-889143] | DE69805242 | D1 | 2002-06-13 | [DE69805242] | DE69805242 | T2 | 2003-03-13 | [DE69805242] |
| GB9714391 | D0 | 1997-09-10 | [GB9714391] | | | | | | | | | | | | | | | | | | | | | | |
| EP0889143 | A1 | 1999-01-07 | [EP-889143] | | | | | | | | | | | | | | | | | | | | | | |
| US5997808 | A | 1999-12-07 | [US5997808] | | | | | | | | | | | | | | | | | | | | | | |
| EP0889143 | B1 | 2002-05-08 | [EP-889143] | | | | | | | | | | | | | | | | | | | | | | |
| DE69805242 | D1 | 2002-06-13 | [DE69805242] | | | | | | | | | | | | | | | | | | | | | | |
| DE69805242 | T2 | 2003-03-13 | [DE69805242] | | | | | | | | | | | | | | | | | | | | | | |

- **Abstract:**

(EP-889143)

A titanium aluminide based alloy consisting of 42-48 at% aluminium, 2-5 at% niobium, 3-8 at% zirconium, 0-1 at% boron, 0-0.4 at% silicon and the balance, apart from incidental impurities, is titanium. The titanium aluminide alloy composition has a satisfactory combination of high tensile strength, acceptable ductility at room temperature and low secondary creep rate at elevated temperature, so as to be suitable for use in high temperature applications for example aero-engines and automobile engines. It is suitable for compressor discs and compressor blades of aero-engines.


Claims

(EP-889143)

1. A titanium aluminide based alloy consisting of 42- 48 at% aluminium, 2-5 at% niobium, 3-8 at% zirconium, 0-1 at% boron, 0-0.4 at% silicon and the balance, apart from incidental impurities, is titanium.
2. A titanium aluminide based alloy as claimed in claim 1 wherein the alloy contains 43-45 at% aluminium.
3. A titanium aluminide based alloy as claimed in claim 1 or claim 2 wherein the alloy contains 3-5 at% niobium.
4. A titanium aluminide based alloy as claimed in claim 1, claim 2 or claim 3 wherein the alloy contains 3-5 at% zirconium.
5. A titanium aluminide based alloy as claimed in any of claims 1 to 4 wherein the alloy contains 0.2-0.5 at% boron.
6. A titanium aluminide based alloy as claimed in any of claims 1 to 5 wherein the alloy contains at least 0.3 at% boron.
7. A titanium aluminide based alloy as claimed in any of claims 1 to 6 wherein the alloy contains 0.1-0.3 at% silicon.
8. A titanium aluminide based alloy as claimed in claim 1 wherein the alloy consists of 43-45 at% aluminium, 3-5 at% niobium, 3-5 at% zirconium, 0.2-0.5 at% boron, 0.1-0.3 at% silicon and the balance, apart from incidental impurities, is titanium.
9. A titanium aluminide based alloy as claimed in claim 8 wherein the alloy consists of 44 at% aluminium, 4 at% niobium, 4 at% zirconium, 0.3 at% boron, 0.2 at% silicon and the balance, apart from incidental impurities, is titanium.
10. An article consisting essentially of an alloy according to any of claims 1 to 9.
11. An article as claimed in claim 10 wherein the article is a compressor blade or a compressor disc.

