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(71) Applicant: **Electric Power Research Institute, Inc.**
Charlotte, NC 28262 (US)

(72) Inventors:
- **Gandy, David**
  China Grove, NC North Carolina 28023 (US)
- **Coleman, Kent**
  Concord, NC North Carolina 28025 (US)
- **Shingledecker, John**
  Concord, NC North Carolina 28027 (US)

(74) Representative: **Brandon, Paul Laurence**
Appleyard Lees
15 Clare Road
Halifax, HX1 2HY (GB)

(54) Method of manufacturing a weld-free apparatus for connection of dissimilar metals using functionally graded compositionally control powder metallurgy and hot isostatic processing methods

(57) A method of manufacturing a weld-free apparatus for use in the connection of dissimilar metals includes the steps of providing a mold designed to replicate a reverse of the apparatus, introducing a low alloy, ferritic steel composition atomized powder into a first portion of the mold, introducing a series of atomized powders incrementally into a second portion of the mold to form a transition region between the ferritic steel composition and an austenitic stainless steel composition, and introducing an austenitic stainless steel composition atomized powder into a third portion of the mold. The method further includes the step of consolidating and melting the atomized powders in a high temperature, high pressure inert gas atmosphere to form the apparatus.

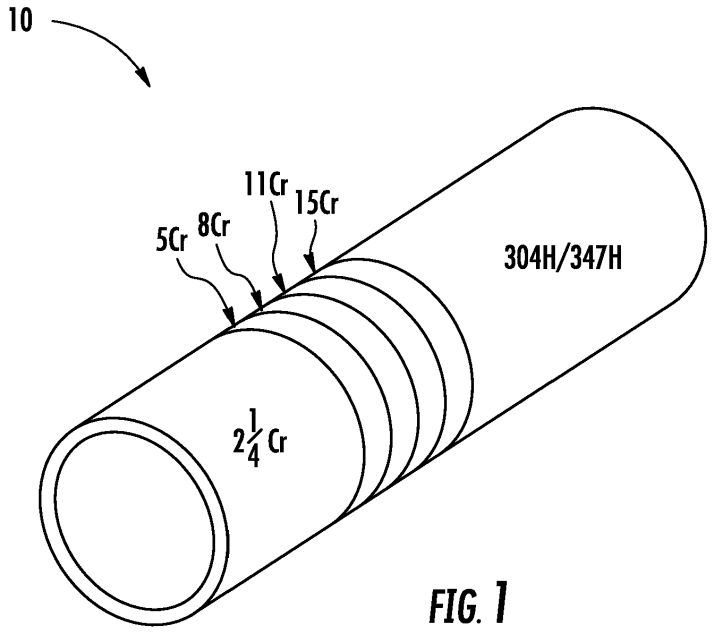

FIG. 1

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Description

BACKGROUND OF THE INVENTION

[0001] This application claims the benefit of Provisional Application No. 61/489,501 filed on May 24, 2011.

[0002] This application relates to a method of manufacturing a weld-free apparatus for use in the connection of dissimilar metals, and more particularly, to a method of providing a weld-free tube Dutchman for use in the connection of dissimilar metals in a power plant environment.

[0003] Conventional fossil power plants employ thousands of dissimilar metal tube welds (DMWs) throughout economizers, superheaters, and reheat assemblies. DMWs are used to provide a transition between carbon, chromium-molybdenum (CrMo), or a creep-strength enhanced ferritic (CSEF) steel tubes to an austenitic stainless steel or nickel based tubes. This transition is necessary as certain parts of the boiler experience higher temperature operation and/or corrosive conditions. The DMW is commonly performed using a nickel-based weld filler metal that provides a coefficient of thermal expansion (CTE) that lies between the two tube materials being joined. This reduces overall stresses in the region of the weld joint, while providing good weldability.

