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(54) **METHOD FOR PRODUCING AN INTEGRATED CRUCIBLE AND MOLD FOR LOW COST
GAMMA-TIAL CASTINGS**

VERFAHREN ZUR HERSTELLUNG EINES TIEGELS MIT INTEGRIERTEM FORM ZUR
PREISWERTEN HERSTELLUNG VON GAMMA-TIAL-GUSSTEILEN

PROCEDE POUR LA PRODUCTION D'UN CREUSET ET MOULE INTEGRES DESTINES A DES
MOULAGES DE GAMMA-TIAL DE FAIBLE COUT

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1989,

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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates generally to an integrated crucible and mold for casting. More particularly, the present invention provides a method for producing a one-piece integrated crucible and invested mold for use in the casting of reactive metals, particularly complex shapes thereof.

Description of the Related Art:

[0002] Melting and casting of reactive metals such as titanium or titanium aluminides is difficult due to the molten metals reactivity with crucibles comprising of alumina, zircon, or silicates which are typically used in casting metals such as iron, nickel or aluminum. Turbocharger rotors are typically cast using nickel superalloy which can be easily melted and cast using invested mold having a zircon facecoat and an alumina-silicate crucible attached to the top of the mold. Molten titanium aluminide will rapidly react with the alumina-silicate crucible making casting impossible.

[0003] Candidate crucible materials include yttria (Y_2O_3), thoria (ThO_2), calcia (CaO) and other exotic rare earth oxides. Thoria is radioactive and suffers from poor thermal shock resistance. For this reason it has not been exploited industrially. However, yttria crucibles are very expensive, \$50 to \$100. The alumina-silicate crucibles used for nickel superalloy castings are less than \$1. Since titanium and titanium aluminide castings compete with nickel castings in a wide variety of applications, the high cost of yttria crucibles effectively prices titanium and titanium aluminide castings out of the market. This is particularly important for cost sensitive applications, for example automotive applications.

[0004] Calcia is also a potential refractory material for titanium and titanium aluminides due to its thermal stability. US Patent No. 4,710,481 to Degawa et. al. discloses melting titanium and titanium alloys in calcia crucibles. However, calcia is highly hydrophilic and spontaneously hydrates in ambient levels of atmospheric moisture. The hydration is accompanied by volume changes which cause cracking and spallation. Calcia crucibles can spontaneously crack after only hours of exposure to atmospheric moisture. For this reason calcia is an impractical material for a crucible in commercial, industrial environments.

[0005] It is therefore desirable to provide industrially practical, low cost molds for the casting of titanium and titanium aluminide metals which overcome the above-mentioned drawbacks. The invention would also find application for other reactive metal castings, for example zirconium alloy castings. It is also desirable to provide a low cost, industrially practical one piece crucible and

investment mold for casting reactive and non-reactive metals.

[0006] It is further desirable to provide a graphite or other inductively suscepting composite crucible containing graphite which is directly attached to an invested mold for the casting of γ -TiAl components and, specifically, to provide a method for producing low cost investment castings of γ -TiAl turbocharger rotors.

SUMMARY OF THE INVENTION

[0007] To overcome the limitation of the prior art and obtain the desired qualities, the present invention provides a graphite crucible attached directly to the top of an invested mold in the shape of the complex molded part, a turbocharger rotor for the specific embodiments disclosed herein, to form an integrated unit. A method for producing the integrated crucible and mold is characterized by the steps of attaching an investment pattern to a cylindrical graphite crucible and building an investment mold shell around the pattern and a mating portion of the crucible. The mold shell is created by dipping the pattern and crucible mating portion in an inert ceramic facecoat slurry, allowing the dipcoat layer to partially dry and/or cure, applying a layer of ceramic stucco over the dipcoat and laminating additional layers of dipcoat and stucco to achieve the desired thickness mold shell.

[0008] The embodiment of the invention described in detail subsequently, provides a one piece crucible/mold system suitable for casting a metal part in vacuum at temperatures exceeding 1400°C.

