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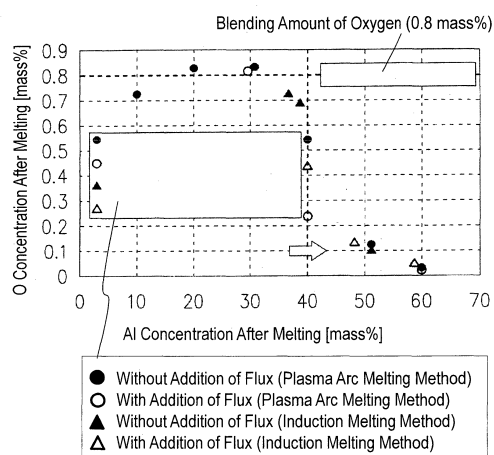
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(54) **METHOD FOR DEOXIDIZING Ti-Al ALLOY**

(57) A Ti-Al alloy having an Al content of at least 40% by mass, said alloy being produced using an alloy material comprising a titanium material and an aluminum material and having a total oxygen content of at least 0.1 % by mass, is melted and held in an atmosphere of at least 1.33 Pa according to a melting process incorporating a water-cooled copper vessel, thereby reducing the oxygen content of the Ti-Al based alloy.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for deoxidizing a Ti-Al alloy to remove oxygen from a Ti-Al alloy manufactured using an alloy material that is composed of a titanium material and an aluminum material and contains oxygen in a total amount of 0.1 mass% or more.

BACKGROUND ART

[0002] In recent years, demand for a Ti-Al alloy as a metal material for airplanes or automobiles is growing. When a titanium alloy such as Ti-Al alloy with the main component being titanium that is an active metal is produced, contamination by oxygen during melting needs to be prevented, and a melting method such as vacuum arc remelting method (VAR), electron beam melting method (EB), plasma arc melting method (PAM), vacuum induction melting method (VIM) and cold crucible induction melting method (CCIM) has been conventionally employed.

[0003] Among these melting methods, the melting method such as VAR, EB and VIM is a melting method of melting an alloy in a vacuum atmosphere, and when such a melting method is employed for melting a Ti-Al alloy, not only Al as an alloy element but also Ti are evaporated during melting to cause an element loss. More specifically, at present, controlling a Ti-Al alloy to a target composition is very difficult in the industrial process, and an increase in the production cost is consequently incurred.

[0004] For the smelting of a Ti-Al alloy having a low oxygen content, it is effective to produce a Ti-Al alloy by using a high-grade titanium material with a low oxygen content, but since the high-grade titanium material is expensive and its price tends to rise particularly in recent years, a need to produce a Ti-Al alloy by use of a relatively low-grade titanium material having a higher oxygen content than the high-grade titanium material but being inexpensive, such as sponge titanium, scrap raw material and rutile ore (TiO_2), is increasing day by day.

[0005] Ti is an active metal and has a very strong bonding force to an impurity, particularly oxygen among others, present in the melting atmosphere, and measures to deal with how to decrease the amount of oxygen entering from the outside during melting and prevent contamination have been heretofore taken. However, it is not easy to remove oxygen once dissolved in solid solution in Ti, and although little is known at present about the effort itself therefor, the related art includes the following proposals.

[0006] Patent Document 1 discloses an invention relating to a production method of a low-oxygen Ti-Al alloy, and a low-oxygen Ti-Al alloy, and it is disclosed in paragraph [0013] that "when Al is forcibly removed in a vacuum atmosphere higher than 1×10^{-2} Torr, the amount of oxygen in the molten alloy is accordingly decreased and by forcibly removing Al from a molten alloy having a composition containing a larger amount of Al than the Al content in a final target composition, it becomes possible to produce a Ti-Al alloy with the final target composition and decrease the amount of oxygen to 200 ppm or less".

[0007] More specifically, the production method of a low-oxygen Ti-Al alloy described in Patent Document 1 is a method for producing a low-oxygen Ti-Al alloy in a high vacuum atmosphere at a pressure lower than 1.33 Pa (1×10^{-2} Torr), but such melting in a high vacuum atmosphere causes a volatilization loss of not only Al as an alloy element but also Ti and although the method may be effective as a production method of a low-oxygen Ti-Al alloy, there is a concern about increase in the production cost, because extra amounts of Ti and Al need to be added.

[0008] Patent Document 2 discloses an invention relating to a low-oxygen Ti-Al alloy and a production method thereof, and it is disclosed in paragraph [0010] that "the present invention has been made to solve the problems above, and an object of the present invention is to provide a high-purity and low-oxygen Ti-Al alloy by, in the smelting of an alloy containing Ti-Al as the main component, deoxidizing the alloy with Ca, evaporating/removing excess Ca, and performing contamination-free uniform melting, and a production method thereof".

[0009] The method may be an effective method for producing a low-oxygen Ti-Al alloy, but this is a method including a plurality of steps of addition and melting of metallic Ca, removal of metallic Ca, and melting for homogenization, is a method where since metallic Ca dissolves in solid solution in titanium, complete removal of remaining Ca is difficult, and is a method suffering from concern for increase in the production cost and production time, contamination of the Ti-Al alloy due to remaining Ca that could not be removed, and change in various properties.

[0010] Patent Document 3 discloses an invention relating to a production method of an ingot of a TiAl-based alloy, and it is disclosed in paragraph [0017] that the oxygen content can be decreased in all regions of the ingot. In addition, claim 1 reads "a method for producing an ingot of a TiAl-based alloy, wherein the oxygen content in a Ti raw material is 800 ppm or less; the oxygen content in an Al raw material is 100 ppm or less; in the case where another alloy component is Cr, V or Nb, the oxygen content therein is 2,000 ppm or less; and in the case where another alloy component is Mn, the oxygen content therein is 3,000 ppm or less".

