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(71) Applicant: **Sintokogio, Ltd.**
Aichi 450-6424 (JP)

(72) Inventor: **OBA Takahumi**
Toyokawa-shi
Aichi 442-8505 (JP)

(74) Representative: **Potter Clarkson LLP**
The Belgrave Centre
Talbot Street
Nottingham NG1 5GG (GB)

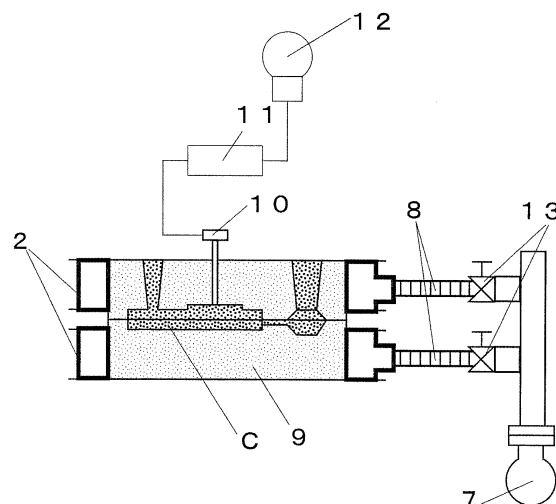
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(54) **CAST-IRON CASTING, METHOD FOR MANUFACTURING CAST-IRON CASTING, AND EQUIPMENT FOR MANUFACTURING CAST-IRON CASTING**

(57) [Problem] The purpose of the present invention is to provide a cast-iron casting, a method for manufacturing a cast-iron casting, and equipment for manufacturing a cast-iron casting, which are capable of performing a plating treatment or an enameling treatment without defects on a surface of the cast-iron casting, regardless of the specifications of the cast-iron casting, without decreasing productivity or increasing manufacturing costs.
[Elected Drawing] Fig. 4

[Solution] In the method for manufacturing a cast-iron casting, a mold is molded by decompressing molding sand, and a melt is poured into the mold. The inside of the mold is decompressed until the temperature of a casting formed by the melt falls to or below an A1 transformation point. The equipment for manufacturing a cast-iron casting comprises: at least one mold; a frame feed device that moves the mold; at least one fixed suction device that decompresses the inside of the mold when the mold is stopped; at least one movable suction device that moves while decompressing the inside of the mold instead of the fixed suction device when the mold is moving; and a temperature sensor that measures the product surface temperature of the casting.

[FIG. 5]



Description

[Technical Field]

5 **[0001]** The present invention relates to a cast-iron casting, a method for manufacturing a cast-iron casting, and equipment for manufacturing a cast-iron casting.

[Background Art]

10 **[0002]** Plating treatments and enameling treatments have existed as techniques for imparting corrosion resistance, wear resistance, heat resistance or the like on surfaces of metal products. Moreover, when performing plating treatments and enameling treatments on a surface of a cast-iron casting, a problem in which the presence of graphite and free cementite on the casting surface have adverse effects on these treatments is known, and techniques or research have been performed in the past in order to overcome this problem.

15 **[0003]** Patent Document 1 discloses cleaning and activating the surface of a steel product and then adding a catalyst that promotes a redox reaction to perform plating.

[0004] Patent Document 2 discloses adhering a pure Fe thin plate to a surface part of a mold that is in contact with a casting, casting molten spheroidal graphite cast iron into a mold, dissolving the pure Fe thin plate on the casting surface, forming a surface layer that inhibits the formation of graphite on the surface of the casting, and then performing zinc plating.

20 **[0005]** Patent Document 3 discloses applying ultra-sonic vibration in a state in which a cast-iron material is immersed in a plating solution, cleaning the surface of the cast-iron material, crushing and dissolving in a plating solution graphite present on this surface, and then forming a plating film that includes graphite in a state in which it has been dispersed on this surface.

25 **[0006]** Non-Patent Document 1 suggests that carbon monoxide and carbon dioxide generated by the oxidation of graphite in the vicinity of casting surfaces in an enameling treatment for cast iron cause bubble-shaped defects.

[0007] Non-Patent Document 2 discloses that metal structures in which defects occur are gradually cooled and enlarged graphite, and those that were conversely quenched to prevent the growth of graphite. This document discloses that it is effective to perform a degassing heat treatment before an enameling treatment in order to improve these structures.