An alloy and method of treating titanium aluminide

GB200616566

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|------------|-----------------|------------|---------------|---------------------------|----|------------|-------------|------------------------------|----|------------|-----------------|---------------------------|----|------------|-------------|---------------------------|----|------------|-------------|
| <ul style="list-style-type: none"> • Patent Assignee ROLLS ROYCE • Inventor HUANG AIJUN LORETTO MICHAEL WU XINHUA HU DAWEI • International Patent Classification C22C-014/00 C22C-021/00 C22C-030/00 C22F-001/04 C22F-001/18 • US Patent Classification PCLO=148669000 PCLX=148421000 PCLX=148437000 PCLX=148442000 PCLX=148688000 PCLX=148707000 • CPC Code C22C-014/00; C22C-021/00; C22F-001/04; C22F-001/18/3; F04D-029/00/2 | <ul style="list-style-type: none"> • Publication Information GB0616566 D0 2006-09-27 [GB200616566]  • Priority Details 2006GB-0016566 2006-08-19 | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">GB0616566</td> <td style="width: 20%;">D0</td> <td style="width: 20%;">2006-09-27</td> <td style="width: 30%;">[GB200616566]</td> </tr> <tr> <td>EP1889939</td> <td>A2</td> <td>2008-02-20</td> <td>[EP1889939]</td> </tr> <tr> <td>US2008041506</td> <td>A1</td> <td>2008-02-21</td> <td>[US20080041506]</td> </tr> <tr> <td>EP1889939</td> <td>A3</td> <td>2008-10-29</td> <td>[EP1889939]</td> </tr> <tr> <td>EP1889939</td> <td>B1</td> <td>2013-10-09</td> <td>[EP1889939]</td> </tr> </table> | | GB0616566 | D0 | 2006-09-27 | [GB200616566] | EP1889939 | A2 | 2008-02-20 | [EP1889939] | US2008041506 | A1 | 2008-02-21 | [US20080041506] | EP1889939 | A3 | 2008-10-29 | [EP1889939] | EP1889939 | B1 | 2013-10-09 | [EP1889939] |
| GB0616566 | D0 | 2006-09-27 | [GB200616566] | | | | | | | | | | | | | | | | | | |
| EP1889939 | A2 | 2008-02-20 | [EP1889939] | | | | | | | | | | | | | | | | | | |
| US2008041506 | A1 | 2008-02-21 | [US20080041506] | | | | | | | | | | | | | | | | | | |
| EP1889939 | A3 | 2008-10-29 | [EP1889939] | | | | | | | | | | | | | | | | | | |
| EP1889939 | B1 | 2013-10-09 | [EP1889939] | | | | | | | | | | | | | | | | | | |

- **Abstract:**

(EP1889939)


A method of treating a titanium aluminide alloy having a single alpha phase field and being capable of producing a massively transformed gamma microstructure by subjecting the alloy to a temperature cycle that produces the massively transformed microstructure having a refined microstructure; the method being characterised in that oxygen securing means are provided within the alloy to prevent diffusion of oxygen to the grain boundary. (see diagramm)

Claims

(EP1889939)

1. A method of enhancing massive transformation of a titanium aluminide alloy having a single alpha phase field characterised in that up to 0.5 at% of oxygen scouring means is incorporated into the alloy which inhibits diffusion of oxygen within the alpha phase field to the grain boundary as the alloy is subjected to a temperature cycle which produces a massively transformed gamma microstructure.
2. A method according to claim 1, wherein the oxygen scouring means is incorporated up to 0.2 at%.
3. A method according to claim 1 or claim 2, wherein the temperature cycle comprises the steps a) heating the titanium aluminide alloy to a temperature above the alpha transus temperature, b) maintaining the titanium aluminide alloy at a temperature above the alpha transus temperature for a predetermined time period, c) cooling the titanium aluminide alloy from the single alpha phase field to produce a massively transformed gamma microstructure.
4. A method according to claim 3, wherein the heat treatment further comprises the step of d) heating the titanium aluminide to a temperature below the alpha transus temperature in the alpha and gamma phase field, e) maintaining the titanium aluminide at the temperature below the alpha transus temperature for a predetermined time period to precipitate alpha plates in the massively transformed gamma microstructure such that a refined microstructure is produced, and f) cooling the titanium aluminide to ambient temperature.
5. A method according to any preceding claim, wherein the oxygen securing means is selected from the group comprising yttrium and hafnium.
6. A method according to any preceding claim, wherein the alloy consists at least 43at% aluminium, 0 to 9at% niobium, 0 to 10at% tantalum, 0.01 to 0.15at% yttrium, the balance being titanium plus incidental impurities.
7. A method according to any preceding claim, wherein step c) comprises cooling the titanium aluminide to ambient temperature.
8. A method according to any preceding claim, wherein the titanium aluminide is cooled by gas cooling, oil cooling, fluidised bed cooling or salt cooling.
9. A method according to any preceding claim, wherein step c) comprises cooling the titanium aluminide at a cooling rate of 4 deg.C.S ⁻¹ to 150 deg.C.S ⁻¹.
10. A method as claimed in any of claims 1 to 9, wherein the titanium aluminide alloy is a cast titanium aluminide component.
11. A method as claimed in claim 10, wherein the method further comprises the step of hot isostatic pressing the cast titanium aluminide component.
12. A method as claimed in any preceding claim, wherein the titanium aluminide alloy provides a compressor blade or a compressor vane.
13. An alloy consisting of 43 to 50 at% aluminium, 0 to 9 at% niobium, 0 to 10 at% tantalum, 0.01 to 0.2 at% of yttrium and /or hafnium, the balance being titanium plus incidental impurities.
14. An alloy according to claim 13, consisting of 45 to 46 at% aluminium, 7 to 9 at% niobium, 0.02 to 0.15 at% yttrium, the balance being titanium plus incidental impurities.
15. An alloy according to claim 13 or claim 14, wherein the niobium plus tantalum is less than or equal to 10at%.
16. An alloy claimed in any of claims 13 to 15, wherein the titanium aluminide alloy is a cast titanium aluminide component.