[0011] The production method of an ingot of a TiAl-based alloy described in Patent Document 3 is an effective method

capable of decreasing the oxygen content of an ingot, but this is a method for obtaining a TiAl-based alloy with a low oxygen content by using a high-grade material having a low oxygen content and is not a method using a low-grade Ti material having a relatively high oxygen content. In addition, described in Examples is only a TiAl alloy having a low Al content of 30 mass%.

[0012] Patent Document 4 discloses an invention relating to a casting method for a titanium-aluminum alloy cast and describes preparing a titanium-aluminum alloy containing predetermined amounts of titanium and aluminum by melting sponge titanium as a raw material and adding, to the molten titanium, aluminum as a raw material, and it is disclosed in claim 2 and paragraph [0020] that the oxygen content in the sponge titanium is 350 ppm or less and also in Examples that the oxygen content of sponge titanium is 0.03 wt%.

[0013] In the casting method for a titanium-aluminum alloy cast described in Patent Document 4, high-grade sponge titanium having an oxygen content of 350 ppm or less (corresponding to 0.035 mass% or less) is used as a raw material, and this is a method for obtaining a titanium-aluminum alloy cast having a low oxygen content but is not a method using a low-grade titanium material having a relatively high oxygen content. In addition, described in Examples is only a titanium-aluminum alloy cast having a low Al content of 34 mass%.

PRIOR ART LITERATURE

PATENT DOCUMENTS

[0014]

Patent Document 1: JP-A-H05-59466
 Patent Document 2: JP-A-H05-140669
 Patent Document 3: JP-A-2009-113060
 Patent Document 4: JP-A-H05-154642

SUMMARY OF THE INVENTION

PROBLEMS THAT THE INVENTION IS TO SOLVE

[0015] The present invention has been made to solve the above-described conventional problems, and an object of the present invention is to provide a deoxidation method of a Ti-Al alloy, in which a Ti-Al alloy having a target composition and a low oxygen content can be easily produced by using a low-grade titanium material having a high oxygen content even when a high vacuum atmosphere is not created.

MEANS FOR SOLVING THE PROBLEMS

[0016] A method for deoxidizing a Ti-Al alloy includes melting and holding a Ti-Al alloy containing 40 mass% or more of Al by a melting method using a water-cooled copper vessel in an atmosphere of 1.33 Pa or more, thereby decreasing an oxygen content in the Ti-Al alloy, the Ti-Al alloy being manufactured using an alloy material composed of a titanium material and an aluminum material, the alloy material containing oxygen in a total amount of 0.1 mass% or more.

[0017] It is preferred that a CaO-CaF₂ flux prepared by blending from 35 to 95 mass% of calcium fluoride with calcium oxide is added before or during melting of the Ti-Al alloy.

[0018] It is preferred that the melting method using the water-cooled copper vessel is any one of an arc melting method, a plasma arc melting method and an induction melting method.

ADVANTAGE OF THE INVENTION

[0019] According to the deoxidation method of a Ti-Al alloy of the present invention, a Ti-Al alloy having a target composition and a low oxygen content can be easily produced with little Al and Ti volatilization losses (substantially no decrease in their contents) by using a low-grade inexpensive titanium material having a high oxygen content of 0.1 mass% or more even when a high vacuum atmosphere is not created.

[0020] Here, when a Ti-Al alloy having an Al content of 40 mass% or more and a low oxygen content obtained by the deoxidation method of a Ti-Al alloy of the present invention is diluted with low-oxygen titanium, a Ti-Al alloy having an Al content of less than 40 mass% and a low oxygen content can be relatively easily produced at a low cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

[FIG. 1] A graph diagram illustrating the relationship between the Al content and the oxygen content in a Ti-Al alloy after melting.

[FIG. 2] A graph diagram illustrating the relationship between the blending amount of calcium fluoride in a CaO-CaF₂ flux and the oxygen content in a Ti-Al alloy after melting.

[FIG. 3] A graph diagram illustrating the relationship between the melting time of a Ti-Al alloy sample and the rate of change in mass between before and after melting.

[FIG. 4] A graph diagram illustrating the relationship between the Al content of a Ti-Al alloy sample and the rate of change in mass between before and after melting.

[FIG. 5] A graph diagram illustrating the maximum amount of oxygen dissolved in solid solution in a Ti-Al alloy.

MODE FOR CARRYING OUT THE INVENTION

[0022] The present inventors have made intensive studies to find out a method capable of easily producing a Ti-Al alloy having a target composition and a low oxygen content with little Al and Ti volatilization losses (substantially no decrease in their contents) by using a low-grade titanium material containing a large amount of oxygen, such as low-grade sponge titanium, scrap raw material and rutile ore (TiO₂), even when a high vacuum atmosphere is not created.

[0023] According to the ternary phase diagram of Ti-Al-O illustrated in X. L. Li, R. Hillel, F. Teyssandier, S. K. Choi, and F. J. J. Van. Loo, Acta Metall. Mater., 40 {11} 3147-3157 (1992), the maximum amount of oxygen dissolved in solid solution in a Ti-Al alloy is assumed to show the relationship indicated by the broken line in FIG. 5. From this fact, the present inventors have focused attention on the phenomenon that a Ti-Al alloy containing a high concentration of Al is decreased in the solute oxygen concentration. As a result, it has been found that despite a Ti-Al alloy manufactured using a low-grade titanium material, as long as it is a Ti-Al alloy containing 40 mass% or more of Al, a deoxidation reaction proceeds during melting using a water-cooled copper vessel even not under a high vacuum atmosphere and in addition, a low-oxygen Ti-Al alloy having a target composition can be easily produced with little Al and Ti volatilization losses (substantially no decrease in their contents). The present invention has been accomplished based on this finding.

