(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 691 165 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.01.1996 Bulletin 1996/02

(51) Int. Cl.[6]: **B22C 9/00**

(21) Application number: **95110408.2**

(22) Date of filing: **04.07.1995**

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **05.07.1994 JP 153366/94**
27.06.1995 JP 160271/95

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**
Aichi-ken (JP)

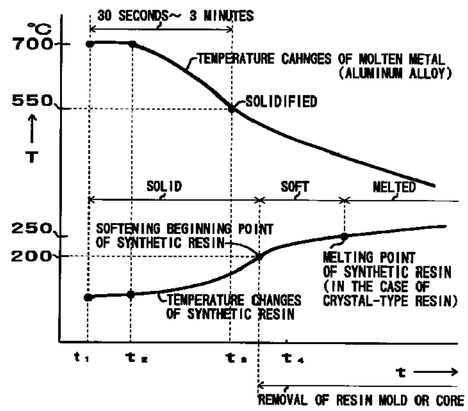
(72) Inventors:
- **Okada, Masamichi**
  Aichi-ken (JP)
- **Okada, Yuji**
  Aichi-ken (JP)
- **Shirakawa, Hirokazu**
  Aichi-ken (JP)
- **Tomitaka, Shuichi**
  Aichi-ken (JP)

(74) Representative: **Tiedtke, Harro, Dipl.-Ing.**
D-80336 München (DE)

(54) Method and apparatus for producing a cast metal product

(57) A method is provided for producing a cast metal product (4) using a mold (1) or core (1') made from a thermoplastic resin. The resinous mold (1) or core (1') is heated after the molten metal for making the cast metal product (4) solidifies so that the resin of the mold (1) or core (1') is melted or softened and is separated from the cast metal product (4). The removed resin may be retrieved and recycled, for example, as material for another resinous mold or core.

F I G. 1



t_1 : START OF SUPPLY OF MOLTEN METAL

t_2 : FINISH OF SUPPLY OF MOLTEN METAL

t_3 : COMPLETION OF SOLIDIFICATION OF MOLTEN METAL

t_4 : OPENING OF DIES

EP 0 691 165 A2

Description

The present invention relates to a method and apparatus for producing a cast metal product using a mold or core made from a synthetic resin.

In conventional castings used in mass production, metal molds or cores and sand molds or cores are frequently used. In the case of metal molds, many products can be produced using only one set of metal molds until the molds at last cause serious abrasion or damage. In the case of sand molds, a set of sand molds is prepared for each product and is destroyed thereafter.

However, conventional castings have the following problems. In the case of metal molds, the molds experience thermal shock due to contact with the very hot molten metal. The thermal cycling shortens the operational life of the molds. In some cases, the molds can collapse unexpectedly. As a solution, spare molds are prepared even if the number of products to be cast is small, which increases production costs. In the case of sand molds, it is difficult to realize good dimensional accuracy, smooth surfaces in the mold cavity, and a constant quality of cast products.

An object of the present invention is to provide a method and apparatus for producing a cast product wherein a mold or core cost is less than in the case of a metal mold or core, and product quality is improved compared with the case of a sand mold or core.

These and other objects, features, and advantages of the present invention will become more apparent and will be more readily appreciated from the following detailed description of the preferred embodiments of the present invention when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a graph, applicable to all embodiments of the present invention, illustrating a relationship between a temperature changes of a resin mold or core and a temperature changes of a molten metal;
FIG. 2 is a cross-sectional view of a resin mold used in an apparatus for producing a cast metal product, in accordance with a first embodiment of the present invention;
FIG. 3 is a schematic cross-sectional view illustrating the steps of a method for producing a cast metal product, in accordance with a second embodiment of the present invention;
FIG. 4 is a cross-sectional view of a molten metal supply device different from the molten metal supply device of FIG. 3;
FIG. 5 is a cross-sectional view of another molten metal supply device different from the molten metal supply device of FIG. 3; and
FIG. 6 is a schematic cross-sectional view of an apparatus for producing a cast metal product, in accordance with a third embodiment of the present invention.

A first embodiment of the present invention relates to an apparatus for producing a cast metal product having a mold made from a synthetic resin. A second embodiment of the present invention relates to a method for producing a cast metal product using a mold made from a synthetic resin. A third embodiment of the present invention relates to an apparatus for producing a cast metal product, the apparatus having a core made from a synthetic resin. Throughout all of the embodiments of the present invention, portions common to all of the embodiments are denoted with the same reference numerals.

First, structures or methods common to all of the embodiments of the present invention will be explained with reference to FIG. 1 and, where appropriate, FIGS. 2 and 3.

An apparatus for producing a cast metal product 4 includes a mold 1 (or core 1') which is made from a synthetic resin. The synthetic resin mold 1 (or core 1') has a molding cavity 2 therein. The mold 1 (or core 1') may comprise a set of molds (or cores). Molten metal (for example, molten aluminum alloy) is supplied to the molding cavity 2 at a pressure which may be higher than 80 MPa or lower. The molten metal is then cooled and solidified to form a cast metal product 4. After the molten metal solidifies, the mold 1 (or core 1') is heated so that it melts or softens. The resin constituting the mold 1 (or core 1') is thereby removed or separated from the cast metal product 4 and may be retrieved to be recycled. When the resin melts, the resin will be automatically removed, and when the resin softens, the resin may be mechanically removed using a suitable tool.

The thermal characteristics of the synthetic resin used to make the mold 1 (or core 1') and its relationship with the thermal characteristics of the molten metal 3 are illustrated in FIG. 1. If the molten metal 3 is an aluminum alloy, a temperature of the molten metal 3 is at about 700°C during a molten metal feeding time period, from time t_1 (initiation of feeding) to time t_2 (completion of feeding). The temperature then decreases to about 550°C in about 30 seconds to 3 minutes, after which the molten metal 3 is completely solidified.

On the other hand, although the temperature of the mold 1 or (core 1') increases due to heat transfer from the molten metal 3, the temperature of the mold 1 or (core 1') does not reach a temperature (about 200°C) at which the synthetic resin begins to soften before time t_3 when the molten metal completely solidifies. This means that the molten metal 3 completes its solidification while the mold 1 (or core 1') is substantially solid. As a result, the mold 1 (or core 1') does not cause deformation in the cast product 4 even if the mold 1 (or core 1') experiences a high pressure from the molten metal 3. A cast metal product 4 with high dimensional accuracy can therefor be produced.

Thereafter, the mold 1 (or core 1') continues to rise in temperature, either receiving residual heat from the cast metal product or being directly heated. The mold 1 (or core 1') begins to soften at an initial softening point of the synthetic resin (about 200°C). In this connection, the softening point means a temperature at which an elastic rate of resin of 10^0 - 10^{-5} GPa is obtained. The temperature of mold 1 (or core 1') continues to rise to about 250°C , at which the resin of the mold 1 (or core 1') is melted or sufficiently softened. More particularly, in the case of a crystal-type resin (for example, polypropylene), the resin will be melted at about 250°C because it has a melting point, while in the case of a non-crystal-type resin (for example, polycarbonate), the resin will soften at about 250°C because it does not have a melting point.

In order to make the mold 1 (or core 1') melt or soften more quickly, the mold 1 (or core 1') may be heated in a furnace 8 together with the cast product 4 to a temperature above about 250°C (see FIG. 3). The mold 1 (or core 1') is removed or separated from the cast metal product 4 by melting or softening the mold 1 (or core 1'). The removed synthetic resin may be recycled to, for example, manufacture another mold 1 (or core 1'). Synthetic resins which have the above-described thermal characteristics include thermoplastic resins such as polycarbonate, polypropylene, and copolymers of propylene and ethylene.

Next, structures or methods unique to each embodiment of the present invention will be explained.

With a first embodiment of the present invention, which is illustrated in FIG. 2, the apparatus for producing a cast metal product 4 includes a mold 1 made from a thermoplastic resin. The mold 1 can be melted or softened by heat from molten metal 3 within the mold 1 or by the furnace 8 after the molten metal 3 solidifies so that the resin of the mold 1 (or core 1') can be removed from the cast product 4. An interior surface of the mold 1 defines a molding cavity 2 and defines the cast product 4 with high dimensional accuracy when the molten metal 3 solidifies. The mold 1 includes an opening 5, through which molten metal 3 is poured into the molding cavity 2. The mold 1 itself can be manufactured using a metal mold (not shown) to cast the mold 1 and is manufactured per each cast product 4. One mold 1 casts only one cast metal product 4.

With a second embodiment of the present invention, which is illustrated in FIG. 3, a casting apparatus includes a mold 1 made from a suitable thermoplastic resin, a mold conveyor 6 for sequentially conveying a plurality of molds 1 in series, a molten metal (for example, molten aluminum alloy) supply device 7 for supplying metal to the molding cavity 2, and a furnace 8 for heating and melting or softening the mold 1. The furnace 8 is located downstream of the molten metal supply device 7 on the conveyor line.

The casting method according to the second embodiment of the present invention conducted using the apparatus described above includes the steps of conveying a mold 1 to the molten metal supply device 7, supplying molten metal 3 to a molding cavity 2 of the mold 1 to form a cast metal product 4, and thereafter heating and melting or softening the mold 1 in the furnace 8 so that the melted or softened resin is removed or separated from the cast metal product 4 after the molten metal 3 solidifies. The removed synthetic resin 3 may be retrieved and can be recycled as material to make another mold.

Though FIG. 3 shows that the molten metal supply device 7 is a pan or ladle 7A, the molten metal supply device 7 is not limited to a pan 7A. More particularly, the molten metal supply device 7 may be a cylinder 7B for injecting molten metal into a molding cavity 2, as shown in FIG. 4, or it may be a vacuum pump 7C for suctioning molten metal from a molten metal holding furnace 9 through a stalk 10 to a molding cavity 2, as shown in FIG. 5.

With a third embodiment of the present invention, which is illustrated in FIG. 6, a casting apparatus in accordance with the third embodiment includes a set of dies 11 and at least one core 1' (for example, one set of cores 1') which is detachably mounted relative to the dies 11. In order to easily detach the cores 1' from the metal dies 11, ejecting springs 12 are provided. A molding cavity 2 is not defined by the dies 11 but by the cores 1'. Due to this structure, when the type of cast products 4 to be made is changed, only cores 1' needs to be changed.

In casting, molten metal 3 is introduced into the molding cavity 2. After the molten metal 3 solidifies, the dies 11 are separated so that the core 1' with the cast product 4 is ejected from the dies 11 by the springs 12. Then, the core 1' with the cast metal product 4 is heated so that the core 1' is melted or softened. The melted or softened resin of the core 1' is thereby separated from the cast metal product 4. The melted synthetic resin may be retrieved to be recycled.

At the next casting cycle, a subsequent core 1' is disposed in the main dies 11, and a casting process is conducted in the same manner as described above. When the product 4 being cast is changed, only the core 1' is changed without needing to change the main dies 11.

In accordance with the method and apparatus according to the present invention, the following advantages are obtained:

With the casting apparatus having a resin mold, production costs are reduced compared to using a metal mold and casting quality is improved compared to using a sand mold.

With the casting method using a resin mold, production costs are reduced compared with using a metal mold, and casting quality is improved compared with using a sand mold.

With the casting apparatus having a resin core, the production costs are reduced compared with a metal core and casting quality is improved compared with a sand core. Further, since the resin core mold is detachable from the main dies, only the resin core needs to be changed when the kind of the cast product is changed, which facilitates casting.

A method is provided for producing a cast metal product (4) using a mold (1) or core (1') made from a thermoplastic resin. The resinous mold (1) or core (1') is heated after the molten metal for making the cast metal product (4) solidifies so that the resin of the mold (1) or core (1') is melted or softened and is separated from the cast metal product (4). The removed resin may be retrieved and recycled, for example, as material for another resinous mold or core.

Claims

1. An apparatus for producing a cast metal product comprising:
   a mold (1) made from a thermoplastic resin, said thermoplastic resin having a softening point lower than a melting point of the cast metal product (4).

2. An apparatus according to claim 1, wherein said thermoplastic resin is selected from the group consisting of polycarbonate, polypropylene, and copolymers of propylene and ethylene.

3. An apparatus according to claim 1, wherein a metal constituting the cast metal product (4) is an aluminum alloy.

4. An apparatus according to claim 1, further comprising:
   a furnace (8) for heating said mold (1) having a cast metal product (4) therein to thereby soften or melt said thermoplastic resin and separate said thermoplastic resin from the cast metal product (4).

5. A method for producing a cast metal product comprising the steps of:
   supplying molten metal to a molding cavity (2) located inside a mold (1) made from a thermoplastic resin; and
   melting or softening the thermoplastic resin after the molten metal solidifies and removing the thermoplastic resin of the mold (1) from the solidified metal.

6. A method according to claim 5, wherein the thermoplastic resin is selected from the group consisting of polycarbonate, polypropylene, and copolymers of propylene and ethylene.

7. A method according to claim 5, wherein said molten metal supplying step comprises supplying a molten aluminum alloy.

8. A method according to claim 5, wherein during said thermoplastic resin melting step, the thermoplastic resin is melted or softened by a residual heat from the molten metal.

9. A method according to claim 5, wherein during said thermoplastic resin melting or softening step, the thermoplastic resin is melted or softened by a residual heat from the molten metal and by applying heat to the thermoplastic resin from an external source.

10. A method according to claim 5, wherein said molten metal supply step comprises supplying the molten metal from a pan (7A).

11. A method according to claim 5, wherein said molten metal supply step comprises supplying the molten metal from an injection cylinder (7B).

12. A method according to claim 5, wherein said molten metal supply step comprises supplying the molten metal using a vacuum pump (7C).

13. An apparatus for producing a cast metal product comprising:
    a main die (11); and
    a mold core (1') disposed within said main die (11) and made from a thermoplastic resin, said thermoplastic resin having a softening point lower than that of the cast metal product (4).

14. An apparatus according to claim 13, wherein said thermoplastic resin is selected from the group consisting of polycarbonate, polypropylene, and copolymers of propylene and ethylene.

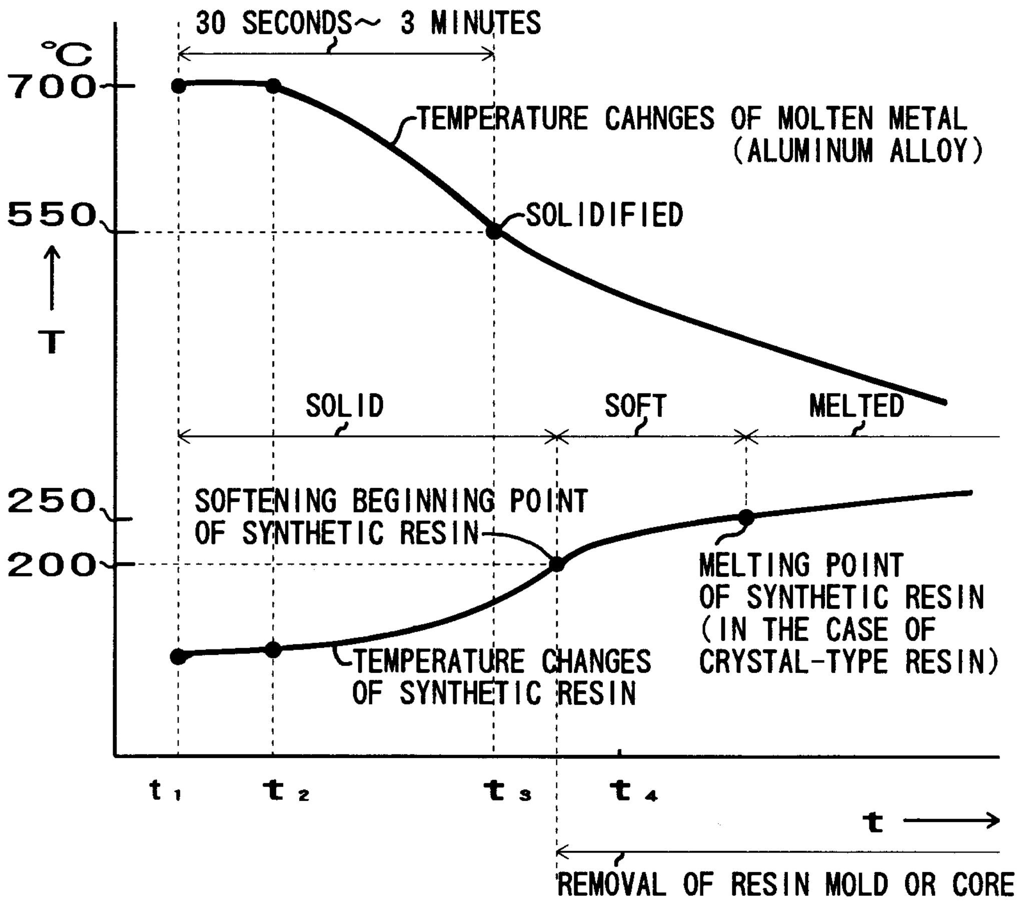
15. An apparatus according to claim 13, wherein a metal constituting the metal cast product (4) is an aluminum alloy.

16. An apparatus according to claim 13, further comprising:
    a furnace (8) for heating said core (1') having the cast metal product (4) therein so as to melt or soften said thermoplastic resin and separate said melted resin from the cast metal product (4).

17. An apparatus according to claim 13, wherein said core (1') is detachably mounted within said main die (11).

18. An apparatus according to claim 13 further comprising:
    at least one spring (12) provided between said main die (11) and said core (1').

F I G. 1



t_1 : START OF SUPPLY OF MOLTEN METAL

t_2 : FINISH OF SUPPLY OF MOLTEN METAL

t_3 : COMPLETION OF SOLIDIFICATION OF MOLTEN METAL

t_4 : OPENING OF DIES

FIG. 2

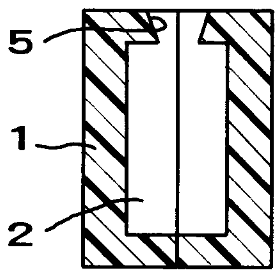


FIG. 3

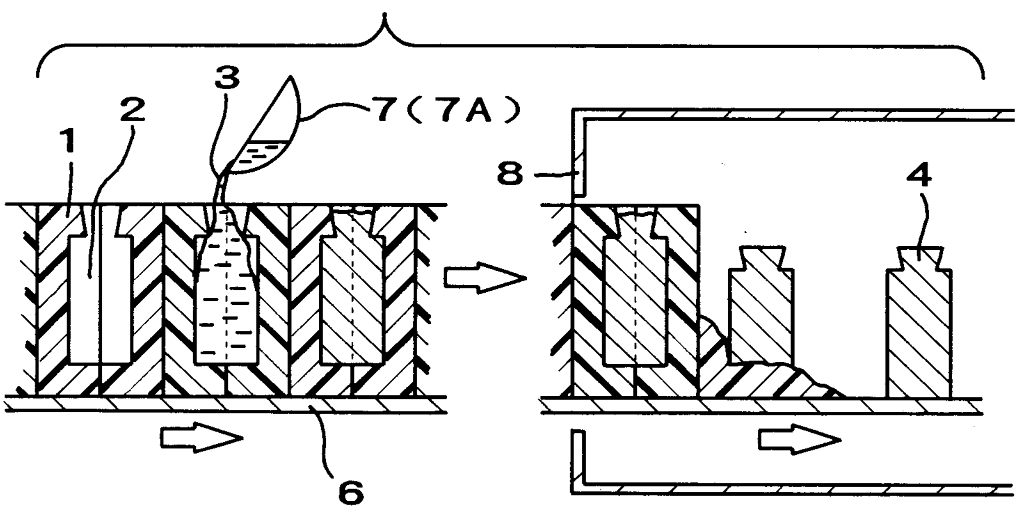


FIG. 4

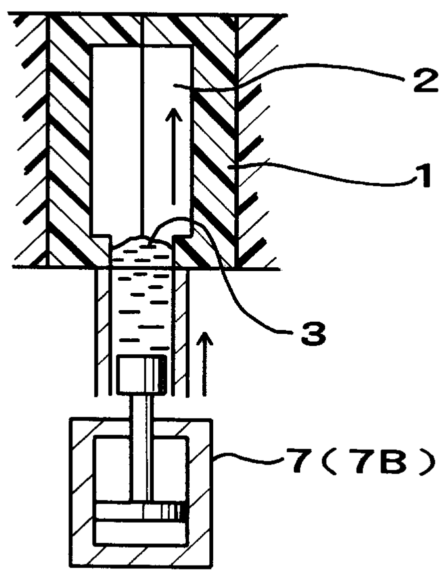
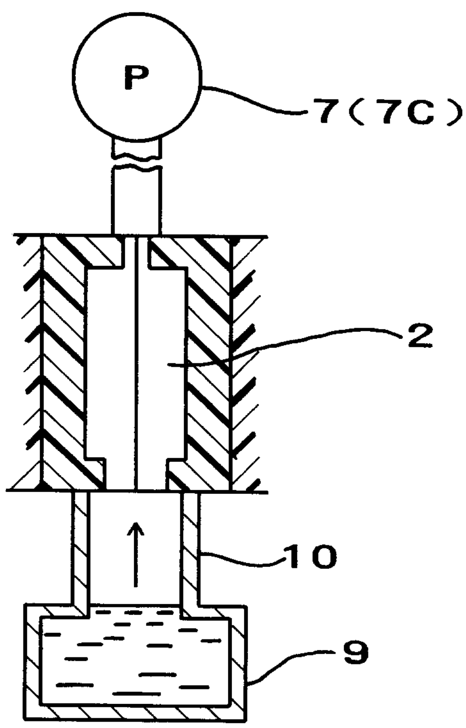


FIG. 5



F I G. 6