Titanium aluminide alloys US5296056

| | |
|--|--|
| <ul style="list-style-type: none">• <u>Patent Assignee</u> AEC ACQUISITION ALLISON ENGINE CHEMICAL BANK ROLLS ROYCE• <u>Inventor</u> JAIN SUSHIL K ROESSLER JAMES R• <u>International Patent Classification</u> C22C-014/00• <u>US Patent Classification</u> PCLO=148421000 PCLX=148403000 PCLX=420418000 PCLX=420421000• <u>CPC Code</u> C22C-014/00 | <ul style="list-style-type: none">• <u>Publication Information</u> US5296056 A 1994-03-22 [US5296056]  <ul style="list-style-type: none">• <u>Priority Details</u> 1992US-07966815 1992-10-26 |
| <ul style="list-style-type: none">• <u>Fampat family</u> US5296056 A 1994-03-22 [US5296056] | |

- **Abstract:**
(US5296056)
A family of gamma titanium aluminide alloys is provided which is based on the intermetallic compound TiAl and includes alloying additions which enable the alloys to exhibit both sufficient mechanical properties and environmental capabilities for use in high temperature applications associated with gas turbine and automotive engines. The preferred alloys have a nominal aluminum content of about 46 atomic percent and further include niobium at about three to about five atomic percent and tungsten at about one atomic percent nominally, so as to selectively enhance the oxidation resistance of the alloy. As species of the preferred alloy, alloying additions of vanadium, chromium and manganese can be included at levels of up to about two atomic percent to enhance the toughness and ductility of the preferred alloy at lower temperatures, such as those encountered during fabrication and during low temperature operations.

Claims

(US5296056)

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1.

A gamma titanium aluminide alloy based on an intermetallic compound TiAl, the gamma titanium aluminide alloy consisting essentially of:

aluminum in an amount of about 45 to about 47 atomic percent;

niobium in an amount of about 2 to about 6 atomic percent;

tungsten in an amount of about 0.25 to about 2 atomic percent;

and

one or both elements selected from the group consisting of chromium and manganese, each of the one or both elements selected being present in an amount of from about 1 to about 2 atomic percent;

with the balance being titanium;

whereby the gamma titanium aluminide alloy exhibits oxidation resistance and fracture toughness.

2. A gamma titanium aluminide alloy as recited in claim 1 further comprising vanadium in an amount of up to about 2 atomic percent.

3. A gamma titanium aluminide alloy as recited in claim 1 wherein the one or both elements consists of chromium in an amount of about 1 to about 2 atomic percent.