[0024] As a result of further continued studies, it has also been found that when a CaO-CaF₂ flux not dissolving in solid solution in titanium and having a specific component composition is added as a deoxidation reaction accelerator before or during melting of a Ti-Al alloy, the deoxidation reaction proceeds more unfailingly. Here, the deoxidation reaction by the addition of CaO-CaF₂ flux to a Ti-Al alloy is a phenomenon developed when Al₂O₃ as a deoxidation product of the Ti-Al alloy is dissolved in solid solution in the CaO-CaF₂ flux added, and the melting point of the CaO-CaF₂ flux must be not more than almost 1,800 K that is estimated to be the melted temperature of the Ti-Al alloy.

[0025] The present invention is described in more detail below based on embodiments.

[0026] The deoxidation method of a Ti-Al alloy of the present invention is a method where a Ti-Al alloy containing 40 mass% or more of Al manufactured using an alloy material composed of a titanium material and an aluminum material and containing oxygen in a total amount of 0.1 mass% or more is melted and held by a melting method using a water-cooled copper vessel, such as arc melting method, plasma arc melting method and induction melting method, in an atmosphere of 1.33 Pa or more, thereby decreasing the oxygen content in the Ti-Al alloy. A low-grade sponge titanium, a scrap raw material, a rutile ore (TiO₂), etc. are used as the titanium alloy.

[0027] The reason why a titanium material having a high oxygen content, such as low-grade sponge titanium, scrap raw material and rutile ore (TiO₂), is used for the manufacture of a Ti-Al alloy is because these titanium materials are inexpensive and easy to procure. The reason why the total content of oxygen in an alloy material composed of this titanium material and an aluminum material is set to 0.1 mass% or more is because if the total content of oxygen in the alloy material is less than 0.1 mass%, the oxygen content is slight and deoxidation itself is not necessary. In the present invention, the upper limit of the oxygen content is not specified, but the upper limit of the total content of oxygen actually contained in the alloy material above is considered to be about 25.0 mass%.

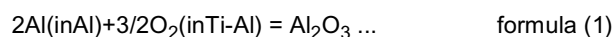
[0028] The reason why the Al content in a Ti-Al alloy manufactured using the alloy material composed of a titanium material and an aluminum material is set to be 40 mass% or more is because when the Al content in the Ti-Al alloy is 40 mass% or more, a deoxidation reaction of the Ti-Al alloy is caused to proceed by a melting method using a water-cooled copper vessel, such as arc melting method, plasma arc melting method and induction melting method, even in an atmosphere of 1.33 Pa or more and not in a high vacuum atmosphere. The deoxidation reaction is a phenomenon developed when the solute oxygen concentration in a Ti-Al alloy having a high Al content is decreased and oversaturated oxygen combines with Al to form Al₂O₃. That is, oxygen is discharged in the form of Al₂O₃ from the Ti-Al alloy. When the Al content in the Ti-Al alloy is 40 mass% or more, a deoxidation reaction proceeds at a temperature of not less than about 1,800 K at which the Ti-Al alloy melts.

[0029] In the present invention, the upper limit of the Al content in the Ti-Al alloy manufactured using an alloy material composed of a titanium material and an aluminum material is not particularly specified, but the upper limit is preferably 70 mass%, more preferably 60 mass%, still more preferably 50 mass%. Since the Ti-Al alloy contains an alloy element other than Al or an impurity such as oxygen, if the content of Al as an alloy element is too large, the proportion of Ti is decreased, and the alloy cannot be a Ti-Al alloy. The atmosphere is set to 1.33 Pa or more, and the upper limit thereof is not specified, but the actual upper limit can be estimated to be about 5.33×10^5 Pa. The lower limit of the atmosphere pressure is preferably 10 Pa, more preferably 1.0×10^2 Pa, and in view of, e.g., ease of control of the atmosphere, the pressure is still more preferably 1.0×10^4 Pa or more.

[0030] When a Ti-Al alloy is deoxidized, a flux is added as a deoxidation reaction accelerator before or during melting of the Ti-Al alloy, whereby a deoxidation reaction can proceed more unfaillingly. The flux added as a deoxidation reaction accelerator to the Ti-Al alloy must be a low-melting-point flux having a lower melting point than the melted temperature of the Ti-Al alloy, and in the present invention, among low-melting-point fluxes, a CaO-CaF₂ flux believed to be most preferable in view of performance, quality and cost is employed.

[0031] In the case of the production of a Ti-Al alloy having a low oxygen content, the deoxidation reaction is more accelerated by the addition of CaO-CaF₂ flux to the Ti-Al alloy, but as described above, if the melting point of the CaO-CaF₂ flux is not more than about 1,800 K that is the melted temperature of the Ti-Al alloy, the deoxidation reaction is accelerated. The reason why the deoxidation reaction is accelerated by the addition of the flux is that since Al₂O₃ produced by the deoxidation reaction is absorbed into the flux, the activity of Al₂O₃ is reduced and the oxygen concentration decreases along therewith.

[0032] The Al deoxidation reaction can be represented by the following formula (1), and the reaction constant can be represented by formula (2). In the Al/Al₂O₃ equilibrium state developed by the deoxidation reaction, K of formula (2) becomes constant, but since change of aAl due to the deoxidation reaction scarcely occurs, when aAl₂O₃ in the following formula (2) is decreased (close to zero when absorbed into the flux), PO₂ (contained oxygen concentration) in formula (2) accordingly decreases.



$$K = a\text{Al}_2\text{O}_3 / (a\text{Al}^2 \cdot \text{PO}_2^{3/2}) \dots \quad \text{formula (2)}$$

[0033] If the blending amount of calcium fluoride in the CaO-CaF₂ flux is less than 35 mass%, the melting point of the CaO-CaF₂ flux exceeds 1,800 K, and the deoxidation reaction accelerating activity by the addition of CaO-CaF₂ flux cannot be obtained. On the other hand, if the blending amount of calcium fluoride exceeds 95 mass%, contamination by fluorine is generated. Accordingly, in the present invention, a CaO-CaF₂ flux prepared by blending from 35 to 95 mass% of calcium fluoride to calcium oxide is added. The blending amount of calcium fluoride in the CaO-CaF₂ flux is more preferably from 60 to 90 mass%. The addition amount of the CaO-CaF₂ flux is preferably from 5 to 20% by mass relative to the mass of the Ti-Al alloy.