30 **[0008]** Non-Patent Document 3 discloses that many defects occur in areas of coarse graphite structures, areas where ledeburite has crystallized, and areas where tempered carbon has crystallized after cementite has decomposed due to rising temperatures during an enameling treatment. To improve this, the document describes that bubble-shaped defects can be significantly suppressed by preventing the coarsening of graphite as a low carbon saturation, increasing phosphorous content to prevent the crystallization of ledeburite, suppressing the decomposition of cementite during the enameling treatment, and further performing a degassing heat treatment before the enameling treatment for a casting for which these measures have been performed.

35 **[0009]** Patent Documents 4 and 5 disclose, in manufacturing an enameled cast iron, that there are fewer bubble defects for those with a non-graphite layer generated on a cast-iron surface structure, there are fewer bubble defects for cast iron of flake graphite cast iron with a low-carbon and high-silicon composition, and that the occurrence of bubble defects can be reduced by adding titanium, even with a high-carbon and low-silicon composition.

40 **[0010]** From the descriptions above as well, it is clear that graphite and free cementite near the casting surface have adverse effects on plating treatments or enameling treatments on the surface of the cast-iron casting. In addition, methods to suppress adverse effects from graphite and free cementite include the likes of: chemically, physically or thermally treating the casting to remove graphite and the like; forming a film that does not include graphite near the casting surface after founding; pouring a melt in a state in which a pure Fe thin plate is attached to the surface of a mold in contact with the melt and forming a non-graphite layer near the casting surface; or controlling the chemical composition of the casting surface and adding an alloy to form a non-graphite layer near the casting surface.

45 **[0011]** Methods of chemically, physically, and thermally treating a casting to remove graphite and the like each require steps of removing graphite and the like near the casting surface after founding. Additionally, treatment conditions must meticulously be set in accordance with each casting product. For this reason, productivity is decreased and manufacturing costs are increased. Regarding the method of forming a film that does not include graphite near the casting surface after founding, graphite that is present on the surface of the cast-iron material directly under the film has not been removed and is still present. For this reason, the adhesion between the graphite and the plating film is impaired, corrosion occurs from this portion, and there is a risk that the plating film in the vicinity thereof will swell or peel off.

50 **[0012]** Regarding the method of pouring a melt in a state in which a pure Fe thin plate has been attached to the surface of a mold in contact with the melt and forming a non-graphite layer near the casting surface, an operation of molding the thin plate in advance in accordance with the shape of the casting and then attaching the plate to the surface of the mold becomes necessary. For this reason, the applicable shapes are limited to very simple ones. Furthermore, there is the problem wherein productivity falls due to such work as further attaching thin plates. The method of controlling the

chemical composition of the casting surface and adding an alloy to form a non-graphite layer near the casting surface would limit the applicability of the product, so depending on the required specifications, it would not be possible to apply this method.

[0013] Meanwhile, in a mold-molding method wherein a melt is poured into a mold using a molding sand that does not contain a binding agent, and the inside of the mold is in a decompressed state, the technique of improving the metal structure and the mechanical properties of a casting to be manufactured by creating air flow near the casting is known. For example, Patent Document 6 discloses a founding method directed to adhering a shielding member to a shielding surface of an original shape member, filling the inside or outside of this shielding member with a heat-resistant granular material, making the heat-resistant granular material have a negative pressure, adsorbing the shielding member on the side of the heat-resistant granular material while releasing the original shape member to form a cavity, and pouring a melt into the cavity, wherein air is introduced into the side of the heat-resistant granular material when the surface layer of the molten metal begins to solidify after the pouring of the melt has been completed.

[0014] Additionally, Patent Document 7 discloses a founding method wherein a melt is injected into a mold molded using silica sand in a dry state, and after the injected melt has solidified, air is flown through the silica sand in a dry state surrounding the casting material, which is formed by the solidification of the melt, to cool the casting material.

[0015] Regarding these techniques, heat transfer through air is not suitably performed for a mold kept in a decompressed state after a melt has been poured, and they pertain to solving the problem wherein the cooling rate of the mold becomes substantially slower compared with other molding methods. These techniques obtained the effect of accelerating the cooling rate by releasing the decompressed state in the vicinity of 1200°C, which is the solidification temperature of the cast iron, and instead introducing atmospheric or compressed air. However, the purpose of these methods is to prevent the crystallization of graphite and instead crystallize cementite. The methods do not have the purpose of decarburization near the casting surface. Thus, free cementite, which has adverse effects on plating treatments or enameling treatments, is present near the casting surface that has been manufactured through such methods, so it is clear from the descriptions of Patent Documents 1 to 5 and Non-Patent Documents 1 to 3 described above that good films cannot be obtained, even if a plating treatment or an enameling treatment is carried out on the surface of such castings.