[0004] Unfortunately with exposure time at temperature, many of these DMW joints have a finite life of 7-12 years before they have to be replaced due to a carbon activity gradient leading to the formation of a creep-strength weak carbon-free zone or deleterious Type I or II carbides. One option employed by many OEMs & repair vendors is to utilize a "Dutchman" to eliminate the need to perform DMWs in the field. A Dutchman is a DMW tube section, usually on the order of 12 inches (304.8 mm) in length, which is produced in a shop facility. It still involves two dissimilar tube alloys and a nickel-based weld between them. The difference, however, is that the Dutchman can be produced in controlled shop conditions and when implemented in service, welders are only required to produce "similar" welds: ferritic-to-ferritic or austenitic-to-austenitic (not DMWs). Welders are no longer required to make difficult DMWs in the field. However, even with the higher quality shop welded Dutchman, failures may still occur prematurely due to the difference in coefficient of expansion.

[0005] Accordingly, there is a need for a method of providing a weld-free apparatus for use in connecting dissimilar metals in a power plant environment.

BRIEF SUMMARY OF THE INVENTION

[0006] These and other shortcomings of the prior art are addressed by the present invention, which provides a method of providing a weld-free apparatus, such as a Dutchman, for use in connecting dissimilar metals.

[0007] According to one aspect of the present invention, a method of providing a weld-free apparatus for use in the connection of dissimilar metals includes the steps of providing a mold designed to replicate a reverse of the apparatus, providing a first metal powder and introducing the first metal powder into a first portion of the mold, providing a second metal powder and introducing the second metal powder into a second portion of the mold, and providing a third metal powder and introducing the third metal powder into a third portion of the mold. The second metal powder forms a transition between the first metal powder and the third metal powder. The method further includes the steps of pulling a vacuum on the mold and sealing the mold to maintain the vacuum, placing the mold into a hot isostatic pressing (HIP) furnace to consolidate and melt the first, second, and third powders, and cooling the mold to room temperature and removing the apparatus from the mold.

[0008] According to another aspect of the present invention, a method of providing a weld-free apparatus for use in the connection of dissimilar metals includes the steps of providing a mold designed to replicate a reverse of the apparatus, introducing a low alloy, ferritic steel composition atomized powder into a first portion of the mold, introducing a series of atomized powders incrementally into a second portion of the mold to form a transition region between the ferritic steel composition and an austenitic stainless steel composition, introducing an austenitic stainless steel composition atomized powder into a third portion of the mold; and consolidating and melting the atomized powders in a high temperature, high pressure inert gas atmosphere to form the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The subject matter that is regarded as the invention may be best understood by reference to the following description taken in conjunction with the accompanying drawing figures in which:

[0010] Figure 1 shows a modified Dutchman that shows a transition from 2-1/4CR low alloy steel to a 304H/347H stainless steel; and

[0011] Figure 2 is a flow diagram showing a method according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Referring to the drawings, a modified apparatus, such as a Dutchman, formed in accordance with an embodiment of the invention is illustrated in Figure 1 and shown generally at reference numeral 10.

[0013] The current invention eliminates the DMW altogether. To create the modified Dutchman 10, functionally graded compositionally controlled powder metallurgy/hot isostatic pressing (HIP) practices are employed. With this process, the composition of the Dutchman tube 10 is gradually transitioned from the ferritic tube composition (carbon-, CrMo, or CSEF steel) to the austenitic SS composition over a 1-3 inch (25.4-76.2 mm) region of the 12 inch (304.8 mm) long Dutchman tube 10. The

gradual transition results in a smoother transition in the tube 10 CTE from one alloy to another and reduces overall stresses.

[0014] Equally important, carbon migration problems (and the concurrent loss in creep strength) often associated with DMWs are eliminated entirely and a smooth transition between tubing thicknesses is provided. The modified Dutchman 10 is processed (manufactured) in the HIP further to achieve consolidation and properties. Once manufactured, it can be used in the field in a similar manner to current Dutchman.