4. A gamma titanium aluminide alloy as recited in claim 1 wherein the one or more elements consists of manganese in an amount of about 1 to about 2 atomic percent.

5. A gamma titanium aluminide alloy as recited in claim 1 further comprising vanadium in an amount of about 1 to about 2 atomic percent.

6. A gamma titanium aluminide alloy based on an intermetallic compound TiAl, the gamma titanium aluminide alloy consisting essentially of:

aluminum in an amount of about 45.5 to about 46.5 atomic percent;

niobium in an amount of about 3 to about 5 atomic percent;

tungsten in an amount of about 0.5 to about 1.5 atomic percent;

and

one or both elements selected from the group consisting of chromium and manganese, each of the one or both elements selected being present in an amount of from about 1 to about 2 atomic percent;

with the balance being titanium;

whereby the gamma titanium aluminide alloy exhibits oxidation resistance and fracture toughness.

7. A gamma titanium aluminide alloy as recited in claim 6 wherein the one or both elements consists of chromium and manganese.

8. A gamma titanium aluminide alloy as recited in claim 6 further comprising vanadium in an amount of up to about 2 atomic percent.

9. A gamma titanium aluminide alloy as recited in claim 6 wherein the one or both elements consists of chromium in an amount of about 1 to about 2 atomic percent.

10. A gamma titanium aluminide alloy as recited in claim 6 wherein the one or both elements consists of manganese in an amount of about 1 to about 2 atomic percent.

11. A gamma titanium aluminide alloy as recited in claim 6 further comprising vanadium in an amount of about 1 to about 2 atomic percent.

12. A gamma titanium aluminide alloy based on an intermetallic compound TiAl, the gamma titanium aluminide consisting essentially of:

aluminum in an amount of about 45 to about 47 atomic percent;

niobium in an amount of about 5 atomic percent;

and

tungsten in an amount of about 0.25 to about 2 atomic percent;

with the balance being titanium;

whereby the gamma titanium aluminide alloy exhibits oxidation resistance and fracture toughness.

13. A gamma titanium aluminide alloy as recited in claim 12 further comprising manganese in an amount of up to about 2 atomic percent.

14. A gamma titanium aluminide alloy as recited in claim 12 wherein the tungsten is present in an amount of about 1 atomic percent.

15. A gamma titanium aluminide alloy as recited in claim 12 further comprising vanadium in an amount of up to about 2 atomic percent.

16. A gamma titanium aluminide alloy as recited in claim 12 further comprising chromium in an amount of up to about 2 atomic percent.

17. A gamma titanium aluminide alloy as recited in claim 12 further comprising one or more elements selected from the group consisting of vanadium, chromium and manganese, wherein each of the one or more elements selected is present in an amount of up to about 2 atomic percent.

Claims

(US20030051780)

We claim:

1.

A method of adding boron to a heavy metal containing titanium aluminide alloy to form a boride dispersion in the heavy metal containing titanium aluminide, comprising:

(a) forming molten heavy metal containing titanium aluminide alloy, (b) adding heavy metal boride particles to the molten heavy metal containing titanium aluminide alloy to form a molten mixture, the heavy metal boride particles having the same form as undesirable heavy metal boride precipitate clusters, (c) cooling and solidifying the molten mixture to form a heavy metal containing titanium aluminide alloy having a uniform dispersion of heavy metal boride particles substantially without the formation of heavy metal boride precipitate clusters.

2. A method as claimed in claim 1 wherein step (a) comprises forming molten tungsten containing titanium aluminide alloy, (b) adding tungsten boride to the molten tungsten containing titanium aluminide alloy to form a molten mixture, the tungsten boride particles having the same form as undesirable tungsten boride precipitate clusters, (c) cooling and solidifying the molten mixture to form a tungsten containing titanium aluminide alloy having a dispersion of tungsten boride particles substantially without the formation of tungsten boride precipitate clusters.