[0016]

[Patent Document 1]	JP H8-170178 A
[Patent Document 2]	JP 2001-200350 A
[Patent Document 3]	JP 2004-143552 A
[Patent Document 4]	JP 2015-42774 A
[Patent Document 5]	JP 2015-42775 A
[Patent Document 6]	JP S58-224066 A
[Patent Document 7]	JP S63-10062 A

[Non-Patent Document 1] Sakurai, Yasushi, Casting enamel, Journal of the Ceramic Association, Vol. 67, No. 759, 1959

[Non-Patent Document 2] Yonekura, Isao, Color enameling techniques for cast-iron kitchenware, Iwate Industrial Research Institute: Research Report No. 10, 2003

[Non-Patent Document 3] Yonekura, Isao & Saitoh, Hiroyuki, Influence of the properties of base castings and surface treatment on the quality of colored enamel film, Iwate Industrial Research Institute: Research Report No. 11, 2004

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0017] For the reasons described above, conventional art techniques all have various issues. Accordingly, the present invention was made in view of the problems described above. The purpose of the present invention is to provide a cast-iron casting, a method for manufacturing a cast-iron casting, and equipment for manufacturing a cast-iron casting, which are capable of performing a plating treatment or an enameling treatment without defects on the surface of the cast-iron casting, regardless of the specifications of the cast-iron casting, without decreasing productivity or increasing manufacturing costs.

[Means for Solving the Problem]

[0018] To overcome the problem described above and achieve the purpose, the present invention comprises: a step for molding a mold by decompressing molding sand; a step for pouring a melt into the mold; and a step for decompressing the inside of the mold until the temperature of the casting formed by the melt falls to or below an A1 transformation point.

[0019] Additionally, the present invention, in the equipment for manufacturing a cast-iron casting that decompresses molding sand and pours a melt into a mold that has been molded to manufacture a cast-iron casting, comprises: at least one mold; a frame feed device that moves the mold; at least one fixed suction device that decompresses the inside of the mold when the mold is stopped; and at least one movable suction device that moves while decompressing the inside of the mold instead of the fixed suction device when the mold is moving, and the mold is repeatedly moved and stopped by the frame feed device until the casting temperature inside of the mold after the melt has been poured falls to or below the A1 transformation point.

[0020] Additionally, the present invention, in the mold-molding method wherein a melt is poured into a mold molded by decompressing molding sand, is manufactured by maintaining decompression inside of the mold until the casting temperature inside of the casting after a melt has been poured falls to or below the A1 transformation point.

[Effects of the Invention]

[0021] According to the present invention, it is possible to oxidize graphite near the casting surface that has adverse effects on the plating treatment or the enameling treatment, and to prevent the occurrence of free cementite, thereby making it possible to easily and inexpensively suppress defects during the plating treatment or the enameling treatment.

[0022] Additionally, according to the present invention, there is no need to control the chemical composition of the casting or add an alloy, making application possible regardless of the thickness of the casting, required quality and the like.

[Brief Description of the Drawings]

[0023]

[Fig. 1] A schematic diagram showing the configuration of equipment for manufacturing a cast-iron casting according to a first embodiment.

[Fig. 2] A schematic diagram showing the state after the movable suction device has moved following a mold sent by the frame feed device.

[Fig. 3] A schematic diagram showing the state of the fixed suction device and the movable suction device immediately after the devices returned to their original positions.

[Fig. 4] A schematic cross-sectional representation of the surroundings of the mold according to a second embodiment.

[Fig. 5] A schematic cross-sectional representation of the surroundings of the mold according to a third embodiment.

[Modes for Carrying Out the Invention]

[0024] The best embodiment of the cast-iron casting, the method for manufacturing a cast-iron casting, and the equipment for manufacturing a cast-iron casting according to the present invention will be explained below, with reference to the attached drawings. The method for manufacturing a cast-iron casting in the present invention pertains to decompressing and molding a mold using molding sand that does not contain a binding agent, and after a melt is poured, maintaining decompression inside of the mold until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point.