[0009] The method of employing the apparatus of the invention for casting of complex components takes advantage of the rapid melting and casting of the γ -TiAl to avoid carbon contamination from the crucible. Carbon is a known contaminant of γ -TiAl. At low levels, i.e. under 2000 ppm (wt%) it is often added to improve creep properties of γ -TiAl. However, at higher levels it strongly reduces the tensile ductility of γ -TiAl. The one piece graphite crucible/investment mold prevents the deleterious contamination of γ -TiAl by the crucible since the design allows for rapid melt times and low superheats, both of which minimize the potential for carbon contamination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The details and features of the present invention will be more clearly understood with respect to the detailed description and drawings in which:

FIG. 1 is a section elevation view of the integrated graphite crucible and invested mold; and
FIG. 2 is a pictorial view of an exemplary turbocharger rotor manufacturable from γ -TiAl using the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] An embodiment of the present invention is shown in FIG. 1. The integral crucible and mold includes a cylindrical graphite sleeve 10 having a bottom 12 adapted to accommodate attachment of a polystyrene invested mold pattern 14 having an attachment runner 15. In the embodiment shown, the attachment runner is sealingly attached to the sleeve with wax 16. The sleeve is sized to accommodate a desired meltstock billet 17. An investment shell 18 is constituted by laminations of a facecoat slurry 20 and ceramic stucco 22 (shown only over a portion of the section for clarity), which extend over and adhere to a bottom mating portion of the graphite sleeve. After firing, which results in vaporization of the pattern, the hardened shell laminate is fixedly attached to the graphite sleeve forming an integral crucible and mold for casting of the desired part. An aperture 24 in the bottom face of the sleeve provides a flow path for the molten casting metal into the mold shell while the rim 26 retains the meltstock billet in the crucible in a position for induction heating.

[0012] A method for creating and employing the apparatus of the present invention includes the steps of attaching the polystyrene turbocharger wheel pattern to the cylindrical graphite sleeve by dipping the top of the polystyrene pattern in hot wax and inserting it into the recess in the bottom of the graphite sleeve. An investment shell is next built around the polystyrene pattern and the lower portion of the sleeve. As embodied herein, the investment mold process begins with dipping the pattern made of wax or plastic having the shape of the desired casting in a facecoat slurry made from any ceramic inert to γ -TiAl, for example, yttria or calcia. An appropriate slurry for creating a calcia facecoat is disclosed in WO 97/43060 entitled Inert Calcia Facecoats for Investment Casting of Titanium and Titanium-Aluminide Alloys having a common assignee with the present application.

[0013] After allowing the dipcoat layer to partially dry and/or cure, alternate layers of ceramic stucco and dipcoat are applied on both the pattern and the lower area of the crucible until a shell of desired thickness is formed. The crucible/invested mold is allowed to dry thoroughly, and then is fired at temperatures near 1000°C for a period of no less than 0.5 hour in an oxidizing atmosphere such as air. The firing results in the complete volatilization of the pattern in a manner familiar to those skilled in the "lost wax" art.

[0014] The crucible/invested mold assembly is then transferred while still hot from the furnace and placed in a casting chamber and evacuated. A cylindrical meltstock billet of the casting metal is inserted in the crucible. The metal is next rapidly melted by inductively heating the graphite crucible. Since graphite is a strong susceptor, the crucible is quickly heated to the melting temperature of the γ -TiAl. The molten metal falls directly into the attached invested mold with the assistance of gravity

with a minimum of superheat and hold time. The short hold time and low superheat prevents significant contamination by carbon from the crucible. The short drop distance, attained as a result of the one piece design of the crucible/investment mold, allows full fill in thin sections. Greater drop distances, as would be required by two piece crucible/investment mold systems result in poor fill due to cooling and premature solidification in the fill tube area. After cooling, the cast metal, now in the shape of the original pattern is removed from the pattern. An exemplary