[0015] Referring to Figure 2, the process begins with a mold (container), Block 11, that replicates a reverse of the final tube dimension. A carbon, low alloy, or CSEF steel composition atomized powder is introduced to approximately one-half of the tube container (minus 1 or so inches or 25.4 or so millimeters), Block 12. For the low alloy steel-to-austenitic SS (normally made from 2-1/4Cr-1Mo to 304H), a transition is required to smoothly transition from 2-1/4Cr to 18Cr SS. Powder is added to the container in increments, starting with 5Cr, then, 8Cr, 11Cr, and 15Cr, Block 13. This occurs over a transition region of 2-3 inches (50.8-76.2 mm). The remainder of the container is filled with an 18Cr SS atomized powder matching the composition of the 304H or 347H SS tube alloy, Block 14. A vacuum is pulled on the container and the container is sealed at one end by welding, Block 15.

[0016] Next, the entire assembly is placed into a HIP furnace and brought to a high temperature and pressure within an inert gas (argon) atmosphere to consolidate and melt the powder, Block 16. After remaining at temperature/pressure for a given time, the entire Dutchman assembly is cooled to room temperature and removed from the HIP furnace, Block 17. An additional heat treatment step to normalize and temper the low alloy steel section of the tube may also be necessary, Block 17. The final modified Dutchman assembly will require pickling, boring, and/or grinding to remove the outside container/canister, Block 18. At this point, the modified Dutchman assembly is ready for final machine preparation on either end before being placed into service.

[0017] The manufacturing process for the 9Cr-to-18Cr (CSEF to austenitic SS) is similar to that of the low alloy steel-to-austenitic SS described above, except that the transition occurs with a 12Cr, 14Cr, and 16Cr alloy powder within the transition region (2-3 inches or 50.8-76.2 mm), Block 13. Thus, the process goes from 9Cr to 18Cr in the final configuration before the modified Dutchman assembly is introduced into the HIP furnace.

[0018] It should be appreciated that while the above description discusses specific metals, the invention is not limited to only the metals or combination of metals discussed or to a specific class of material. Rather, the invention is directed, generally, to the formation of an apparatus that eliminates DMWs. It should also be appreciated that while the discussion above is directed to the formation of a Dutchman, the Dutchman is used as example only and the method described above is applicable to the manufacturing or forming of other apparatuses or devices in an effort to eliminate DMWs.

[0019] The foregoing has described a method for providing a weld-free apparatus for connecting dissimilar metals in a power plant environment. While specific embodiments of the present invention have been described, it will be apparent to those skilled in the art that various modifications thereto can be made without departing from the spirit and scope of the invention. Accordingly, the foregoing description of the preferred embodiment of the invention and the best mode for practicing the invention are provided for the purpose of illustration only and not for the purpose of limitation.

Claims

1. A method of providing a weld-free apparatus for use in the connection of dissimilar metals, comprising the steps of:

   (a) providing a mold designed to replicate a reverse of the apparatus;
   (b) providing a first metal powder and introducing the first metal powder into a first portion of the mold;
   (c) providing a second metal powder and introducing the second metal powder into a second portion of the mold;
   (d) providing a third metal powder and introducing the third metal powder into a third portion of the mold, wherein the second metal powder forms a transition between the first metal powder and the third metal powder;
   (e) pulling a vacuum on the mold and sealing the mold to maintain the vacuum;
   (f) placing the mold into a hot isostatic pressing (HIP) furnace to consolidate and melt the first, second, and third powders; and
   (g) cooling the mold to room temperature and removing the apparatus from the mold.

2. The method according to claim 1, wherein the first metal powder is a low alloy ferritic steel composition atomized powder.

3. The method according to claim 1, wherein the third powder is an austenitic stainless steel composition atomized powder.

4. The method according to claim 1, wherein the mold is maintained in the HIP furnace at a high temperature and high pressure within an inert gas atmosphere.

5. The method according to claim 1, further including the step of heat treating the apparatus.

6. The method according to claim 1, further including the step of pickling, boring, and grinding to remove the mold from the apparatus.

7. The method according to claim 1, further including the step of machining the apparatus to final dimensions.

8. A method of providing a weld-free apparatus for use in the connection of dissimilar metals, comprising the steps of:

(a) providing a mold designed to replicate a reverse of the apparatus;
(b) introducing a low alloy, ferritic steel composition atomized powder into a first portion of the mold;
(c) introducing a series of atomized powders incrementally into a second portion of the mold to form a transition region between the ferritic steel composition and an austenitic stainless steel composition;
(d) introducing an austenitic stainless steel composition atomized powder into a third portion of the mold; and
(e) consolidating and melting the atomized powders in a high temperature, high pressure inert gas atmosphere to form the apparatus.