[0025] The purpose of the present invention is to create a non-graphite layer near the casting surface by maintaining decompression inside of the mold to create a state in which air continuously flows to the casting surface, and oxidizing graphite and free cementite, which have adverse effects on the plating treatment or the enameling treatment. To do so, this state must be maintained until the temperature at which a eutectoid reaction finishes completely, that is, an Acm transformation point in a metastable system, or the temperature at or below the A1 transformation point in a stable system, is reached. In the present invention, the target material is cast iron, and operations that result in metastable coagulation reactions in Fe-C-based binary alloy phase diagrams such as forced quenching are not performed, so decompression is maintained inside of the mold until the temperature falls to or below the A1 transformation point, which is the coagulation reaction completion temperature of the stable system.

[0026] Moreover, eutectic or eutectoid reactions of graphite or cementite occur at temperatures lower than: an A2 transformation point, which is the magnetic transformation temperature of Fe; an A3 transformation point, which is when a crystal structure changes from a body-centered cubic lattice to a face-centered cubic lattice; and an A₄ transformation point, which is when a crystal structure changes again from a face-centered cubic lattice to a body-centered cubic lattice. As such, it is insufficient to release the decompressed state after maintaining decompression inside of the mold until the temperature falls to or below the respective transformation points.

[0027] In the mold-molding method in which a melt is poured in a state in which the inside of the mold using molding sand that does not contain a binding agent is decompressed in the present invention, there is a decompression mold-

molding method (hereinafter referred to as "V-process"), which is a mold-molding/melt-pouring process having: a shielding member adhering step for adhering the shielding member to the surface of an original pattern plate; a step for placing a mold frame body on the adhered shielding member and filling the mold frame body with the molding sand that does not contain a binding agent; a step for sealing the upper surface of the molding sand so there is negative pressure inside of the mold frame body, thereby adsorbing the shielding member to the molding sand side and molding the shielding member; a step for releasing the original pattern plate from the shielding member and molding a half mold having a mold surface; a step for matching the half mold with another half mold that has been similarly molded to form a founding cavity; a step (melt pouring step) for injecting molten metal (a melt) into the founding cavity; and thereafter, a step for releasing the negative pressure state inside of the mold frame body and taking out the casting. Additionally, an evaporative pattern founding method is included, wherein: a pattern comprising a foam body made of a resin is embedded in molding sand that does not include a binding agent; and the inside is decompressed to form a mold, and while still in a decompressed state, the foam body made of a resin is melted as a melt is poured.

[0028] In the present invention, a state must be created in which air is always flowing over the casting surface to form a decarburization layer. However, if the decompression pressure of the mold is made to be in a state extremely close to the atmospheric pressure, molding sand drops onto the casting surface, so the state in which air is always flowing over the casting surface cannot be created. Conversely, if the decompression pressure is made to be in a state close to a vacuum, the state in which air is always flowing over the casting surface can be created, but the melt will seep into the gaps between the molding sand grains and cause substantial insertion defects. As such, the decompression pressure should preferably be between -10 kPa to -70 kPa.

[0029] Additionally, the molding sand in the present invention may be of any type, such as silica sand, olivine sand, chromite sand, zircon sand, and ceramic artificial sand. However, to decarburize near the casting surface in a decompressed state, molding sand with high air permeability when filled as a mold is suitable, so molding sand with a low proportion of grains having a diameter of less than 53 μm is suitable. With molding sand having an excessive proportion of grains having a diameter of less than 53 μm , the air permeability of the mold is insufficient, there will not be sufficient air flow near the casting surface, and it will not be possible to form the decarburization layer. As such, the proportion of grains having a diameter of less than 53 μm should preferably be 10% or less.

[0030] After a melt is poured, the time needed until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point differs depending on the mass and thickness of the product. After a melt is poured, in the equipment for manufacturing a cast-iron casting that has as many fixed suction devices and movable suction devices as the number of frames needed to perform processes until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point, the surface temperature of a casting C inside of the mold cannot be directly measured, so the time needed until the temperature of the casting falls to or below the A1 transformation point must be confirmed through a founding simulation after setting founding conditions beforehand, or by experimentally performing founding and actually measuring the time needed until the temperature falls to or below the A1 transformation point.

(First embodiment)

[0031] Fig. 1 is a schematic diagram showing the configuration of equipment for manufacturing a cast-iron casting according to the first embodiment.