EXAMPLE I

[0015] A turbocharger rotor pattern made polystyrene plastic was fitted to a recess in the bottom of a graphite crucible using wax to join the pattern to the crucible. The plastic was dipped in the facecoat slurry made from a yttria facecoat inert to γ -TiAl. After allowing the dipcoat layer to partially dry and/or cure, alternate layers of ceramic stucco and dipcoat were applied on both the pattern and the lower area of the graphite crucible until a shell of desired thickness was formed. It was subsequently redipped multiple times into backup coatings of flintgrains and alumina silicate powders to form an integrated investment mold, shown schematically in Figure 1. The crucible/invested mold containing the plastic turbocharger pattern was allowed to dry thoroughly, and then was fired at temperatures near 1000°C for a period of 0.5 hour in air. The graphite crucible/invested turbocharger mold assembly was then transferred while still hot from the furnace, charged with the casting metal meltstock billet, placed under a quartz bell jar and evacuated. The graphite crucible and metal were next heated by induction resulting in melting of the metal. A drawing of the cast TiAl rotor made from this process is shown in figure 2.

[0016] Having now described the invention in detail as required by the patent statutes, those skilled in the art will recognize modifications and substitutions to the specific embodiments disclosed herein. Such modifications and substitutions are within the scope and intent of the present invention as defined in the following claims.

Claims

1. A method for producing an integral crucible and mold for casting of reactive metals comprising the steps of:

attaching an investment pattern to a cylindrical graphite crucible sleeve;
forming an investment shell around the pattern and a mating portion of the crucible sleeve;
firing the shell and attached crucible sleeve for complete cure of the shell and volatilization of

the pattern.

2. A method as defined in claim 1 wherein the step of attaching the investment pattern to the crucible sleeve comprises:

dipping a mating portion of the pattern in hot wax; and
inserting the mating portion of the pattern into a recess in the graphite crucible sleeve.

3. A method as defined in claim 1 wherein the step of forming comprises:

dipping the in pattern in a facecoat slurry;
allowing the dipcoat layer to partially dry or cure;
applying alternating layers of ceramic stucco and dipcoat on both the pattern and the mating portion of the crucible sleeve until a shell of desired thickness is formed.

4. A method as defined in claim 3 wherein the step of applying alternating layers is followed by a step of allowing the shell to dry thoroughly.

5. A method as defined in claim 1 wherein the pattern is polystyrene plastic.

6. A method as defined in claim 1 wherein the firing is accomplished at temperatures near 100°C for a period of no less than 0.5 hour in an oxidizing atmosphere such as air.

7. A method as defined in claim 3 wherein the step of applying alternating layers is followed by the step of applying at least one laminating layer of flint grains and alumina silicate powders.

8. A method as defined in claim 3 wherein the facecoat slurry forming an inert ceramic.

9. A method as defined in claim 8 wherein the inert ceramic comprises yttria.

10. A method as defined in claim 8 wherein the inert ceramic comprises calcia.

Patentansprüche

1. Verfahren zur Herstellung einer einteiligen Tiegel/Form-Anordnung zum Vergießen von reaktiven Metallen, bei dem man:

ein Ausschmelzmodell an einer zylindrischen Graphittiegelhülle befestigt;

um das Modell und einen Paßteil der Tiegelhülle herum eine Ausschmelzschale herstellt;

die Schale und die daran befestigte Tiegelhülle zur vollständigen Härtung der Schale und Verflüchtigung des Modells brennt.

2. Verfahren nach Anspruch 1, bei dem man beim Befestigen des Ausschmelzmodells an der Tiegelhülle:

einen Paßteil des Modells in heißes Wachs taucht und

den Paßteil des Modells in eine Aussparung in der Graphittiegelhülle hineinschiebt.

3. Verfahren nach Anspruch 1, bei dem man im Herstellungsschritt:

das Modell in eine Überzugaufschlammung eintaucht;

die durch Eintauchen aufgebraute Überzugschicht antrocknen oder anhärtend läßt und

sowohl auf das Modell als auch auf den Paßteil der Tiegelhülle alternierende Schichten aus Keramikstuck und durch Eintauchen aufgebrautem Überzug aufbringt.

4. Verfahren nach Anspruch 3, bei dem man nach dem Aufbringen alternierender Schichten die Schale gründlich trocknen läßt.

5. Verfahren nach Anspruch 1, bei dem man als Modell Polystyrol-Kunststoff einsetzt.

6. Verfahren nach Anspruch 1, bei dem man das Brennen bei Temperaturen nahe 100°C über einen Zeitraum von mindestens 0,5 Stunden in einer oxidierenden Atmosphäre wie Luft durchführt.

