

[54] METHOD OF CLEANING NICKEL ALLOY
BY FILTERING

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[52] U.S. Cl. **75/82, 75/93 R, 75/135**

[51] Int. Cl. **C22c 1/00**

[58] Field of Search **75/93 R, 82, 45, 61, 129,
75/135; 266/34 R**

[56]

References Cited

UNITED STATES PATENTS

1,472,006 10/1923 Jones 75/61
1,972,432 9/1934 von Grisewald et al. 75/93 UX

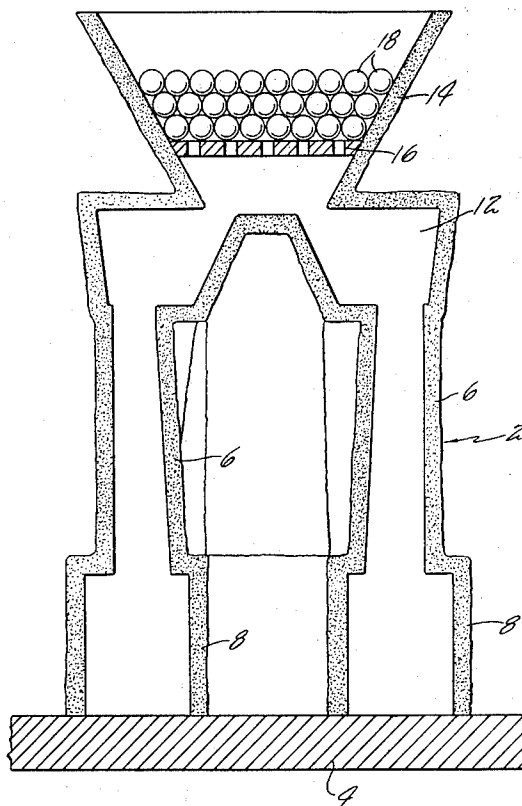
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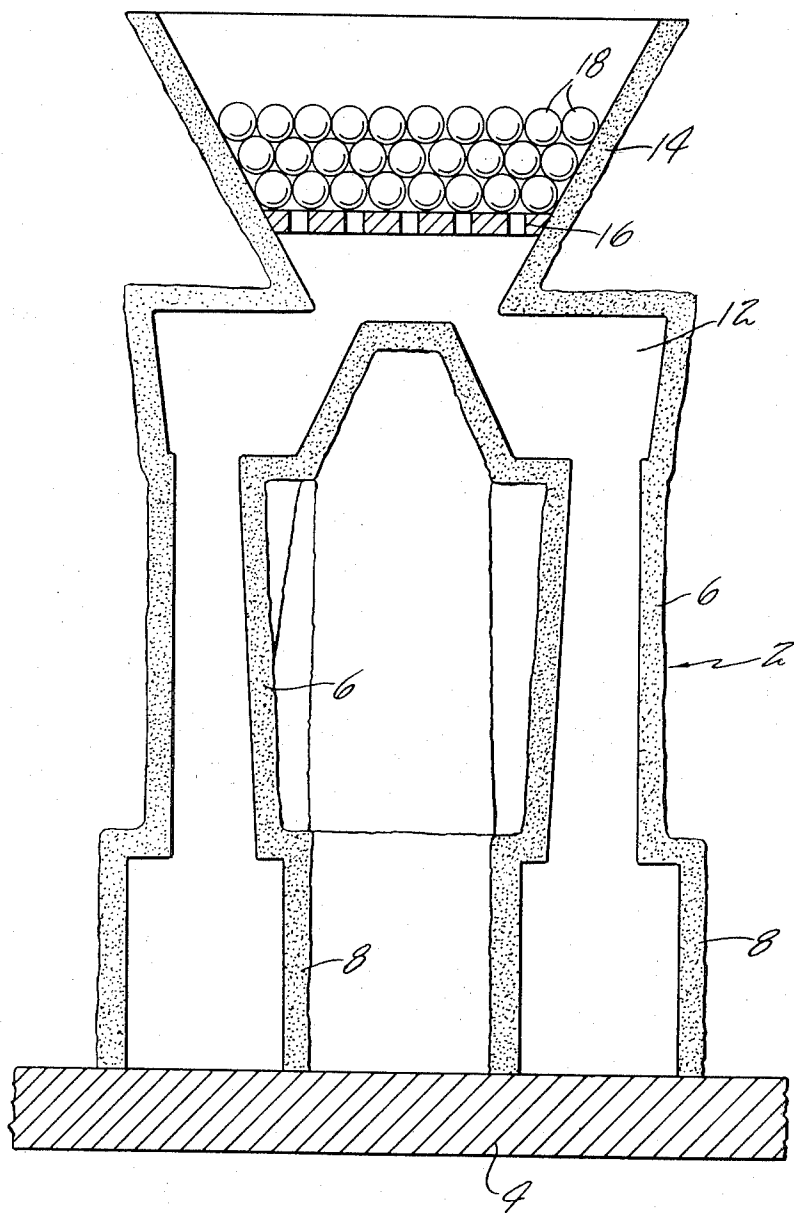
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ABSTRACT

In casting alloys that are prone to the formation of dross such as single or complex oxides of one or more of the metals making up the alloy or crucible, such dross is filtered out by a ceramic filter positioned in the filler for the mold. More specifically, oxides formed in the melt are removed by a filter made up of ceramics formed from metal oxides since the oxides have a tendency to adhere to each other.