[0034] Here, the deoxidation method of a Ti-Al alloy of the present invention has been explained as a method for decreasing the oxygen content of a Ti-Al alloy with little Al and Ti volatilization losses (substantially no decrease in their contents), and the substantially allowable rate of decrease in the Al or Ti content is 5.0% or less. That is, "substantially" indicates 5.0% or less.

EXAMPLES

[0035] The present invention is described in greater detail below by referring to Examples, but the present invention is not limited to these Examples and can be implemented by appropriately adding changes as long as they comply with the gist of the present invention, and these changes all are included in the technical scope of the present invention.

(Relationship Between Al Content in Ti-Al Alloy and Oxygen Content After Melting)

• Plasma Arc Melting Method, Without Addition of Flux

[0036] Deoxidation of a Ti-Al alloy having an oxygen content of 0.8 mass% manufactured using an alloy material composed of a titanium material and an aluminum material was conducted by melting and then holding the alloy in a 100 kW plasma arc furnace using a water-cooled copper vessel. In order to examine the effect of the Al content of the Ti-Al alloy on the deoxidation reaction caused by melting, samples manufactured using Ti-Al alloys having an Al content of 10 mass%, 20 mass%, 30 mass%, 40 mass%, 50 mass%, and 60 mass%, respectively, were prepared. Here, the amount of each sample was 100 g, only Ar was used as the plasma gas, and the pressure during melting was 1.20×10^5 Pa. FIG. 1 illustrates the relationship between the Al concentration (Al content) in the Ti-Al alloy after melting and holding

performed using a 100 kW plasma arc furnace and the oxygen concentration (oxygen content) after melting.

[0037] As seen from FIG. 1, the oxygen content after melting of the Ti-Al alloy was around 0.8 mass% and was not changed when the Al content was from 10 to 30 mass%, but in Ti-Al alloys having an Al content of 40 mass% or more, the oxygen content was decreased after melting. It is found from this result that when the Al content in the Ti-Al alloy is 40 mass% or more, a deoxidation reaction is caused to proceed by melting.

• Plasma Arc Melting Method, With Addition of Flux

[0038] With respect to the Ti-Al alloys having an Al content of 30 mass%, 40 mass% and 60 mass%, in which the oxygen content was decreased after melting in the test above, in order to examine how the deoxidation reaction is accelerated by the addition of CaO-CaF₂ flux, deoxidation of the Ti-Al alloy by plasma arc melting was conducted under completely the same conditions as in the case of not adding the CaO-CaF₂ flux except for adding the flux. Here, the blending amount of calcium fluoride in the CaO-CaF₂ flux was 80 mass%, and the addition amount of the CaO-CaF₂ flux was 5 g. The results are illustrated in FIG. 1.

[0039] As seen from FIG. 1, when the CaO-CaF₂ flux was added, in either case where the Al content was 40 mass% or 60 mass%, deoxidation was more accelerated, compared with the case of not adding the CaO-CaF₂ flux. The oxygen content (mass ratio; hereinafter, the oxygen content is all indicated by the mass ratio) in the Ti-Al alloy after melting was, in the case of an Al content of 40 mass%, 5,400 ppm without the addition of CaO-CaF₂ flux and 2,400 ppm with the addition of CaO-CaF₂ flux and, in the case of an Al content of 60 mass%, was 280 ppm without the addition of CaO-CaF₂ flux and 220 ppm with the addition of CaO-CaF₂ flux.

• In Case of Using Titanium Oxide Material as Titanium Material

[0040] Separately, deoxidation of a Ti-Al alloy having an oxygen content of 16.3 mass% manufactured using an alloy material composed of a titanium oxide material and an aluminum material was conducted by melting and then holding the alloy in a 100 kW plasma arc furnace using a water-cooled copper vessel. At this time, the Al content in the Ti-Al alloy was set to 60 mass%, and both cases of adding and not adding the CaO-CaF₂ flux were conducted. Here, only Ar was used as the plasma gas, the pressure during melting was 1.20×10^5 Pa, the blending amount of calcium fluoride in the CaO-CaF₂ flux was 80 mass%, and the addition amount of the CaO-CaF₂ flux was 5 g.

[0041] The oxygen content in the Ti-Al alloy after melting and holding was about 540 ppm without the addition of CaO-CaF₂ flux, and even in a material having an oxygen content of more than 10 mass% manufactured using titanium oxide for the raw material, the deoxidation effect was fairly exerted. In the case of adding the CaO-CaF₂ flux, the oxygen content in the Ti-Al alloy was about 330 ppm, and it could be confirmed that a higher deoxidation effect is exerted by the addition of flux.

• Induction Melting Method, Without Addition of Flux

[0042] A deoxidation test of a Ti-Al alloy having an oxygen content of 0.8 mass% manufactured by employing an induction melting method using a water-cooled copper vessel, in place of the plasma arc melting method, was conducted in the same manner as in the case of the plasma arc melting method. In order to examine the effect of the Al content of the Ti-Al alloy on the deoxidation reaction, each of Ti-Al alloys having an Al content of 37 mass%, 39 mass%, and 51 mass% was smelted. Here, in each melting, the melted amount was 20 kg, the atmosphere in the melting chamber was Ar, and the pressure during melting was 7.0×10^4 Pa. FIG. 1 illustrates the relationship between the Al concentration (Al content) and the oxygen concentration (oxygen content) in the Ti-Al alloy after melting and holding performed using an induction melting furnace, together with the data in the case of using the plasma arc melting method.