3. A method as claimed in claim 1 wherein step (a) comprises forming molten tantalum containing titanium aluminide alloy, (b) adding tantalum boride to the molten tantalum containing titanium aluminide alloy to form a molten mixture, the tantalum boride particles having the same form as undesirable tantalum boride precipitate clusters, (c) cooling and solidifying the molten mixture to form a tantalum containing titanium aluminide alloy having a dispersion of tantalum boride particles substantially without the formation of tantalum boride precipitate clusters.

4. A method as claimed in claim 1, wherein the titanium aluminide alloy comprises up to 2.0 at % boron.

5. A method as claimed in claim 4 wherein the titanium aluminide alloy comprises up to 1.0 at % boron.

6. A method as claimed in claim 1 wherein the titanium aluminide alloy comprises more than 0.5 at % boron.

7. A method as claimed in claim 1 wherein the heavy metal boride particles added have a size of 1 to 5 μm .

8. A method as claimed in claim 1 wherein the density of heavy metal boride precipitate clusters is up to 3 cm^{-2} .

9. A method as claimed in claim 8 wherein the density of heavy metal boride precipitate clusters is less than 2 cm^{-2} .

10. A method as claimed in claim 1 wherein the heavy metal boride precipitate clusters have a maximum size of 150 μm .

11. A method as claimed in claim 1 wherein the heavy metal boride precipitate clusters have a maximum size of 100 μm .

12. A method as claimed in claim 1 wherein the titanium aluminide alloy comprises a gamma titanium aluminide.

13. A method as claimed in claim 12 wherein the gamma titanium aluminide alloy preferably comprises 44 to 52 at % aluminum, one or more of tungsten and tantalum each in an amount of 0.05 to 8.0 at %, up to 2.0 at % boron and balance titanium plus incidental impurities.

14. A method as claimed in claim 13 wherein the gamma titanium aluminide additionally comprises up to 3 at % chromium, up to 6 at % niobium, up to 2 at % manganese.

15. A method as claimed in claim 13 wherein the gamma titanium aluminide alloy comprises 45 to 47 at % aluminum, 2 to 6 at % niobium, 0.25 to 2 at % tungsten and the balance titanium plus incidental impurities.

16. A method as claimed in claim 15 wherein the gamma titanium aluminide comprises 45 at % aluminum, 5 at % niobium and 1 at % tungsten.

17. A method as claimed in claim 16 wherein the gamma titanium aluminide alloy comprises 1 to 2 at % chromium and/or 1 to 2 at % manganese.

18. A method as claimed in claim 1 wherein the method comprises forming the titanium aluminide alloy into a turbine blade, a turbine vane, a compressor blade, or a compressor vane.

19. A method as claimed in claim 18 wherein the titanium aluminide alloy is cast or forged.

20. A heavy metal containing titanium aluminide alloy, the titanium aluminide containing heavy metal boride particles substantially without heavy metal boride precipitate clusters, the heavy metal boride particles having the same form as the undesirable heavy metal boride precipitate clusters, and the titanium aluminide alloy comprises up to 2.0 at % boron.

21. A heavy metal containing titanium aluminide alloy as claimed in claim 20 wherein the density of the heavy metal boride precipitate clusters is less than 2 cm^{-2} .

22. A heavy metal containing titanium aluminide alloy as claimed in claim 20 wherein the heavy metal boride precipitate clusters have maximum size of 100 μm .

23. A heavy metal containing titanium aluminide alloy as claimed in claim 20 wherein the heavy metal is tungsten and the heavy metal boride is tungsten boride.

24. A heavy metal containing titanium aluminide alloy as claimed in claim 20 wherein the heavy metal is tantalum and the heavy metal boride is tantalum boride.

25. A heavy metal containing titanium aluminide alloy as claimed in claim 20 wherein the titanium aluminide alloy comprises a gamma titanium aluminide.

26. A heavy metal containing titanium aluminide as claimed in claim 25 wherein the gamma titanium aluminide alloy preferably comprises 44 to 52 at % aluminum, one or more of tungsten and tantalum each in an amount of 0.05 to 8.0 at %, up to 2.0 at % boron and balance titanium plus incidental impurities.