The equipment for manufacturing a cast-iron casting 1 is equipment that uses the V-process to manufacture a cast-iron casting, constituted by comprising: a mold 2 using molding sand that does not contain a binding agent; a molding board 3; a frame feed device 4; a fixed suction device 5; and a movable suction device 6. The mold 2 is a mold that has been formed by molding sand inside of a mold frame body. Here, Fig. 1 shows the state of the fixed suction device 5 and the movable suction device 6 at the time just before the mold 2 moves. While the mold 2 is stopped, the fixed suction device 5 sucks each mold 2 and decompresses the inside of the mold 2. When the mold 2 moves, the fixed suction device 5 separates, and instead, the movable suction device 6 adheres to and sucks the mold 2, decompressing the inside of the mold 2. Thereafter, the movable suction device 6 follows the mold 2 and moves. After the movement is completed, the movable suction device 6 separates, and instead, the fixed suction device 5 adheres to and sucks the mold 2, decompressing the inside of the mold 2. To perform these actions after a melt is poured, the equipment has at least as many fixed suction devices 5 and movable suction devices 6 as the number of frames needed to perform the processes until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point.

[0032] In Fig. 1, the mold 2 moves from the right side of the figure to the left side, and the mold 2 on the right end is in a state just after a melt has been poured, while the mold 2 on the left end, after a melt has been poured, is in a decompressed state until the temperature of the mold incorporated in the mold falls to or below the A1 transformation point. To move a mold 2 after a melt has been poured to the mold 2 on the right end, first, the frame feed device 4 adheres to each molding board 3 on which the molds 2 at both ends have each been placed, and the molding board 3 is fixed from both sides. Additionally, the mold 2 is kept in a decompressed state by the fixed suction device 5 being in

communication with a piping 7 to a suction source (not shown). Furthermore, the movable suction device 6 in communication with a hose 8 that freely moves to the suction source (not shown) adheres to the mold 2, and the mold 2 is decompressed while the fixed suction device 5 simultaneously separates.

[0033] Next, the frame feed device 4 operates and moves the mold 2 (mold frame) placed on the molding board 3. Fig. 2 is a schematic diagram showing the state after the movable suction device 6 has moved following the mold 2 sent by the frame feed device 4. The movable suction device 6 is coupled to the frame feed device 4 by a coupling mechanism (not shown), so the movable suction device 6 follows the actions of the frame feed device 4 and moves. In this manner, the mold 2 is kept in a decompressed state by the movable suction device 6 even during movement.

[0034] Next, when the movement of one frame has completed, the mold 2 on the left end is transported by a transport device (not shown) to the next step, which is a secondary cooling step or a removal step. Additionally, a new frame in which a melt has not been poured is transported to the right side by the transport device (not shown), which is provided with a suction device, from a molding step, which is the previous step. Furthermore, the fixed suction device 5 adheres to the mold 2, and the mold 2 is decompressed while the fixed suction device 6 simultaneously separates. In this manner, the decompressed state of the mold 2 is maintained by the fixed suction device 5. Thereafter, the adhesion of the molding board 3 by the frame feed device 4 is released, and following the return of the frame feed device 4 to its original position, the movable suction device 6 also moves and returns to its original position. Fig. 3 is a schematic diagram showing the state of the fixed suction device 5 and the movable suction device 6 immediately after the devices have returned to their original positions.

[0035] When returning to the original positions, the number of molds 2 placed on the series of molding boards 3 that are adhered and fixed with the frame feed device 4 is determined by a cycle time, which is the time needed to mold a mold, as well as the time taken until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point. For example, with a cycle time of three minutes/frame, if the time until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point after a melt has been poured is to be 15 minutes after confirming with the founding simulation or by experimentally performing founding, then the number of molds 2 that must be kept in a decompressed state until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point after pouring would be $15 \div 3 = \text{five frames}$.

[0036] In addition, in Fig. 3, the molds 2, which are placed on the series of molding boards 3 and which are adhered and fixed by the frame feed device 4, are all cooled while kept in a decompressed state by the fixed suction device 5 and the movable suction device 6, but are not limited to such. For example, if the number of molds 2 that need to be kept in a decompressed state until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point after a melt has been poured were to be five frames, then the sixth and subsequent frames may be moved by the frame feed device 5 without sucking the mold as the secondary cooling process.