[0043] As seen from FIG. 1, similarly to the case of employing the plasma arc melting method, the oxygen content after melting was decreased at around a region where the Al content exceeded 40 mass%. It is found from this result that similarly to the plasma arc melting method, when the Al content in the Ti-Al alloy is 40 mass% or more, a deoxidation reaction is caused to proceed by melting also in the case of the induction melting method.

• Induction Melting Method, With Addition of Flux

[0044] With respect to Ti-Al alloys having an Al content of 40 mass%, 48 mass% and 59 mass%, in order to examine how the deoxidation reaction is accelerated by the addition of CaO-CaF₂ flux, deoxidation of the Ti-Al alloy by an induction melting method using a water-cooled copper vessel was conducted. Here, in each melting, the atmosphere in the melting chamber was Ar, the pressure during melting was 7.0×10^4 Pa, the blending amount of calcium fluoride in the CaO-CaF₂ flux was 80 mass%, and the addition amount of the CaO-CaF₂ flux was 10% of the mass of metal. The results are illustrated in FIG. 1.

[0045] As seen from FIG. 1, even when an induction melting method using a water-cooled copper vessel was employed, in the case of adding the CaO-CaF₂ flux, the deoxidation was further accelerated in all of the cases where the Al content is 40 mass%, 48 mass% and 59 mass%, as compared with the case of not adding the CaO-CaF₂ flux.

(Blending Amount of Calcium Fluoride in CaO-CaF₂ Flux)

[0046] Deoxidation of a Ti-Al alloy was conducted by plasma arc melting using a 100 kW plasma arc furnace all under the same conditions as in Examples above except that a Ti-Al alloy having an Al content of 40 mass% was used and the blending amount of calcium fluoride in the CaO-CaF₂ flux added was changed. Here, the CaO-CaF₂ flux was previously spread around the Ti-Al alloy before melting. The results are illustrated in FIG. 2.

[0047] On the basis of 5,400 ppm that is the oxygen content after melting when the CaO-CaF₂ flux is not added, the degree of deoxidation reaction accelerating effect by the addition of CaO-CaF₂ flux was examined. As seen from FIG. 2, a most notable deoxidation reaction accelerating effect was obtained when a CaO-CaF₂ flux prepared by blending from 60 to 90 mass% of calcium fluoride to calcium oxide was added, but a high deoxidation reaction accelerating effect was observed also when 40 mass% or more of calcium fluoride was blended. It is found from this test result that a deoxidation effect is obtained by the addition of a CaO-CaF₂ flux prepared by blending from 35 to 95 mass% of calcium fluoride to calcium oxide. Here, as seen from FIG. 2, when a CaO-CaF₂ flux prepared by blending 30 mass% of calcium fluoride to calcium oxide was added, the deoxidation was not accelerated. This is because the CaO-CaF₂ flux was not melted due to its too high melting point.

(Changes in Mass and Al Content of Ti-Al Alloy Between Before and After Melting)

[0048] The material yield affected by volatilization when melting the Ti-Al alloy by using a 100 kW plasma arc furnace was evaluated by examining the changes in mass and Al content of each of the samples above between before and after melting. At this time, only Ar was used as the plasma gas, and the pressure during melting was 1.20×10^5 Pa.

[0049] FIG. 3 illustrates the relationship between the melting time and the rate of change in mass of the sample between before and after melting. As seen from FIG. 3, the change in mass of the sample was scarcely observed between before and after melting. FIG. 4 illustrates the relationship between the Al concentration (content) of the sample and the rate of change in mass between before and after melting. As seen from FIG. 4, the change in mass of the sample was scarcely observed between before and after melting, revealing that Al was not volatilized by melting using a 100 kW plasma arc furnace. It is found from these results that in the melting by use of a plasma arc furnace, which is an example of the melting using a water-cooled copper vessel, Al as an alloy element and furthermore Ti are not volatilized during melting of the Ti-Al alloy.

[0050] While the present invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope of the present invention.

[0051] This application is based on Japanese Patent Application No. 2014-180431 filed on September 4, 2014, Japanese Patent Application No. 2014-180432 filed on September 4, 2014, Japanese Patent Application No. 2015-6764 filed on January 16, 2015, Japanese Patent Application No. 2015-6765 filed on January 16, 2015, and Japanese Patent Application No. 2015-131029 filed on June 30, 2015, the contents of which are incorporated herein by way of reference.

INDUSTRIAL APPLICABILITY

[0052] According to the present invention, a Ti-Al alloy having a low oxygen content can be produced at a low cost, and the method is useful as a production method of a metal material for airplanes or automobiles.

Claims

1. A method for deoxidizing a Ti-Al alloy, comprising melting and holding a Ti-Al alloy containing 40 mass% or more of Al by a melting method using a water-cooled copper vessel in an atmosphere of 1.33 Pa or more, thereby decreasing an oxygen content in the Ti-Al alloy, the Ti-Al alloy being manufactured using an alloy material composed of a titanium material and an aluminum material, the alloy material containing oxygen in a total amount of 0.1 mass% or more.
2. The method for deoxidizing a Ti-Al alloy according to claim 1, wherein a CaO-CaF₂ flux prepared by blending from 35 to 95 mass% of calcium fluoride with calcium oxide is added before or during melting of the Ti-Al alloy.

3. The method for deoxidizing a Ti-Al alloy according to claim 1 or 2, wherein the melting method using the water-cooled copper vessel is any one of an arc melting method, a plasma arc melting method and an induction melting method.