27. A heavy metal containing titanium aluminide as claimed in claim 26 wherein the gamma titanium aluminide additionally comprises up to 3 at % chromium, up to 6 at % niobium, up to 2 at % manganese.

28. A heavy metal containing titanium aluminide as claimed in claim 27 wherein the gamma titanium aluminide alloy comprises 45 to 47 at % aluminum, 2 to 6 at % niobium, 0.25 to 2 at % tungsten and the balance titanium plus incidental impurities.

29. A heavy metal containing titanium aluminide as claimed in claim 28 wherein the gamma titanium aluminide comprises 45 at %





aluminum, 5 at % niobium and 1 at % tungsten.

30. A heavy metal containing titanium aluminide as claimed in claim 27 wherein the gamma titanium aluminide alloy comprises 1 to 2 at % chromium and/or 1 to 2 at % manganese.

31. A heavy metal containing titanium aluminide alloy as claimed in claims 20 wherein the titanium aluminide alloy is in the shape of a turbine blade, a turbine vane, a compressor blade, or a compressor vane.

Method for producing components with a high load capacity from tial alloys

WO200248420

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|-----------------------------|----------------|------------|---------------|---------------------------|---|------------|---------------|----------------------------|----|------------|--------------|-----------------------------|----|------------|---------------|---------------------------|----|------------|-------------|------------------------------|----|------------|----------------|------------------------------|---|------------|----------------|---------------------------|----|------------|-------------|---------------------------|----|------------|-------------|--------------------------|---|------------|-------------|----------------------------|----|------------|--------------|----------------------------|----|------------|--------------|---------------------------|----|------------|-------------|
| <ul style="list-style-type: none"> • Patent Assignee LEISTRITZ LEISTRITZ TURBINENKOMPONENTEN REMSCHIED LEISTRITZ TURBINENKOMPONENTEN REMSCHIED ROLLS ROYCE THYSSENKRUPP AUTOMOTIVE THYSSENKRUPP TURBINENKOMPO NENTEN • Inventor JANSCHER PETER KNIPPSCHILD LOTHAR SCHREIBER KARL ROTH-FAGARASEANU DAN • International Patent Classification B21J-005/00 B22F-003/02 C22C-014/00 C22F-001/00 C22F- 001/02 C22F-001/18 • US Patent Classification PCLO=148669000 PCLX=148421000 PCLX=148670000 PCLX=148671000 PCLX=420418000 PCLX=420420000 • CPC Code C22F-001/18/3 | <ul style="list-style-type: none"> • Publication Information WO200248420 A2 2002-06-20 [WO200248420]     • Priority Details 2000DE-1062776 2000-12-15 2001DE-1002497 2001-01-19 2001DE-1004639 2001-02-02 2001DE-1050674 2001-10-17 2001WO-EP13290 2001-11-16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">WO200248420</td> <td style="width: 15%;">A2</td> <td style="width: 15%;">2002-06-20</td> <td style="width: 40%;">[WO200248420]</td> </tr> <tr> <td>AU2185902</td> <td>A</td> <td>2002-06-24</td> <td>[AU200221859]</td> </tr> <tr> <td>DE10150674</td> <td>A1</td> <td>2002-07-04</td> <td>[DE10150674]</td> </tr> <tr> <td>WO200248420</td> <td>A3</td> <td>2002-08-08</td> <td>[WO200248420]</td> </tr> <tr> <td>EP1341945</td> <td>A2</td> <td>2003-09-10</td> <td>[EP1341945]</td> </tr> <tr> <td>US2004094248</td> <td>A1</td> <td>2004-05-20</td> <td>[US2004094248]</td> </tr> <tr> <td>JP2004538361</td> <td>A</td> <td>2004-12-24</td> <td>[JP2004538361]</td> </tr> <tr> <td>US6997995</td> <td>B2</td> <td>2006-02-14</td> <td>[US6997995]</td> </tr> <tr> <td>EP1341945</td> <td>B1</td> <td>2008-01-09</td> <td>[EP1341945]</td> </tr> <tr> <td>AT383454</td> <td>T</td> <td>2008-01-15</td> <td>[ATE383454]</td> </tr> <tr> <td>DE10150674</td> <td>B4</td> <td>2008-02-07</td> <td>[DE10150674]</td> </tr> <tr> <td>DE50113483</td> <td>D1</td> <td>2008-02-21</td> <td>[DE50113483]</td> </tr> <tr> <td>JP4259863</td> <td>B2</td> <td>2009-04-30</td> <td>[JP4259863]</td> </tr> </table> | | WO200248420 | A2 | 2002-06-20 | [WO200248420] | AU2185902 | A | 2002-06-24 | [AU200221859] | DE10150674 | A1 | 2002-07-04 | [DE10150674] | WO200248420 | A3 | 2002-08-08 | [WO200248420] | EP1341945 | A2 | 2003-09-10 | [EP1341945] | US2004094248 | A1 | 2004-05-20 | [US2004094248] | JP2004538361 | A | 2004-12-24 | [JP2004538361] | US6997995 | B2 | 2006-02-14 | [US6997995] | EP1341945 | B1 | 2008-01-09 | [EP1341945] | AT383454 | T | 2008-01-15 | [ATE383454] | DE10150674 | B4 | 2008-02-07 | [DE10150674] | DE50113483 | D1 | 2008-02-21 | [DE50113483] | JP4259863 | B2 | 2009-04-30 | [JP4259863] |
| WO200248420 | A2 | 2002-06-20 | [WO200248420] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AU2185902 | A | 2002-06-24 | [AU200221859] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DE10150674 | A1 | 2002-07-04 | [DE10150674] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WO200248420 | A3 | 2002-08-08 | [WO200248420] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EP1341945 | A2 | 2003-09-10 | [EP1341945] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| US2004094248 | A1 | 2004-05-20 | [US2004094248] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| JP2004538361 | A | 2004-12-24 | [JP2004538361] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| US6997995 | B2 | 2006-02-14 | [US6997995] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EP1341945 | B1 | 2008-01-09 | [EP1341945] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AT383454 | T | 2008-01-15 | [ATE383454] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DE10150674 | B4 | 2008-02-07 | [DE10150674] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DE50113483 | D1 | 2008-02-21 | [DE50113483] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| JP4259863 | B2 | 2009-04-30 | [JP4259863] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