(Second embodiment)

[0037] The second embodiment relates to the configuration of the surroundings of the mold 2 in the equipment for manufacturing a cast-iron casting 1 of the first embodiment. The second embodiment will be explained with reference to the attached drawings. Regarding the configuration of the equipment for manufacturing a cast-iron casting according to the present embodiment, the portions that differ from the first embodiment will be explained. The other portions are the same as in the first embodiment, so reference will be made to the above-given descriptions, and the descriptions will here be omitted.

[0038] The equipment for manufacturing a cast-iron casting 1 is constituted by comprising: a mold 2; a molding board 3; a frame feed device 4; a fixed suction device 5; and a movable suction device 6. Fig. 4 is a schematic cross-sectional representation of the surroundings of the mold 2 according to the second embodiment. Fig. 4 shows a V-process mold, constituted by: the mold 2 using molding sand 9 that does not contain a binding agent; the fixed suction device 5; a temperature sensor 10; and a control device 11, the temperature sensor 10 being in a state in which it has been inserted and contacted with the thickest area of the casting C inside of the mold 2. The temperature sensor 10 stands by beforehand directly above the thickest area of the casting C outside the mold 2. The standby position of the temperature sensor 10 changes depending on the product, so the position in the horizontal direction of each of the thickest areas and the height from a reference surface are stored beforehand in a storage device (not shown), and the control device 11 moves the temperature sensor 10 on the basis of this information. Additionally, the mold 2 is in communication with a suction source (not shown) through the fixed suction device 5 and the piping 7.

[0039] After information indicating that the pouring of a melt has completed is inputted into the control device 11, the temperature sensor 10 is inserted and contacted with the thickest area of the casting C inside the mold 2 by an inserting/removing device (not shown). This allows the temperature information of the surface of the casting C to be inputted into the control device 11.

[0040] When the control device 11 senses that the product surface temperature of the casting C has reached or fallen below the A1 transformation point with the information from the temperature sensor 10, the control device 11 separates

the fixed suction device 5 from the mold 2 and releases the decompressed state. Next, the temperature sensor 10 is removed by the inserting/removing device (not shown).

[0041] There are no particular limitations on the means for inputting the information indicating that the pouring of a melt has completed into the control device 11. For example, after the pouring of a melt has completed, an operator may push a push-button connected to the control device 11 to input the information indicating that the pouring of a melt has completed, or may measure the temperature of the upper surface of flow off using a non-contact thermometer, monitor the information on the temperature of the upper surface of flow off with the control device 11, determine that the pouring of a melt has completed after the temperature of the upper surface of flow off has reached the melt temperature, and insert and contact the temperature sensor 10.

(Third embodiment)

[0042] The third embodiment, as in the second embodiment, relates to the configuration of the surroundings of the mold 2 in the equipment for manufacturing a cast-iron casting 1 of the first embodiment. The third embodiment will be explained with reference to the attached drawings. Regarding the configuration of the equipment for manufacturing a cast-iron casting according to the present embodiment, the portions that differ from the second embodiment will be explained. The other portions are the same as in the second embodiment, so reference will be made to the above-given descriptions, and the descriptions will here be omitted.

[0043] The equipment for manufacturing a cast-iron casting 1 is constituted by comprising a mold 2; a molding board 3; a frame feed device 4; a fixed suction device 5; and a movable suction device 6. Fig. 5 is a schematic cross-sectional representation of the surroundings of the mold 2 according to the third embodiment. Fig. 5 shows a V-process mold, comprising: the mold 2 using molding sand 9 that does not contain a binding agent; a temperature sensor 10; a control device 11; a warning light 12, and a two-way valve 13, the temperature sensor 10 being in a state in which it has been inserted and contacted with the thickest area of the casting C inside of the mold 2. The temperature sensor 10 stands by beforehand directly above the thickest area of the casting C outside the mold 2, similar to the second embodiment. The standby position of the temperature sensor 10 changes depending on the product, so the position in the horizontal direction of each of the thickest areas and the height from a reference surface are stored beforehand in a storage device (not shown), and the control device 11 moves the temperature sensor 10 on the basis of this information. Additionally, the mold 2 is coupled to a two-way valve 13 through a hose 8, which is easily removable. The two-way valve 13 is in communication with a suction source (not shown) through the piping 7.