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FIG. 1

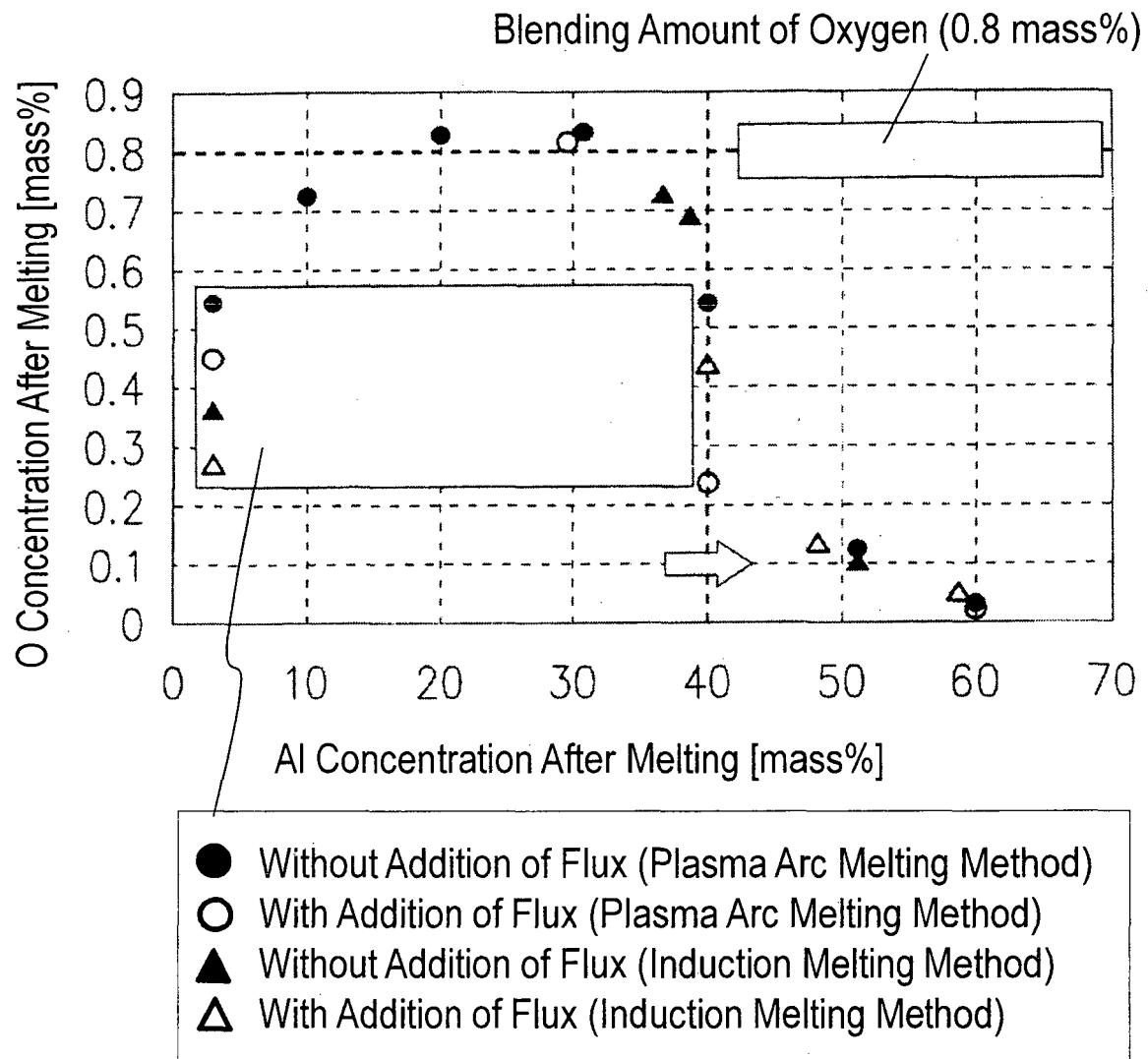


FIG. 2

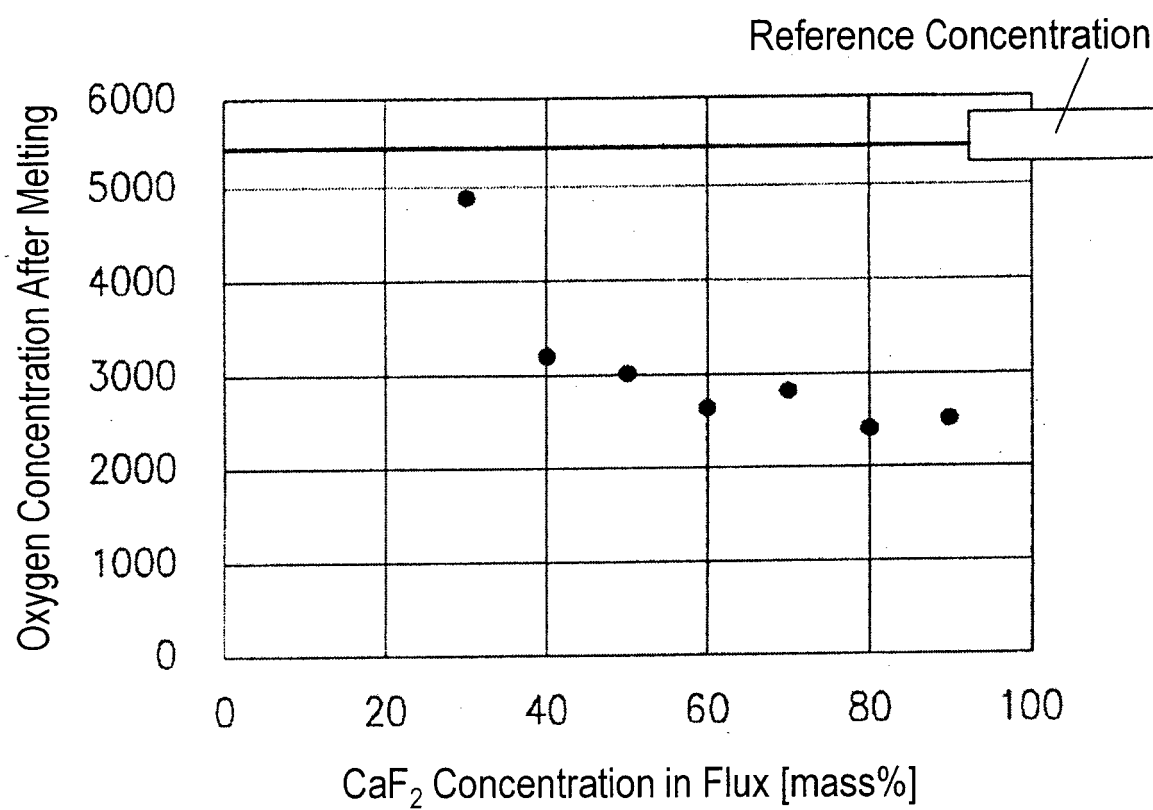


FIG. 3

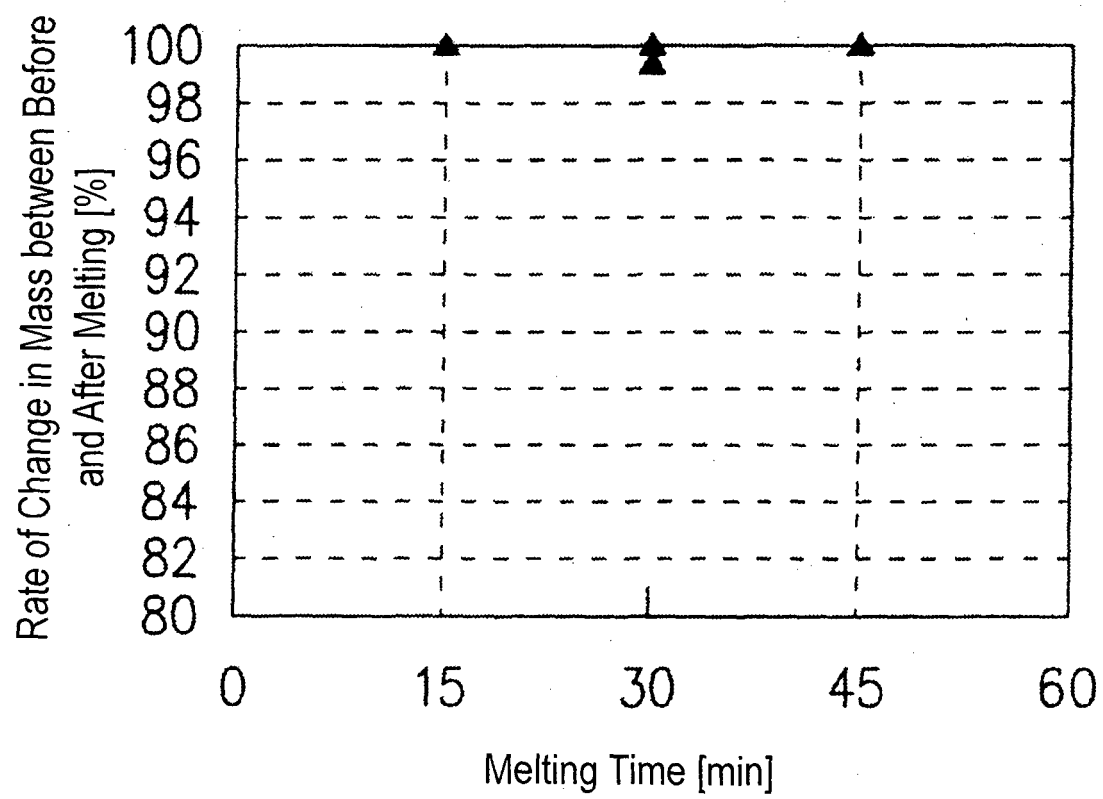


FIG. 4

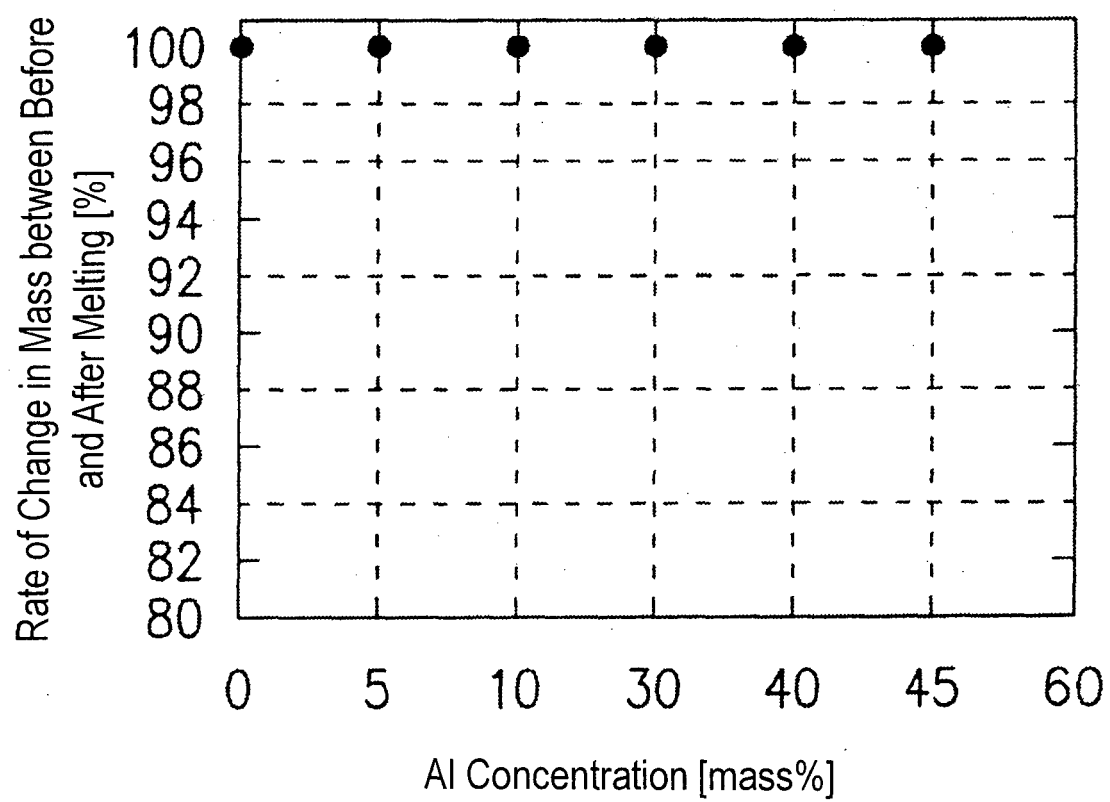
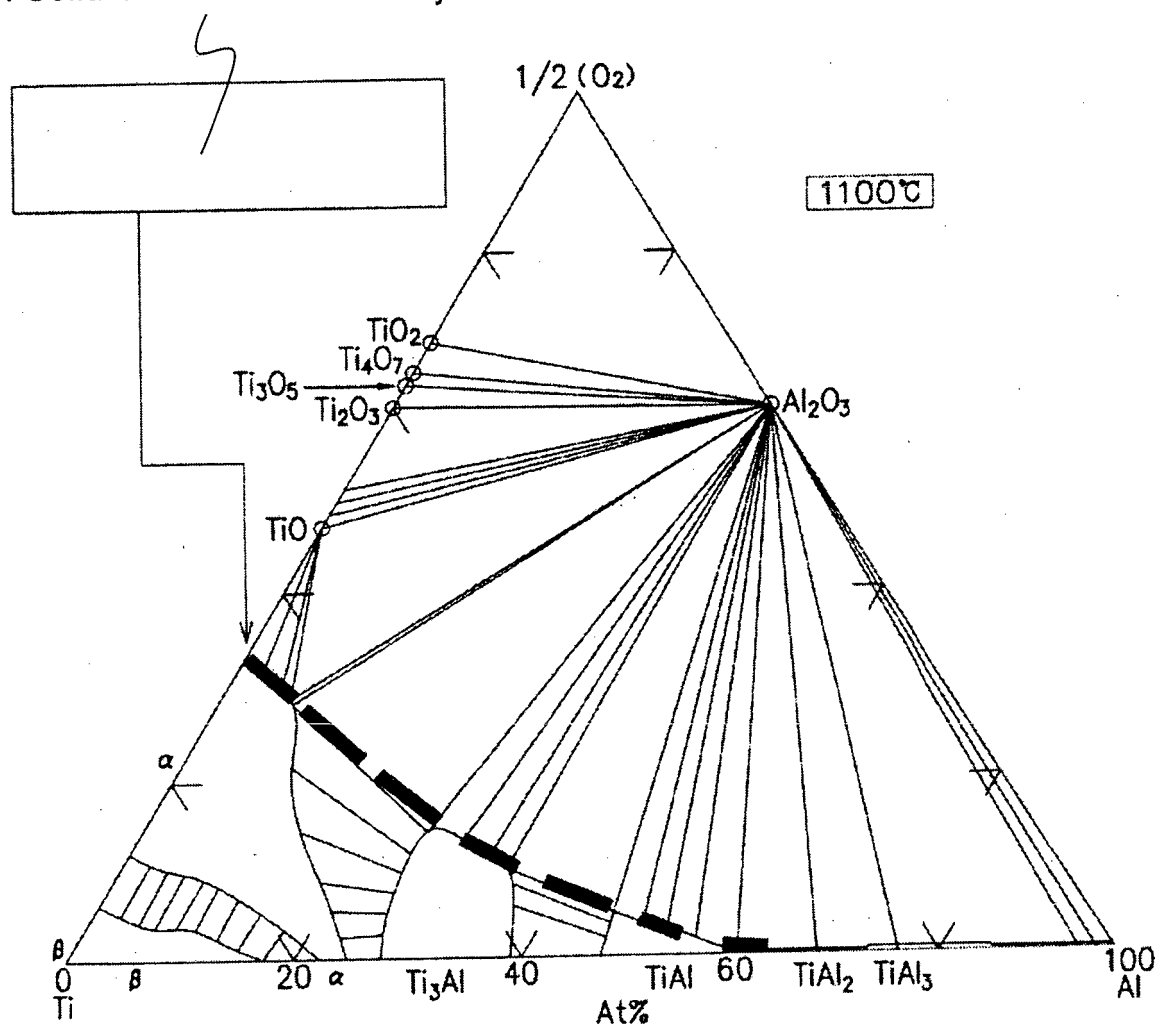


FIG. 5

Maximum Amount of Oxygen Dissolved
in Solid Solution in Ti-Al Alloy



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/074970

A. CLASSIFICATION OF SUBJECT MATTER

C22C1/02(2006.01)i, C22B9/04(2006.01)i, C22B9/10(2006.01)i, C22B9/20
(2006.01)i, C22C14/00(2006.01)i, C22C21/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C1/02, C22B9/04, C22B9/10, C22B9/20, C22C14/00, C22C21/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 05-059466 A (Kobe Steel, Ltd.), 09 March 1993 (09.03.1993), entire text (Family: none)	1-3
A	JP 05-140669 A (Kobe Steel, Ltd.), 08 June 1993 (08.06.1993), entire text (Family: none)	1-3
A	JP 04-103732 A (President of The Kyoto University), 06 April 1992 (06.04.1992), entire text (Family: none)	1-3

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
17 November 2015 (17.11.15)

Date of mailing of the international search report
24 November 2015 (24.11.15)

Name and mailing address of the ISA/
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REFERENCES CITED IN THE DESCRIPTION

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