- **Abstract:**

(EP1341945)

The invention relates to a method for producing components with a high load capacity from alpha+gamma TiAl alloys, especially for producing components for aircraft engines or stationary gas turbines. According to this method, enclosed TiAl blanks of globular structure are preformed by isothermal primary forming in the alpha+gamma- or alpha phase area. The preforms are then shaped out into components with a predetermined contour by means of at least one isothermal secondary forming process, with dynamic recrystallization in the alpha+gamma- or alpha phase area. The microstructure is adjusted by solution annealing the components in the alpha phase area and then cooling them off rapidly. (From US6997995 B2)

Claims

(EP1341945)

1. Method of manufacturing components with a high load capacity from alpha + gamma TiAl alloys, in particular components for aircraft engines or stationary gas turbines, in that encapsulated TiAl blanks of globular structure are preformed by isothermic primary deformation in the alpha + gamma or alpha phase domain, the preforms are worked by at least one isothermic secondary deformation process with dynamic recrystallisation in the alpha + gamma or alpha phase domain to give components of specifiable contour and the components are solution-treated in the alpha phase domain and then rapidly cooled to adjust the microstructure.
2. Method according to claim 1, characterised in that isothermic primary deformation takes place by forging or extrusion in the alpha + gamma phase domain in the temperature range of 1,000 deg.C and 1,340 deg.C.
3. Method according to claim 1, characterised in that isothermic primary deformation takes place by forging or extrusion in the alpha phase domain between 1,340 deg.C and 1,360 deg.C.
4. Method according to one of claims 1 to 3, characterised in that isothermic primary deformation takes place by forging or extrusion in the alpha + gamma phase domain in the temperature range from 1,000 deg.C to 1,340 deg.C.
5. Method according to one of claims 1 to 4, characterised in that the deformation process is carried out in a tool which is composed of molybdenum or graphite and which is in particular heated.
6. Method according to one of claims 1 to 5, characterised in that blanks composed of a TiAl base alloy are used for primary and secondary deformation having the composition (in % by atoms): 43% - 47% Al 5% - 10% Nb max. 1.0% B max. 0.5% C remainder titanium and impurities due to smelting.
7. Method according to one of claims 1 to 6, characterised in that the deformation and solution treatment process takes place in an inert atmosphere.
8. Method according to one of claims 1 to 7, characterised in that the cooling to the final structure setting from the alpha phase domain above 1340 deg.C takes place very rapidly, in particular at a rate of 10 deg.C/s - 20 deg.C/s in oil.