7. Verfahren nach Anspruch 3, bei dem man nach dem Aufbringen alternierender Schichten mindestens eine Laminierschicht aus Flintkörnern und Aluminiumsilicatpulvern aufbringt.

8. Verfahren nach Anspruch 3, bei dem die Überzugaufschlammung eine inerte Keramik bildet.

9. Verfahren nach Anspruch 8, bei dem die inerte Keramik Yttriumoxid enthält.

10. Verfahren nach Anspruch 8, bei dem die inerte Keramik Calciumoxid enthält.

Revendications

1. Procédé de production d'un creuset et d'un moule d'un seul tenant pour couler des métaux réactifs, comprenant les étapes consistant à: 5
 - fixer un modèle perdu à une cuvette de creuset en graphite cylindrique;
 - former une coquille perdue autour du motif et d'une partie concourante de la cuvette de creuset; 10
 - cuire la coquille et la cuvette de creuset fixée pour achever le durcissement de la coquille et volatiliser le modèle. 15
2. Procédé selon la revendication 1 dans lequel l'étape consistant à fixer le modèle perdu à la cuvette de creuset comprend:
 - le fait de tremper une partie concourante du motif dans de la cire chaude; et 20
 - le fait d'insérer la partie concourante du motif dans un creux ménagé dans la cuvette de creuset en graphite. 25
3. Procédé selon la revendication 1 dans lequel l'étape de formation comprend:
 - le fait de tremper le modèle dans une suspension d'apprêt; 30
 - le fait de laisser la couche de coulis sécher ou durcir partiellement;
 - le fait d'appliquer des couches alternées de stuc de céramique et de coulis à la fois sur le modèle et sur la partie concourante de la cuvette de creuset jusqu'à ce qu'une coquille d'épaisseur voulue soit formée. 35
4. Procédé selon la revendication 3 dans lequel l'étape consistant à appliquer des couches alternées est suivie d'une étape consistant à laisser sécher complètement la coquille. 40
5. Procédé selon la revendication 1 dans lequel le motif est du plastique de polystyrène. 45
6. Procédé selon la revendication 1 dans lequel la cuisson est réalisée à des températures proches de 100°C pendant pas moins de 0,5 heure dans une atmosphère oxydante telle que l'air. 50
7. Procédé selon la revendication 3 dans lequel l'étape consistant à appliquer des couches alternées est suivie de l'étape consistant à appliquer au moins une couche de stratification de grains siliceux et de poudres de silicate d'alumine. 55
8. Procédé selon la revendication 3 dans lequel la sus-

pension d'apprêt forme une céramique inerte.

9. Procédé selon la revendication 8 dans lequel la céramique inerte comprend de l'oxyde d'yttrium.
10. Procédé selon la revendication 8 dans lequel la céramique inerte comprend de la chaux.