2 Claims, 1 Drawing Figure





METHOD OF CLEANING NICKEL ALLOY BY FILTERING

This is a division, of application Ser. No. 291,126, filed Sept. 21, 1972 now U.S. Pat. No. 3,815,661.

BACKGROUND OF THE INVENTION

The presence of nonmetallic inclusions or dross in the alloy has been a major source of casting rejection in forming such cast parts as turbine blades and vanes since such dross is a defect in the casting. In some parts the dross is on the surface of the cast article but in many cases the dross is located internal to the casting. Such dross is generally an oxide of one or more of the metals of the alloy or crucible and the formation of these oxides may occur due to furnace conditions or they may be from oxidation caused during the making of the master melt.

SUMMARY OF THE INVENTION

One feature of the invention is an arrangement for removal of the dross during the pouring of the metal alloy into the mold. Another feature is the use of a filter through which the molten alloy is poured and which will remove dross from the molten metal during the casting of either hardware or master melt.

According to the invention filter elements made up of a ceramic such as aluminum oxide are positioned in the filler cup for the mold and collect on the surface the oxides in the alloy being poured. The energy relations between the interfaces of the ceramic elements and the oxides in the alloy favor adherence of the dross to the filter elements. The invention has broad application to the removal of many oxides from the molten alloys; the invention has particular utility in the removal of hafnium dioxide from alloys in which hafnium is an alloying element and in this event the ceramic may be in the form of spheres and may be formed from aluminum oxide.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a sectional view through a mold showing the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The device is shown in use in a mold for making a directionally solidified casting which in this arrangement is a columnar grained cast article. Referring to the drawing, a shell mold 2 is formed by shell molding techniques for use in the lost wax method of casting and such molds are normally used in a vacuum or in an inert atmosphere. The mold rests on a water-cooled chill block 4 of conventional construction. The mold shown has two article forming portions 6 which are duplicates in the arrangement shown. At the base of the mold is a growth zone 8. Directly above the growth zone is the article forming portion 6. At the top of the article forming portion is a header 12 which communicates with the several mold sections and which also carries a filler cup 14. It will be understood that this type of mold is of a well known construction as described in Barrow, et al. U.S. Pat. No. 3,405,220. The invention is equally applicable to molds adapted for forming single crystal articles as described in the patent to Pearcey U.S. Pat. No. 3,494,709 and it has use in more conventional

molds of the type used for casting articles in which the grain is random or equiaxed.

In accordance with the invention, the filler cup has a perforated baffle 16 therein and on this baffle are positioned a large number of ceramic elements 18 preferably in the form of spheres. These elements or spheres are preferably made of a metal oxide such as aluminum oxide (Al_2O_3). Other oxides may be equally usable such as BeO , SiO_2 , MgO , ZrO_2 , $MgAl_2O_4$, Mg_2SiO_4 , $ZrSiO_4$.

The invention is presently in use in the removal of hafnium dioxide (HfO_2) from investment cast directionally-solidified gas turbine blades and vanes and the filter used in this case is ceramic balls formed from aluminum oxide and the balls are preferably about one-half inch in diameter. Several layers of these balls are desirable so that the molten alloy in flowing over the balls is caused to move in a circuitous path for exposure of more molten alloy to the surface of the balls.

The interfacial energy between the hafnium dioxide dross and the surface of the balls is sufficiently low to cause the dross to adhere to the surface of the balls and thereby be removed from the alloy before it flows from the filler cup into the article portions of the mold. Prior to the time that the filter was in use, the dross suspended in the liquid alloy migrated to the surface of the mold and adhered to it. The result was the accumulation of the oxide on the surface of the cast article where it could readily be seen and where it was detrimental and would result in the discard of that particular cast article.

When the alloy used is cast in the more conventional molds so that the grain structure is equiaxed, the hafnium dioxide dross is more frequently internal to the casting and the dross particles tend to be rounded in shape. The internal location of these defects is believed to be related to the rapid solidification that occurs in conventional equiaxed castings which trap the dross within the casting before it can migrate to the mold surface.

This filter has been used particularly with the alloy known as PWA 1422 which has the following composition:

	Min.	Max.
Carbon	0.08	0.14
Manganese	—	0.20
Chromium	8.00	10.00
Cobalt	9.00	11.00
Tungsten	11.50	13.50
Columbium	0.75	1.25
Titanium	1.75	2.25
Aluminum	4.75	5.25
Hafnium	1.75	2.50
Boron	0.010	0.020
Zirconium	—	0.20
Nickel	Remainder	

Where the balls used in the filter were about one-half inch diameter balls made of aluminum oxide positioned in the filler cup to a depth of about 2 to 3 inches, substantially all of the hafnium dioxide was removed by adhering to the balls making up the filter.