Claims

(WO2014204534)

WHAT IS CLAIMED IS:

1 .

A case for use in a gas turbine engine comprising a sheet metal skin made from a first material including titanium, the sheet metal skin formed to define a plurality of concave features and to define an internal cavity, and

a core made from a second material including titanium and aluminum arranged in the internal cavity and integrally bonded to the sheet metal skin to reinforce the sheet metal skin.

2. The case of claim 1 , wherein the sheet metal skin includes a first sheet metal portion having a first edge and a second sheet metal portion having a second edge arranged adjacent to the first edge to form a joint therebetween.

3. The case of claim 2, wherein joint is sealed by a weld line.

4. The case of claim 1 , wherein the second material is a gamma titanium-aluminide alloy.

5. The case of claim 4, wherein the gamma titanium- aluminide alloy has an aluminum content of about 46 percent by weight.

6.

A component for use in a gas turbine engine comprising a sheet metal skin made from a first material including titanium, the sheet metal skin formed to define a plurality of concave features and to define an internal cavity, and

a core made from a second material including titanium and aluminum arranged in the internal cavity and integrally bonded to the sheet metal skin to reinforce the sheet metal structure.

7. The component of claim 6, wherein the sheet metal skin includes a first sheet metal portion having a first edge and a second sheet metal portion having a second edge arranged adjacent to the first edge to form a joint therebetween.

8. The component of claim 7, wherein joint is sealed by a weld line.

9. The component of claim 6, wherein the second material is a gamma titanium-aluminide alloy.

10. The component of claim 9, wherein the gamma titanium- aluminide alloy has an aluminum content of about 46 percent by weight.

1 1 .

The component of claim 6, wherein the component is manufactured by a process including the steps of (i) filling the internal cavity of the sheet metal skin with a powder metal material, (ii) sealing the internal cavity of the sheet metal skin with the powder metal material inside to form a near-net shaped preform, and (iii) heating the near-net shaped preform to a predetermined temperature at which the powder metal material is sintered to provide the core.

12. The component of claim 1 1 , wherein the heating step is performed in a pressurized atmosphere.

13. The component of claim 1 1 , wherein the process further includes the step of (iv) drilling holes into the component to form post-processed features.

14. The component of claim 1 1 , wherein the process further includes the step of (iv) polishing external surfaces of the component to provide controlled surfaces.

15.

A method comprising the steps of

forming a first portion and a second portion of a titanium alloy sheet metal structure,

partially joining the first portion and the second portion of the titanium alloy sheet metal structure,

filing the titanium alloy sheet metal structure with a gamma titanium aluminide powder metal,

creating a near-net shape perform by sealing the titanium alloy sheet metal structure, and

hot isostatic pressing the near-net shape perform to integrally bond the titanium alloy sheet metal structure with the gamma titanium aluminide powder metal.

16. The component of claim 15, wherein the method further includes the step of drilling holes into the component to form post-processed features.

17. The component of claim 15, wherein the method further includes the step of polishing external surfaces of the component to provide controlled surfaces.

18. The component of claim 15, wherein the gamma titanium- aluminide powder has an aluminum content of about 46 percent by weight.