9. The method according to claim 8, wherein the series of atomized powders that form the transition region start with a lower alloy steel powder and increases in each series to a higher alloy steel powder.

10. The method according to claim 8, wherein the transition region comprises a series of four atomized powders, wherein the first atomized powder is a 5Cr steel powder, the second atomized powder is an 8Cr steel powder, the third atomized powder is an 11 Cr steel powder, and the fourth atomized powder is a 15Cr steel atomized powder.

11. The method according to claim 10, wherein the ferritic steel composition atomized powder is a 2-1/4Cr steel powder and the austenitic stainless steel composition atomized powder is an 18Cr steel powder.

12. The method according to claim 8, wherein the transition region comprises a series of three atomized powders, wherein the first atomized powder is a 12Cr steel powder, the second atomized powder is a 14Cr steel powder, and the third atomized powder is an 16Cr steel powder.

13. The method according to claim 12, wherein the ferritic steel composition atomized powder is a 9Cr steel powder and the austenitic stainless steel composition atomized powder is an 18Cr steel powder.

14. The method according to claim 8, wherein the first and third portions of the mold comprise about three-fourths of the mold and the second portion of the mold comprises about one-fourth of the mold.

15. The method according to claim 8, further including the step of heat treating the apparatus to normalize and temper low alloy sections of the apparatus.

16. The method according to claim 8, further including the step of removing the mold from the apparatus.

17. The method according to claim 8, further including the step of machining the apparatus to final dimensions.

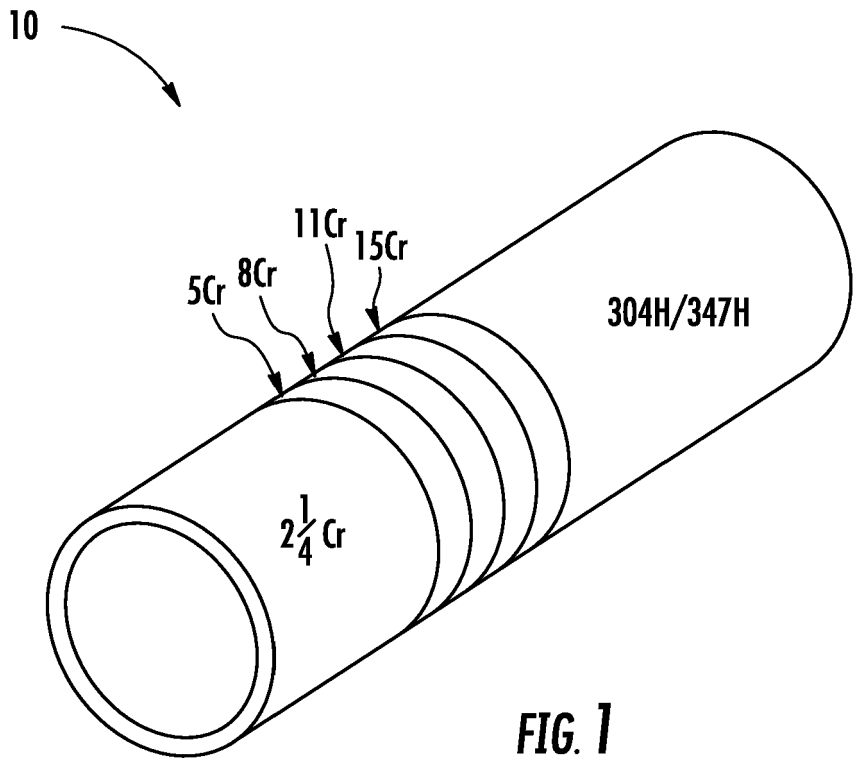

FIG. 1

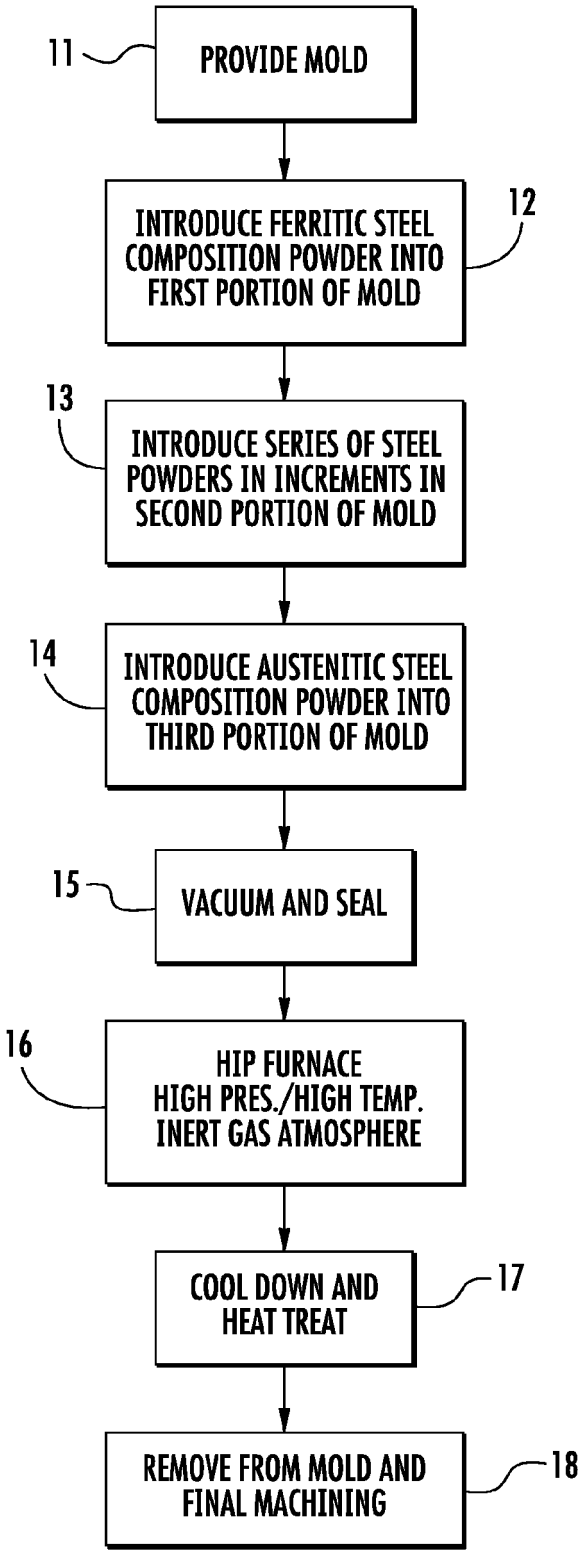
11
PROVIDE MOLD
12
INTRODUCE FERRITIC STEEL COMPOSITION POWDER INTO FIRST PORTION OF MOLD
13
INTRODUCE SERIES OF STEEL POWDERS IN INCREMENTS IN SECOND PORTION OF MOLD
14
INTRODUCE AUSTENITIC STEEL COMPOSITION POWDER INTO THIRD PORTION OF MOLD
15
VACUUM AND SEAL
16
HIP FURNACE HIGH PRES./HIGH TEMP. INERT GAS ATMOSPHERE
17
COOL DOWN AND HEAT TREAT
18
REMOVE FROM MOLD AND FINAL MACHINING

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 8970

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	MATERIALS SCIENCE FORUM TRANS TECH PUBLICATIONS LTD. SWITZERLAND, vol. 631-2, 2010, pages 273-278, XP8155659, ISSN: 0255-5476, DOI: DOI:10.4028/WWW.SCIENTIFIC.NET/MSF.631-632.273 * Materials used and fabrication process of FGPJ *	1-17	INV. B22F3/15
X	JP 2001 214231 A (KUBOTA KK) 7 August 2001 (2001-08-07) * abstract *	1-17	

TECHNICAL FIELDS SEARCHED (IPC)
B22F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 September 2012	Morra, Valentina

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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05-09-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2001214231 A	07-08-2001	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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