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(54) METHOD OF MANUFACTURING COMPONENTS

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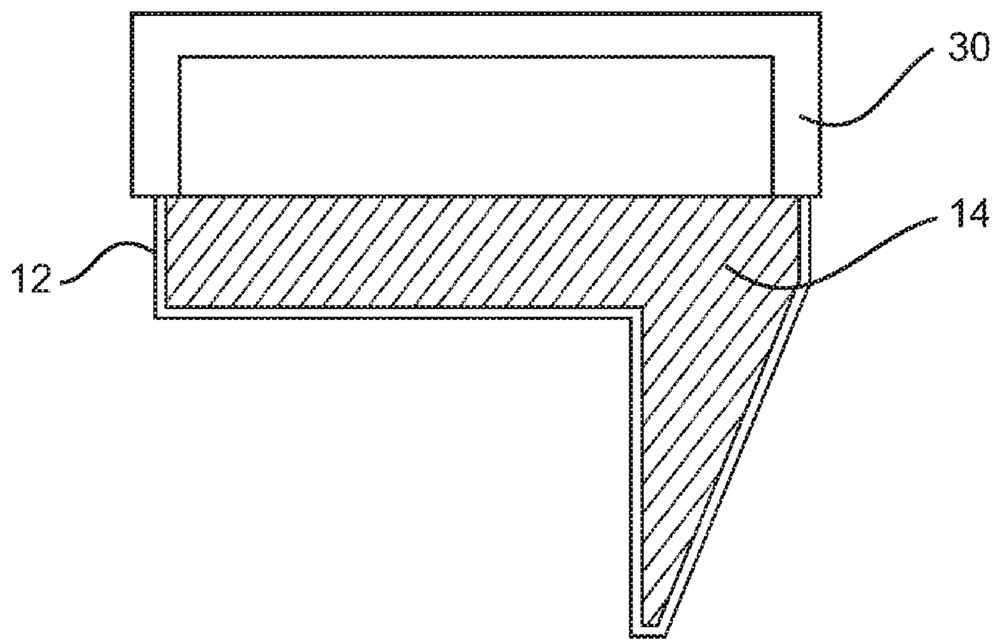
(57) **ABSTRACT**

A method of forming a wear resistant component is disclosed. The method includes the metallurgical bonding of an abrasion resistant alloy to a substrate within a furnace. A gas flow restricting means is used to restrict the flow of gaseous oxygen into the region of the metallurgical bond, allowing a furnace to be used without vacuum extraction.



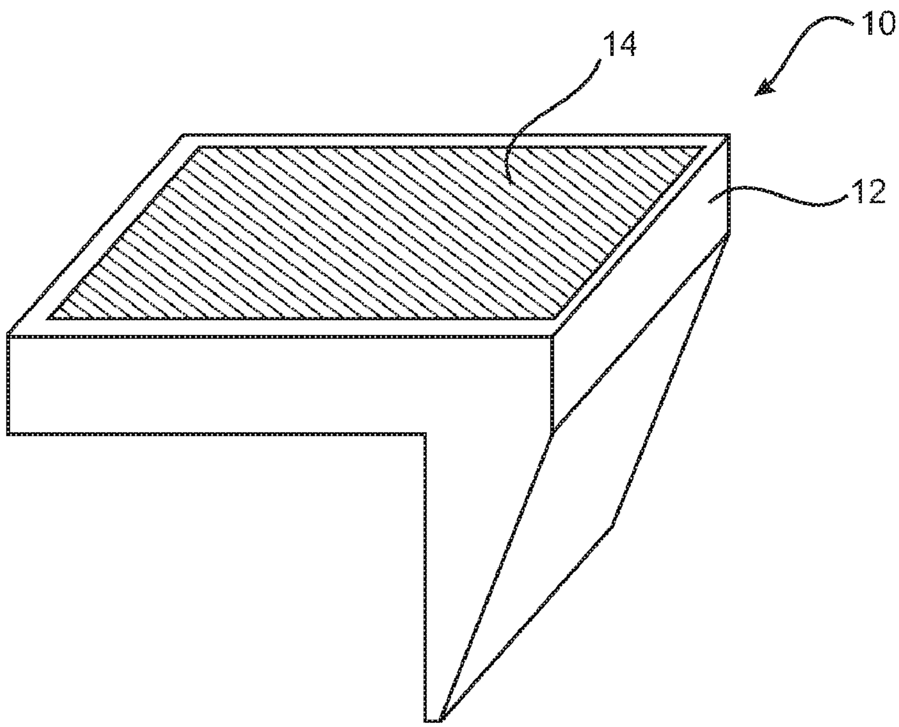


Fig 1

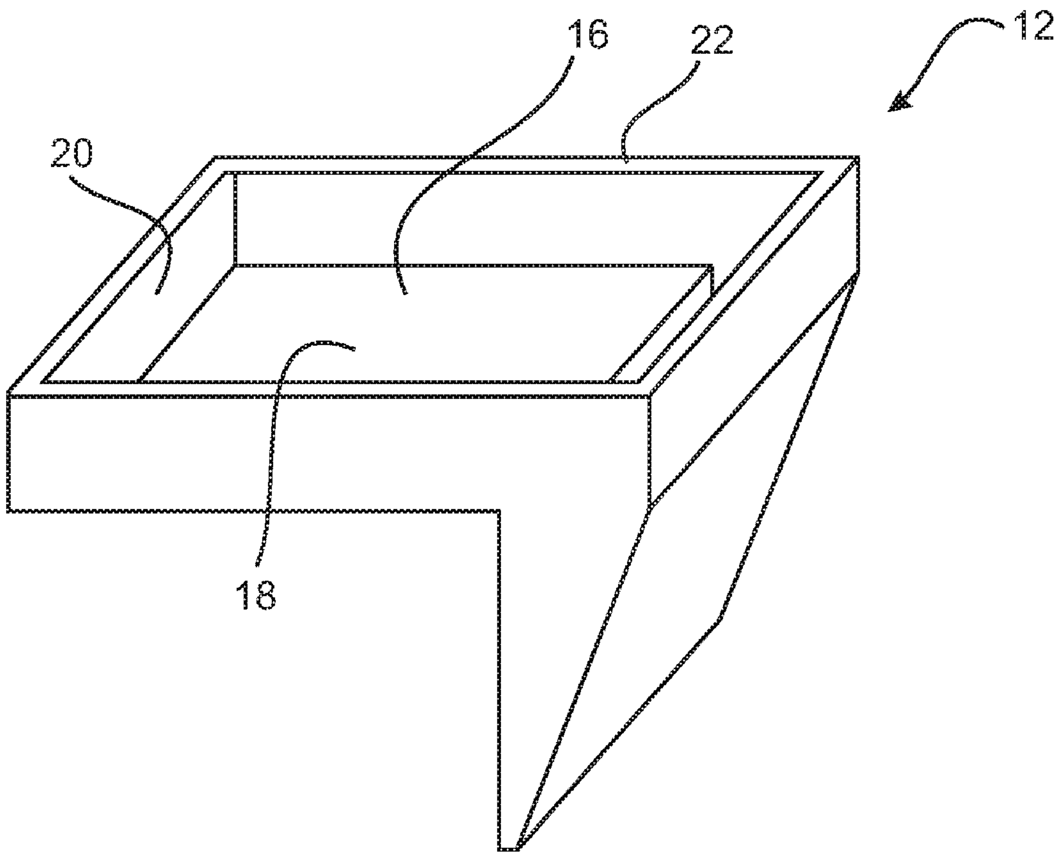


Fig 2

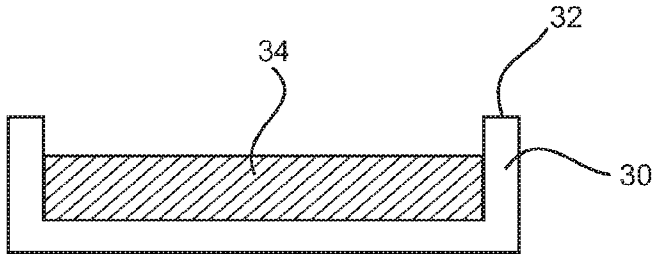


Fig 3(a)

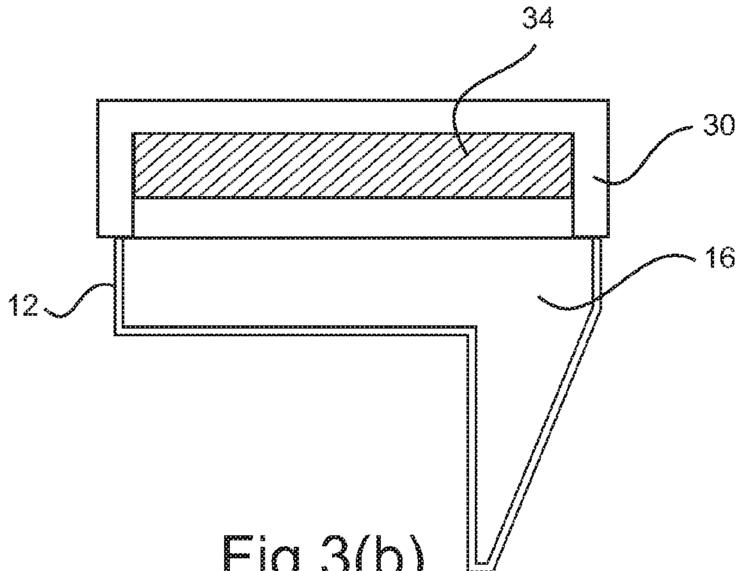


Fig 3(b)

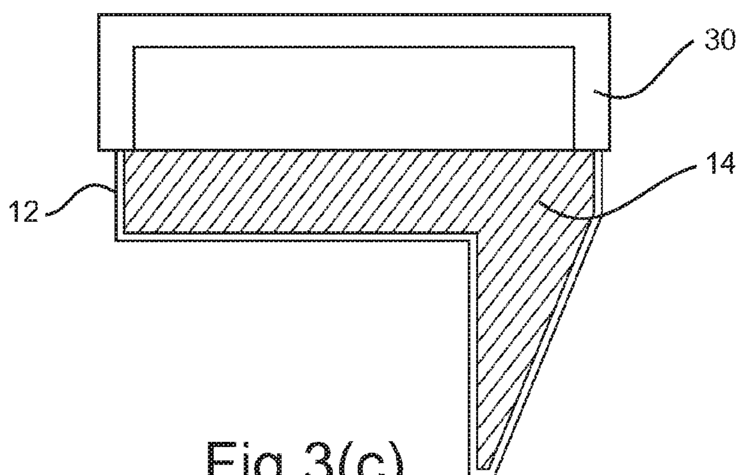


Fig 3(c)

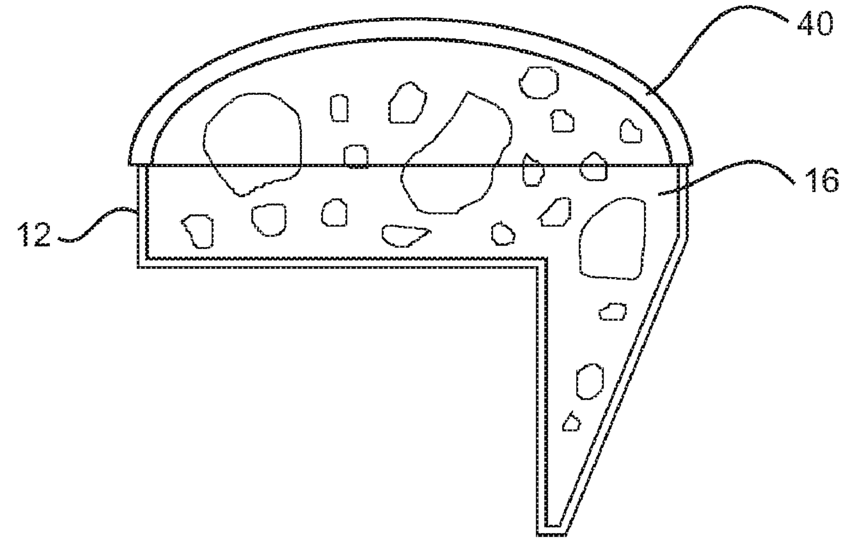


Fig 4(a)

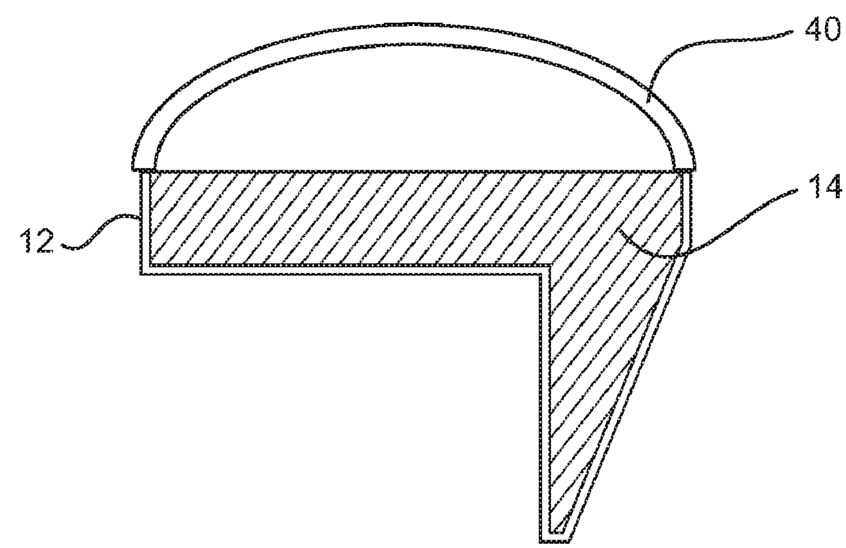


Fig 4(b)

METHOD OF MANUFACTURING COMPONENTS

FIELD OF THE INVENTION

[0001] The present invention relates to the formation of components having a shell formed from a first metallic material and an inner body formed from a second metallic material. It has particular application to the formation of wear resistant metallic components.

BACKGROUND TO THE INVENTION

[0002] Parts of earth moving machinery and related equipment are subject to significant wear during use, principally due to abrasion. In an attempt to reduce the effects of this abrasion, wear components are often mounted to earth moving buckets and similar machinery. Typical wear components include wear bars, bucket heel shrouds and edge components. The wear components are arranged to protect the parts of the machinery which would otherwise wear most rapidly. The wear components are designed to be relatively easy to replace, when worn.

[0003] It is desirable to make these wear components from abrasive resistant materials, in order to extend their working life and provide an enhanced benefit. It is also necessary to use materials which can withstand substantial impact forces, and the resulting stresses within the material. In general, it has been found that materials of high resistance to abrasive wear, such as chromium white irons and tungsten carbide composites, are generally too brittle to withstand the impact forces to which the wear components are frequently subjected.

[0004] Additional difficulties have been experienced in successfully attaching components made of these materials to heavy equipment. The materials are generally incapable of being welded, and the provision of holes and the like in the component for mechanical attachment can lead to unacceptable stress concentrations and resultant failure when in use.

[0005] As a result, most wear members are made from quenched and tempered steel, as this provides excellent strength properties along with a degree of resistance to abrasion. Nonetheless, it has long been considered desirable to provide wear members with a higher resistance to abrasive wear than that provided by quenched and tempered steel.

[0006] Attempts have been made to overcome the limitations of more highly abrasion resistant materials by bonding these materials to base metals such as steel. In one such process, white iron is cast to a block, which is then machined to a highly smooth finish. A steel substrate is similarly machined to a highly smooth finish. The steel substrate can then be vacuum brazed to the white iron block using a copper filler. This method requires very high machining tolerances, equating to a fraction of a millimetre. Additionally, the copper braze can provide a structural weak point in the wear member.

[0007] An alternative process has been proposed in International PCT publication number WO 02/13996. This application describes a process for forming a component from two metallic materials, where the materials form a metallic bond. The method requires an inner material to have a liquidus temperature which is lower than the solidus temperature of an outer material. The materials are bonded within a furnace, where the materials are heated above the liquidus temperature of the inner material and are then maintained at this elevated temperature for sufficient time to allow fusing of the materials.

[0008] The conditions within the furnaces used in the above processes are tightly controlled to prevent oxidation of either the first or the second metal. The furnace employed is a vacuum furnace, which is firstly evacuated of oxygen and may then be purged with an appropriate quantity of an inert gas such as nitrogen. Such a furnace is expensive both to install and operate. Additionally, such furnaces frequently have adverse environmental impacts, with potential for noxious emissions. There are often limits to where vacuum furnaces can be sited.

[0009] In another process, white iron has been cast directly onto a steel plate in a foundry mould.

[0010] These processes result in a white iron block having a steel plate bonded on one side. It is then possible to attach the white iron to a wearing structure by welding of the steel block to the structure. Such an operation can be problematic, as care must be taken not to 'pick up' any of the white iron in the weld, as this will compromise weld integrity.

[0011] The present invention seeks to provide a method for manufacturing components such as wear resistant components which provides some of the advantages of WO 02/13996 without requiring the evacuation and purging of a vacuum furnace.

SUMMARY OF THE INVENTION

[0012] In accordance with the present invention there is provided a method for manufacturing a component, the method comprising the steps of:

- **[0013]** (i) providing an outer shell formed by a first metallic material, the outer shell having a base and side walls defining a cavity, the cavity being open at an upper end thereof;
- **[0014]** (ii) providing a second metallic material above the base of the cavity;
- **[0015]** (iii) providing a gas flow restricting means to restrict the flow of gas into the cavity;
- **[0016]** (iv) heating the first and second metallic materials to above the solidus temperature of the second metallic material so that the second metallic material flows and covers the base of the cavity;
- **[0017]** (v) heating the metallic materials above the liquidus temperature of the second metallic material;
- **[0018]** (vi) cooling the materials below the solidus temperature of the second metallic material so that a metallurgical bond is formed between the first and second metallic materials.

[0019] The invention envisages a possible additional step of machining of the outside of the shell following cooling to remove any oxidation which occurs during the heating.

[0020] The invention is based on the understanding that the existence of a small quantity of oxygen in the interface between the first and second metallic materials may still allow for the formation of a sufficiently strong metallurgical bond. With this understanding, the present invention proposes not to remove all oxygen from the environment in which the metals are being heated, but rather to restrict the flow of oxygen into the actual location of the bond. It is understood that this may result in oxidation occurring away from the bond location, but such oxidation is likely to be only to the surface of the component and hence can be machined away.

[0021] The method may include an additional step of maintaining the metallic materials above the liquidus temperature of the second metallic material for a sufficient period of time to allow at least partial fusion of the second material to the first material. It is expected that the materials will be held at this temperature sufficiently for substantially complete fusion to occur about the boundary between the first and second metallic materials. This time may be in the order of 15 minutes to 120 minutes.

[0022] In its simplest form, the gas flow restricting means may be a cover sized and shaped to locate across the open end of the cavity. In a preferred embodiment, the gas flow restricting means may be a container within which some or all of the second metallic material is located. In this embodiment, the steps of providing the second metallic material and of providing the gas flow restricting means may be achieved through providing the second metallic material in a container, the container having an opening complementary to the open end of the cavity, and then inverting the container and locating it above the cavity. Melting of the second metallic material will cause it to flow from the container into the cavity.

[0023] The present invention may be used in conjunction with the methods of co-pending PCT application PCT/AU2009/000816, the contents of which are incorporated herein by reference. When performed in this manner, the second metallic material may be provided as alloy constituents, chosen so that during the process of the present invention the alloy constituents melt and mix to form a desired alloy composition, bonded to the outer shell.

[0024] The second metallic material may be an abrasion resistant metal, such as an abrasion resistant white cast iron. It is anticipated that white cast irons containing carbides of one or more of chromium, molybdenum, tungsten, niobium, vanadium and boron, or other suitable carbides, may be suitable for use in the method of the present invention.

[0025] It is anticipated that the present invention will allow wear resistant components to be produced using relatively small and inexpensive kilns or furnaces, operating with a significantly smaller environmental impact than vacuum furnaces. The types of kiln which may be suitable for the method include kilns generally used for the firing of pottery, provided they have a sufficiently high operating temperature. The kiln may be heated by any convenient heat source, including conventional sources such as gas or electricity, or alternatively by sources such as oil or diesel fuel. Heating could also be provided by non-traditional means, such as induction heating or microwave heating.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] It will be convenient to further describe the invention with reference to preferred embodiments of the method of the present invention. Other embodiments are possible, and consequently, the particularity of the following discussion is not to be understood as superseding the generality of the preceding description of the invention. In particular, although the drawings and the discussion below discuss the use of the present invention in the formation of a wear resistant heel shroud, it will be understood that the present invention is applicable for the formation of a wide range of components. In the drawings:

[0027] FIG. **1** is a perspective of a wear resistant heel shroud formed using a method in accordance with the present invention;

[0028] FIG. **2** is a perspective of an outer shell of the heel shroud of FIG. **1**, shown prior to the operation of the present invention;

[0029] FIG. **3**(*a*) is a cross sectional schematic view of a container used in one embodiment of the present invention;

[0030] FIGS. **3**(*b*) and **3**(*c*) are sequential, cross sectional schematic views of the outer shell of FIG. **2** and the container of FIG. **3**(*b*) during formation of the heel shroud;

[0031] FIGS. **4**(*a*) and **4**(*b*) are cross sectional schematic views of the heel shroud of FIG. **1** during formation in accordance with a second embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENT

[0032] FIG. **1** shows a wear resistant mechanical component, being a heel shroud **10**. The heel shroud **10** has an outer shell **12**, which may be formed from a high strength, weldable material such as a ferrous based material, or a nickel or titanium based alloy. The heel shroud **10** has an inner body **14**, which is formed from an abrasion resistant material such as a chromium white iron. The following discussion refers to the method of manufacturing such an article.

[0033] FIG. **2** shows the outer shell **12** of the heel shroud **10**, before the formation of the inner body **14**. The outer shell **10** defines a cavity **16**, having a base **18** and side walls **20**. The cavity **16** has an opening **22** at an upper end thereof. The opening **22** is substantially square.

[0034] FIG. **3**(*a*) shows a container **30**, formed of a heat resistant material such as a ceramic material. The container **30** has an open top **32**. The open top **32** is substantially complementary in shape to the opening **22** of the outer shell **12**, such that, when the container **30** is inverted, it can be placed about the opening **22** of the outer shell **12** to substantially seal the opening as shown in FIG. **3**(*b*).

[0035] The container **30** is filled with an abrasion-resistant material such as a chromium white iron **34**.

[0036] In order to form the heel shroud **10**, the container **30** is inverted and placed atop the outer shell **12** as shown in FIG. **3**(*b*). The outer shell **12** and the container **30** are then heated in a furnace to a temperature above the solidus temperature of the chromium white iron **34**.

[0037] Once it begins to melt, the chromium white iron flows from the container **30** into the cavity **16**. The quantity of chromium white iron within the container **30** is chosen so as to fill the cavity **16**. Furnace gases are precluded from entering into the cavity **16** due to a seal provided about the cavity opening **22** by the container **30**. Even where this is not a gas-tight seal, its effect is to greatly diminish the propensity for gas to flow into the cavity **16**. The container **30** thereby acts as a gas flow restricting means.

[0038] The covered shell **12** containing white iron **34** is then heated above the liquidus temperature of the chromium white iron. At this point the white iron begins to fuse with the internal shell walls, thus giving rise to a metallurgical bond. This temperature is maintained for a predetermined time, which may be between 15 minutes and 120 minutes, depending on the particular metals used and the temperature to which the shell **12** is heated.

[0039] Once the shell has been heated for a sufficient period, the entire arrangement can be cooled, to solidify the white iron **34** as the inner body **14** of the heel shroud **10**.

[0040] Depending on the nature of the gases present in the furnace, and on the nature of the outer shell **12**, oxidation of the outer shell **12** may have occurred. In order to remove and oxidised parts, and to remove any burrs and the like, the heel shroud **10** may then be subjected to a machining operation.

[0041] FIGS. **4**(*a*) and **4**(*b*) show a different embodiment of the present invention, where constituent parts of the heel shroud inner body **14** are placed within the cavity **16**, which is then covered by a cover **40**. As in the embodiment of FIG. **3**, the cover **40** acts to restrict the flow of gases into the cavity **16**. The covered shell **12** may then be heated to a level where enough of the constituent ingredients melt so as to form the required alloy, as described in co-pending application number PCT/AU2009/000816.

[0042] Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention. For instance, it will be appreciated that some of the second material (or its constituents) can be provided within the cavity **16**, with the remainder provided within the container **30**.

1. A method of manufacturing a component, the method comprising the steps of:

(i) providing an outer shell formed by a first metallic material, the outer shell having a base and side walls defining a cavity, the cavity being open at an upper end thereof;

(ii) providing a second metallic material above the base of the cavity;

(iii) providing a gas flow restricting means to restrict the flow of gas into the cavity;

(iv) heating the first and second metallic materials to above the solidus temperature of the second metallic material so that the second metallic material flows and covers the base of the cavity;

(v) heating the metallic materials above the liquidus temperature of the second metallic material;

(vi) cooling the materials below the solidus temperature of the second metallic material so that a metallurgical bond is formed between the first and second metallic materials.

2. A method of manufacturing a component as claimed in claim **1**, including a further step of machining of the outside of the shell following cooling to remove any oxidation which occurs during the heating.

3. A method of manufacturing a component as claimed in claim **1**, whereby following heating of the metallic materials the temperature of the metallic materials is maintained above the liquidus temperature of the second metallic material for a sufficient period of time to allow at least partial fusion of the second material to the first material.

4. A method of manufacturing a component as claimed in claim **3**, wherein the temperature of the metallic materials is maintained above the liquidus temperature for at least 15 minutes.

5. A method of manufacturing a component as claimed in claim **1**, whereby the gas flow restricting means is a cover, the cover being sized and shaped to locate across the open end of the cavity.

6. A method of manufacturing a component as claimed in claim **1**, wherein the gas flow restricting means is a container within which some or all of the second metallic material is located.

7. A method of manufacturing a component as claimed in claim **6**, wherein the steps of providing the second metallic material and of providing the gas flow restricting means are achieved through providing the second metallic material in a container, the container having an opening complementary in shape to the open end of the cavity, and then inverting the container and locating it above the cavity.

8. A method of manufacturing a component as claimed in claim **1**, wherein the second metallic material is provided as alloy constituents, chosen so that when heated above their liquidus temperature the alloy constituents melt and mix to form a desired alloy composition, which bonds to the outer shell on cooling.

9. A method of manufacturing a component as claimed in claim **1**, wherein the first metallic material has a higher tensile strength than the second metallic material, and wherein the second metallic material is more resistant to abrasion than the first metallic material.

10. A method of manufacturing a component as claimed in claim **9**, wherein the first metallic material is a ferrous based material.

11. A method of manufacturing a component as claimed in claim **9**, wherein the first metallic material is a nickel or titanium based alloy.

12. A method of manufacturing a component as claimed in claim **9**, wherein the second metallic material is a white cast iron.

13. A method of manufacturing a component as claimed in claim **12**, wherein the second metallic material is a white cast iron containing carbides of at least one of chromium, molybdenum, tungsten, titanium, niobium, vanadium or boron.

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