When this alloy was cast without the use of the filter, the hafnium dioxide dross was found to be spread out along the alloy-mold interface and appears somewhat agglomerated below the surface of the casting. It is believed that since the directional-solidification cycle in

producing directionally solidified parts kept the alloy liquid in the mold for an extended period of time, the dross had an opportunity to migrate to the shell surface and adhere to it. When the filter was used, substantially all of these imperfections disappeared and the hafnium dioxide was found to have accumulated on the spheres making up the filter.

Another alloy for which the filter system has been used is the alloy PWA 1455 which has the following composition:

	Min.	Max.
Carbon	0.08	0.13
Manganese	—	0.20
Chromium	7.50	8.50
Cobalt	9.50	10.50
Molybdenum	5.75	6.25
Aluminum	5.75	6.25
Tantalum	4.00	4.50
Hafnium	1.10	1.60
Titanium	0.80	1.20
Boron	0.010	0.020
Nickel	Remainder	

This alloy was cast in the form of a conventional equiaxed casting. Without the filter, the hafnium dioxide dross appeared internal to the casting and the individual particles tended to be rounded in shape. The fact that the dross was located internally in the casting is believed to be a result of the rapid solidification which occurs so that the dross is trapped before it can migrate to the mold surface. In pouring this alloy with a filter in position, it was found that substantially all of the hafnium dioxide dross was removed by the filter before it had a chance to reach the article forming portions of the mold. In using the filter in this way, the filter itself is not heated to as high a temperature as it would in the production of directionally solidified hardware but in spite of the fact that the filter temperature is considerably colder, there was no problem in an adequate flow of molten alloy through the filter and sound castings were achieved.

Another conventionally cast superalloy used was PWA 655 which has the following composition:

	Min.	Max.
Carbon	—	0.20
Chromium	13.00	15.00
Molybdenum	3.50	5.50
Columbium	1.00	3.00
+ Tantalum		
Titanium	0.75	1.25
Aluminum	5.50	6.50
Boron	0.005	0.015
Zirconium	0.05	0.12
Cobalt	—	1.00
Nickel	Remainder	

This alloy when cast conventionally is prone to dross formation but with the use of the filter substantially

dross free, sound castings with an acceptable grain size were achieved even though the part produced was 12 inches in length. The dross formed in this alloy is found to contain Al_2O_3 , $Mg(AlCr)_2O_4$ and $NiAl_2O_4$ and it was found that these oxides were readily removed from the molten alloy stream. It is believed that the filter will also be usable in removal of other dross oxides which occur in air and vacuum melted cobalt, nickel and iron base alloys, such oxides being $CoCr_2O_4$, Fe_2O_3 , $MgFe_2O_4$, $NiAl_2O_4$, $FeSiO_3$ and $CoFe_2O_4$ among others.

In addition to using the filter in making article castings for use, it has been found equally usable in the production of master melts such are used by the investment casting industry. These melts often contain an excessive amount of detrimental oxides and such oxides would be routinely removed by the filter if such a filter were used. The filter concept has been used in the production of experimental master melts where cleanliness of the master melt is essential.

It is also expected that other oxides than aluminum oxide would be effective without serious modification of the necessary surface energy relations. Such filter materials could be for example BeO , SiO_2 , MgO , ZrO_2 (stabilized), $MgAl_2O_4$, Mg_2SiO_4 and $ZrSiO_4$. Certain of these materials might be usable in certain specific applications, for example, MgO or ZrO_2 for processes requiring temperatures above the melting point of Al_2O_3 (3660°F), SiO_2 (glass) where increased thermal shock resistance is needed, $MgAl_2O_4$ for alloys which form a spinel type dross or Mg_2SiO_4 to filter silicate dross materials.

Other sizes and shapes of spheres may be used for the filter. Decreasing the sphere diameter or employing several sizes of spheres could increase the filter efficiency, for example. It will be necessary in changing the size of the spheres to make sure that the increase in the resistance to the metal flow is not such as to prevent filling of the mold within an adequate time.

We claim:

1. The process of cleaning a molten nickel base alloy containing a dross said alloy including as an essential element a metal subject to oxidation during preparation of the molten alloy and said dross comprising an oxide of said metal, by removing the dross from the alloy, said removal comprising the steps of heating a ceramic filter consisting of a bed of a plurality of substantially spherical ceramic particles made of an oxide, said bed having more than one layer of said ceramic particles in contact with one another, and pouring the molten alloy containing dross through said filter whereby metal oxides of the dross are caused to adhere to the particles and be retained thereby, and recovering substantially dross free alloy.

2. The process of claim 1 in which said metal is hafnium and said particles are alumina.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,869,282

DATED : Mar. 4, 1975

INVENTOR(S) : Patrick M. Curran et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Insert on page 1:

-- [73] Assignee: United Aircraft Corporation
East Hartford, Conn. --

Signed and sealed this 27th day of May 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks