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

(11) Publication number: 0 099 470 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 83105779.9

(22) Date of filing: 13.06.83

(51) Int. Cl.³: B 22 D 21/00
B 22 C 5/08, B 22 C 1/00

(30) Priority: 18.06.82 GB 8217743

(43) Date of publication of application:
01.02.84 Bulletin 84/5

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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(54) Casting non-ferrous metals.

(57) A method of casting non-ferrous metals having a melting point below that of ferrous metals comprising the steps of making a mould predominantly of zircon sand and a chemically hardenable organic resin binder which can be hardened at a temperature not exceeding 50°C, casting molten non-ferrous metal into said mould to make a casting and separating the used sand from the casting. The mould and cores, if any, comprises, in addition to a catalyst or hardening agent for the resin binder;

50% to 100%	ziron sand;
0.4% to 1.0%	resin binder, by total weight of sand;
0% to 50%	sand or sands other than zircon sand, by total weight of sand.

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Title: "Casting non-ferrous metals"

This invention relates to casting non-ferrous metals having a melting point below that of ferrous metals such as aluminium, magnesium and copper and alloys based thereon.

The use of zircon sand as a foundry moulding material is well known in the production of iron and steel castings. US-A-3,212,144 and US-A-1,886,249 disclose the use of zircon sand for moulds for casting ferrous metals where clay is used as the binder. Both these specifications are concerned with mouldable mixtures and therefore incorporate "green sand" technology. As a result, large expensive capital plant is required involving a large sand re-cycling and re-conditioning plant and the formation of moulds by such processes as "jolt-squeeze" or "high pressure" or other variants.

US-A-2,535,662 discloses the use of zircon sand for moulds for casting ferrous metals where linseed oil is the binder. The hardening of the linseed oil bonded sand is carried out in an oven. This process is costly in energy and is accepted throughout the industry as being at a grave disadvantage because of distortion during baking.

BE-A-864,207 discloses that zircon sand is used mainly because of its high refractoryness, i.e. it has high thermal stability and it does not fracture nor melt under conditions of thermal shock and so provides improved casting surface finishes relative to silica sands when casting ferrous metals.

Usually such moulds are produced by the Croning (Shell) process, which uses phenolic based thermo-setting resins. Although the process has a reasonable reputation for the accuracy of the resulting castings, the accuracy is necessarily limited by the use of hot metal patterns, which are subject to thermal distortion and the distortion of the thin shell moulds.

In ferrous foundries using the Shell Process, the expensive zircon sand is re-claimed by a number of existing thermal reclamation systems, most of which heat the sand to a temperature in the range 800°C to 1,000°C to burn off the remaining resin prior to re-coating with fresh resin. The high cost of such reclamation is usually recoverable in the relatively high price of such ferrous shell-moulded castings.

All of the above specifications relate to a different field to that of Applicant's invention being concerned with the casting of ferrous metals.

Because aluminium, magnesium, copper and other metals having a melting point below that of ferrous metals and alloys based thereon do not require the refractoriness of zircon sand, moulds for these metals have traditionally been made only in silica or other cheaper sands.

According to the present invention, we provide a method of casting non-ferrous metals having a melting point below that of ferrous metals comprising the steps of making a mould predominantly of zircon sand and a chemically hardenable organic resin binder which can be hardened at a temperature not exceeding 50°C, casting molten non-ferrous metal into said mould to make a casting and separating the used sand from the casting.

The mould and cores, if any, may comprise, in addition to a catalyst or hardening agent for the resin binder;

50% to 100%	zircon sand;
0.4% to 1.0%	resin binder, by total weight of sand;
0% to 50%	sand or sands other than zircon sand, by total weight of sand.

The organic resin binder is preferably a resin which can be hardened at or substantially at room temperature.

The organic resin binder may comprise phenolic, furane, or isocyanate base resin which can be hardened by a solid or liquid catalyst but which is preferably gas hardened.

Zircon sand preferably comprises the whole of the sand of which the mould and cores, if any, are made.

The zircon sand may have a particle grain size lying in the range 50μm to 500μm. An average grain size of approximately 100μm is common but as low as 75μm is experienced.

The mould, and core if any, may be made by hand filling and ramming or by blowing on an automatic core or mould blowing machine. In the case of a mould, a moulding box or a boxless process may be used.

Preferably the method includes the steps of returning the sand to grain size and reclaiming the separated used sand such as by the method described hereinafter, which method and apparatus are the subject of our U.K. Application No. 8137797, and then using the thus reclaimed sand to make a mould in which molten non-ferrous metal is cast to make a casting followed by separating the used sand from the casting, again reclaiming the sand by the above described method and re-using the reclaimed sand to make a further mould.

The use of zircon sand for complete moulds and cores for non-ferrous metals is not an obvious choice, indeed the cost of zircon and the cost of reclaiming zircon blocked the concept of its use in this way until the present invention.

The present invention provides a number of extremely important and unlooked for benefits as follows.

The accuracy of cored holes and wall thicknesses defined by cores, are improved by a factor of up to twenty times. External features of castings are typically five times more accurate than their silica sand cast counterparts. This improvement in accuracy follows from the low expansion combined with the high thermal capacity of zircon sand compared to silica. It enables the accuracy to exceed the accuracy of all other casting methods known to date including investment and pressure die casting. The high thermal capacity increases freezing rate and also improves mechanical properties.

Sand expansion defects, such as scabs, rat-tails, finning, flash and the like are eliminated.

The levels of addition of the resin binder are significantly lower than those used for the Croning Shell Process. Because the patterns are used at or near to room temperature, they retain their accuracy and so produce accurate moulds and cores. Also, the moulds can be made of any convenient thickness as a thick shell, or in the form of block moulds, or can be made in steel boxes or frames. In this way, also, accuracy can be conserved compared and contrasted for example with a thin Croning Shell mould which is easily distorted.

In the present invention, the zircon sand is reclaimed by maintaining a mass of the sand without agitation of sand in the container whilst permitting the gas to percolate through the sand and whilst the sand is held in a treatment teperature range of 250°C to below 600°C for a time to achieve good reclamation.

The treatment temperature may lie in the range 250°C to 400°C, preferably in the range 250°C to 350°C.

The treatment temperature may lie in the range 300°C to below 400°C.

More preferably, the treatment temperature lies in the range 300°C to 350°C.

The treatment time may lie in the range 4-30 hours and may lie in the range 4-24 hours.

It has been found that no mixing or agitation of the sand is required, the desired reclamation occurring solely due to residence of the sand at the above mentioned temperature and for the above mentioned time. There is therefore no need to provide any mechanical mixing or agitating device in apparatus for performing the method.

The mass of sand being treated may lie in the range 20 to 100 tons.

The invention will now be described in more detail by way of example, with reference to the accompanying drawings, wherein:-

FIGURE 1 is a diagrammatic plan view of an apparatus for performing a method embodying the invention; and

FIGURE 2 is a diagrammatic cross-sectional view of an apparatus for reclaiming used zircon sand.

Referring to Figure 1, a foundry includes a moulding station 1 where moulds are made of zircon sand bonded with a furane resin. The moulds may be made by hand filling or ramming but, in the present example, are blown using an automatic mould blowing machine. The mould may be used in conventional mould boxes or a boxless process, as in the present example, may be used. If desired a phenolic resin, isocyanate or similar resin which can be hardened by solid or liquid catalyst but which is preferably gas hardened at room temperature or up to 50°C may be used. A core or cores are similarly made of such resin bonded zircon sand, although if desired a different binder system may be used compared with that of the remainder of the mould. The core or cores is/are positioned, as necessary, within the mould cavity at a mould assembly station 2 where the cope and drag halves of the mould are closed. In the present example, the mould comprises:

98% zirconium silicate sand;

0.55% furane resin, by weight of sand;

0.20% MEKP (methyl ethyl ketone peroxide) by weight of sand;

2.0% usual impurities such as oxides of transition elements.

The resin was hardened using SO_2 gas amounting to about 0.25% SO_2 equivalent by weight of sand.

The sand has average grain size of 145μm.

These moulds are transferred by a conveyer 3 to a casting station 4 where molten metal, in the present example magnesium alloy, is cast through ingates in the mould into the mould cavity and around the core or cores when present.

After casting, the full mould is transferred by the conveyor 3 to a shakeout station 5 where the sand of the mould and core or cores, when present, are shaken out of the casting by a shakeout machine. The used lumps of zircon sand initially shaken out of the casting are returned to grain size by the vibratory action of the shakeout machine at the shakeout station 5. Alternatively, the sand lumps can be returned to grain size by a separate attrition or crushing unit, not shown. The sand, returned to grain size, is fed by a conveyor 6 to a sand reclaiming plant 7 where the sand is reclaimed and then supplied by a conveyor 8 to the moulding station 1 where binder is mixed with the reclaimed sand and new cope and drag parts of a mould made and transferred to the mould assembly station 2.

The reclaiming plant 7 comprises, referring to Figure 2, a closed hopper 10 to which sand is supplied by the conveyor 6. Sand is fed from the bottom of the hopper 10 by a screw conveyor 11 into a container 12 containing electrical heating element 13 and sparge tubes 14. Fluidising air is fed to the sparge tubes 14 via a duct 15 by a fan 16.

Sand is heated to a temperature lying in the range 250-400^{o}C to the fluidised bed. As a result, little or no reclamation occurs in the fluidised bed. However, if desired the sand may be heated to a higher temperature, for example up to 600^{o}C in which case some reclamation of the sand occurs in the fluidised bed, the extent of reclamation depending upon the dwell time of the sand in the bed.

Sand flows from the container 12 through a duct 16 into a relatively large container 17 where the sand dwells, unagitated, as indicated at 29. In the example illustrated, the temperature of the sand entering the container 17 is only slightly below the temperature in the fluid bed. If it is necessary to feed the sand over a greater distance, for example as a result of location of the container 12 remote from the container 17, suitable thermal insulation and/or auxiliary heating means may be necessary to prevent excessive cooling of the sand.

The sand is allowed to dwell unagitated in the container 17 at a temperature lying in the range 250-400^{o}C, although the maximum temperature may be 600^{o}C, for a time sufficient to achieve reclamation. Where oxygen for the slow combustion process occurring within the container 17 is obtained from air rising from the exit 19 and percolating through the mass of sand 18 in the container 17, the dwell time typically lies in the period four to twenty four hours.

However, if desired air may be caused to pass through the sand at a flow rate of at least 400/L/min m^2 in which case the dwell time is measured in minutes.

In each case the used air is removed from the container 17 by an updraught through a conduit 20, extending to a cyclone 21 where the extracted dust fines and the like are withdrawn as indicated at 22 whilst invisible fumes are discharged to atmosphere as indicated at 23.

The table below sets out the operating conditions in respect of two reclaiming operations carried out on zircon sand which has been used to manufacture non-ferrous metal castings. After treatment under conditions set out in the table, the sand was re-used and found to produce high quality moulds in which non-ferrous metals again cast.

Table I

Temp.in Fluid Bed ^oC	Av.Temp.in Container ^oC	Dwell Time in Container Hrs.
334	327	19
305	299	25

CLAIMS:

1. A method of casting non-ferrous metals having a melting point below that of ferrous metals comprising the steps of making a mould predominantly of zircon sand and a chemically hardenable organic resin binder which can be hardened at a temperature not exceeding 50^{o}C, casting molten non-ferrous metal into said mould to make a casting and separating the used sand from the casting.

2. A method according to Claim 1 wherein the mould and cores, if any, comprises, in addition to a catalyst or hardening agent for the resin binder;

50% to 100%	zircon sand;
0.4% to 1.0%	resin binder, by total weight of sand;
0% to 50%	sand or sands other than zircon sand, by total weight of sand.

3. A method according to Claim 1 or Claim 2 wherein the organic resin binder is a resin which can be hardened at or substantially at room temperature.

4. A method according to any one of the preceding claims wherein the organic resin binder comprises phenolic, furane, or isocyanate base resin.

5. A method according to Claim 4 wherein the resin is hardenable by a solid or liquid catalyst.

6. A method according to Claim 4 wherein the resin is hardenable by means of a gas hardener.

7. A method according to any one of the preceding claims wherein the zircon sand comprises the whole of the sand of which the mould and cores, if any, are made.

8. A method according to any one of the preceding claims wherein the zircon sand has a particle grain size lying in the range 50 to 500μm

9. A method according to any one of the preceding claims wherein the mould is made by hand filling and ramming or by blowing on an automatic core or mould blowing machine using a moulding box or a boxless process.

10. A method according to any one of the preceding claims wherein the non-ferrous metal comprises aluminium, magnesium, copper or alloys based thereon.

11. A method according to any one of the preceding claims wherein the method includes the steps of returning the sand to grain size and reclaiming the separated sand and then using the thus reclaimed sand to make a mould in which molten non-ferrous metal is cast to make a casting followed by separating the used sand from the casting, again reclaiming the sand and re-using the reclaimed sand to make a further mould.

12. A method according to Claim 11 wherein the sand is reclaimed by placing a mass of the sand in a stationary container and providing a supply of combustion supporting gas to the container and maintaining the mass of sand in a treatment temperature range for a time sufficient to reclaim the sand, wherein the mass is maintained without agitation in the container whilst permitting the gas to percolate through the sand and whilst the sand is held in a treatment temperature range of 250°C to below 600°C for a time to achieve good reclamation.

13. A method according to Claim 12 wherein the treatment temperature lies in the range 250°C to 400°C.

14. A non-ferrous casting when made by a method according to any one of the preceding claims.

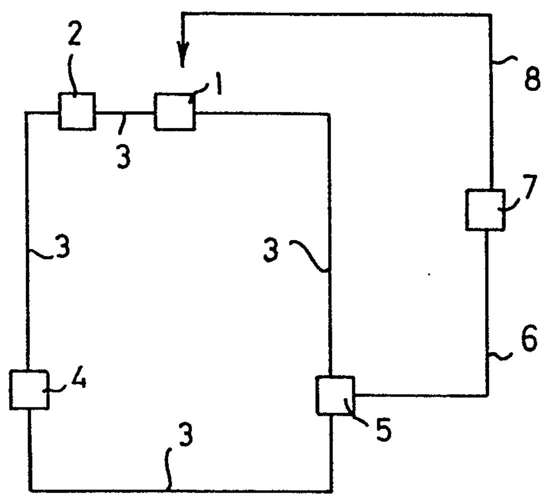

FIG 1

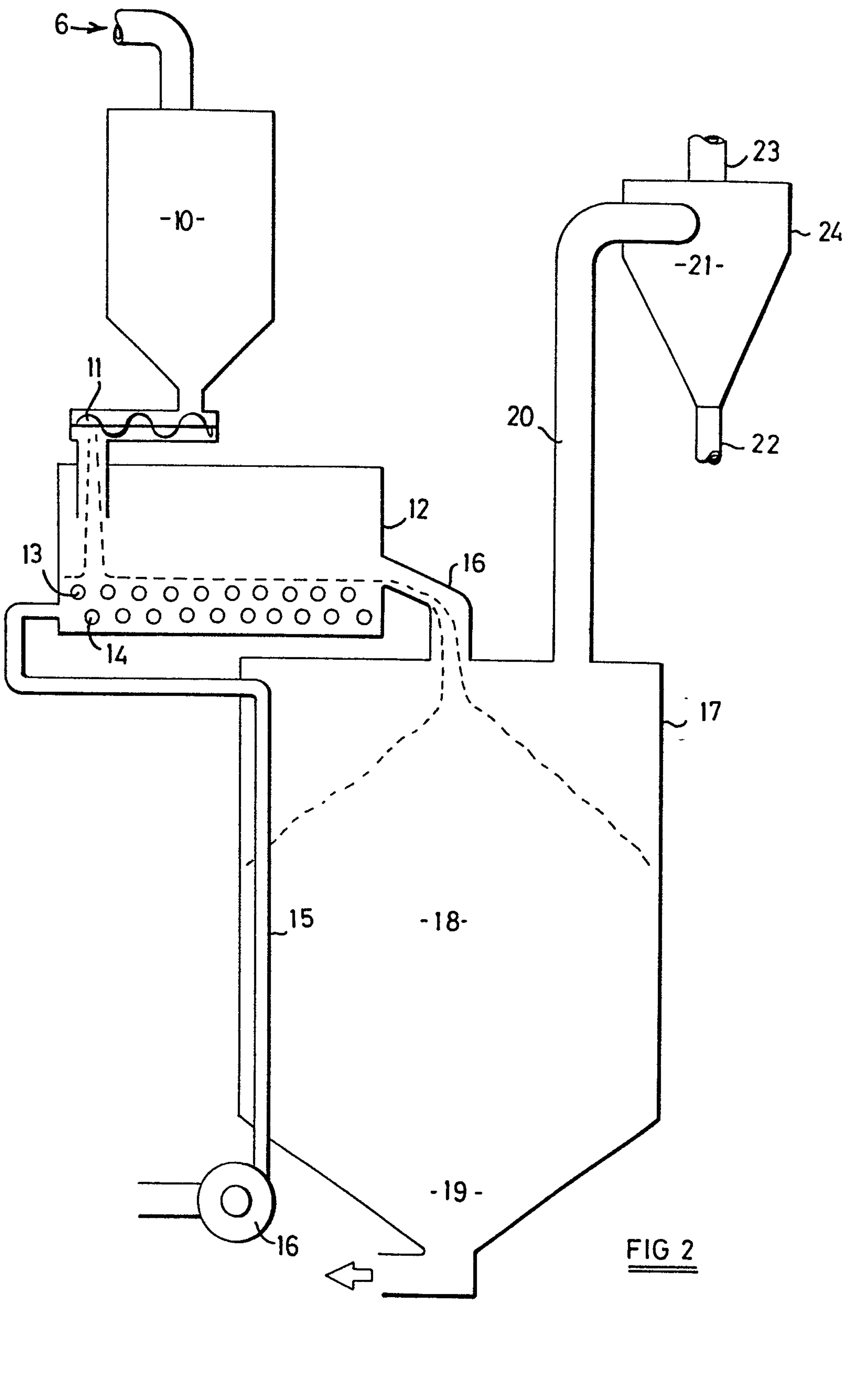

FIG 2

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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 83 10 5779

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
D,Y	US-A-3 212 144 (F.R. CAPPS) * Column 3, lines 24-26; column 5, lines 25-30, 39-42; column 7, lines 41-44, 65-67 *	1,10, 11	B 22 D 21/00 B 22 C 5/08 B 22 C 1/00
D,Y	BE-A- 864 207 (E.I. DU PONT DE NEMOURS) * Page 8, lines 18-26; page 9, lines 1-26; page 10, lines 7-18; claim 4 *	1-4,7	
D,Y	US-A-2 535 662 (R.D. AHLES) * Whole document *	1,8	
P,Y	EP-A-0 054 288 (COSWORTH) * Abstract *	12,13	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
D,A	US-A-1 886 249 (LE RUE P. BENSING)		B 22 C B 22 D
X	US-A-3 179 990 (S.E. FREEMAN) * Column 1, lines 13-14, 60-71; column 2, lines 1-28; column 3, lines 26-54 *	1-3,6	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-09-1983	MAILLIARD A.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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