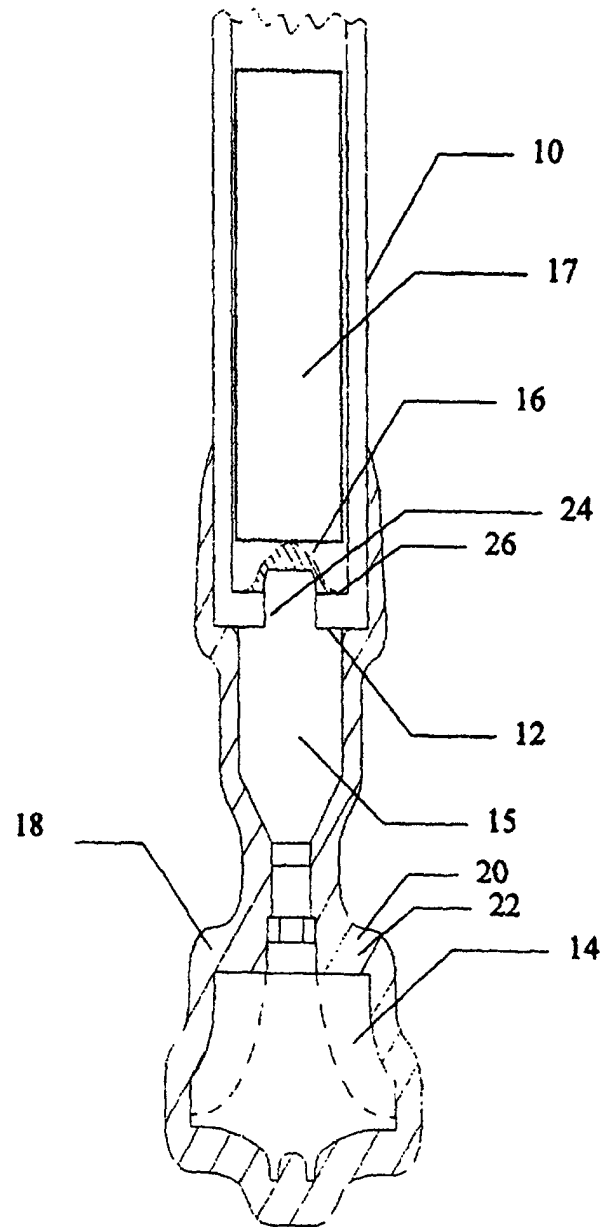


FIG. 1

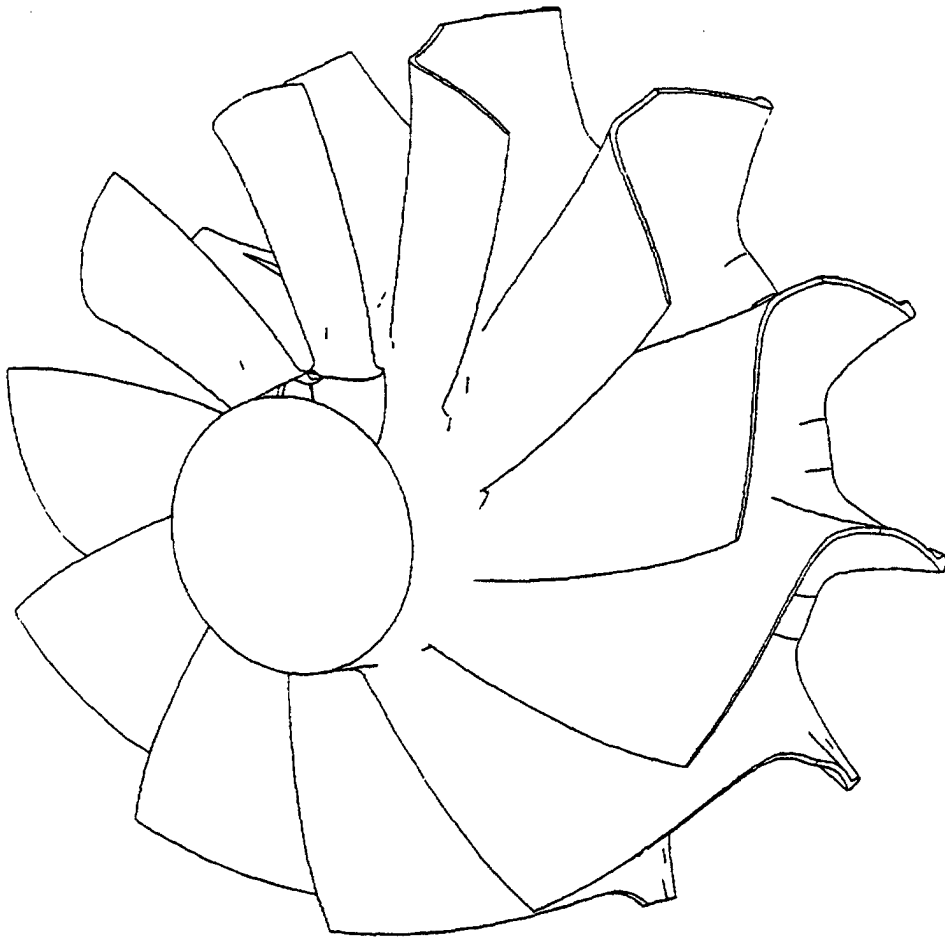


FIG. 2