[0044] Similar to the second embodiment, after information indicating that the pouring of a melt has completed is inputted into the control device 11, the temperature sensor 10 is inserted and contacted with the thickest area of the casting C inside of the mold 2 by an inserting/removing device (not shown). This allows the temperature information of the surface of the casting C to be inputted into the control device 11.

[0045] When the control device 11 senses that the product surface temperature of the casting C has reached or fallen below the A1 transformation point with the information from the temperature sensor 10, the control device 11 lights the warning light 12. When the operator confirms that the warning light 12 is lit, the operator manually closes the two-way valve 13, and removes the hose 8 from the mold 2 to release the decompressed state. Next, the temperature sensor 10 is removed by the inserting/removing device (not shown).

[0046] Similar to the second embodiment, there are no particular limitations on the means of inputting the information indicating that the pouring of a melt has completed into the control device 11. For example, after the pouring of a melt has completed, the operator may push a push-button connected to the control device 11 to input the information indicating that the pouring of a melt has completed, or measure the temperature of the upper surface of flow off using a non-contact thermometer, monitor the information on the temperature of the upper surface of flow off with the control device 11, determine that the pouring of a melt has completed after the temperature of the upper surface of flow off has reached the melt temperature, and insert and contact the temperature sensor 10.

[0047] Moreover, examples in the V-process were raised for the first to third embodiments, but the configuration and action of the equipment are similar even in the case of the evaporative-pattern casting method.

[0048] Additionally, molding sand that does not contain a binding agent is used in the first to third embodiments, but trace amounts of a binding agent may be contained in the molding sand so long as a state in which air is continually flowing over the casting surface can be created in a state in which the inside of the mold has been decompressed.

[0049] As is clear from the explanations above, the present invention, in the manufacturing method for a cast-iron casting in which a plating treatment or enameling treatment is performed on the surface thereof after founding, uses molding sand that does not contain a binding agent, and uses a mold-molding method that pours a melt in a state in which the inside of the mold has been decompressed, and after a melt has been poured, decompression is maintained inside of the mold until the temperature of the casting incorporated in the mold falls to or below the A1 transformation point, so there is a state in which air is always flowing over the casting surface. As such, in the casting in a high-temperature state, graphite near the surface is rapidly oxidized, so a decarburization layer is formed near the casting

surface. Conversely, the mold is in a decompressed state, so free cementite resulting from quenching does not occur. For this reason, abnormal structures near the casting surface that have an adverse effect on the plating treatment or the enameling treatment are not formed, and it is clear that the effects of the present invention are very significant for a person of ordinary skill in the art.

[Description of Reference Symbols]

[0050]

- 1 Equipment for manufacturing a cast-iron casting
- 2 Mold
- 3 Molding board
- 4 Frame feed device
- 5 Fixed suction device
- 6 Movable suction device
- 7 Piping
- 8 Hose
- 9 Molding sand
- 10 Temperature sensor
- 11 Control device
- 12 Warning light
- 13 Two-way valve

Claims

1. A method for manufacturing a cast-iron casting comprising:

- a step for molding a mold by decompressing molding sand;
- a step for pouring a melt into the mold; and
- a step for decompressing the inside of the mold until the temperature of the casting formed by the melt falls to or below an A1 transformation point.

2. The method for manufacturing a cast-iron casting according to claim 1, wherein the molding sand does not contain a binding agent.

3. The method of manufacturing a cast-iron casting according to claim 1 or 2, wherein the pressure inside of the mold is maintained between -10 kPa to -70 kPa.

4. The method for manufacturing a cast-iron casting according to any one of claims 1 to 3, wherein the proportion of grains having a diameter of less than 53 μm in the molding sand that does not contain a binding agent is 10% or less.

5. Equipment for manufacturing a cast-iron casting that decompresses molding sand and pours a melt into a mold that has been molded to manufacture a cast-iron casting, comprising:

- at least one mold;
- a frame feed device that moves the mold; at least one fixed suction device that decompresses the inside of the mold when the mold is stopped; and
- at least one movable suction device that moves while decompressing the inside of the mold instead of the fixed suction device when the mold is moving, wherein the mold is repeatedly moved and stopped by the frame feed device until the casting temperature inside of the mold after the melt has been poured falls to or below an A1 transformation point.

6. The equipment for manufacturing a cast-iron casting according to claim 5, wherein a plurality of the molds is present, the frame feed device simultaneously moves the plurality of the molds, and at least the same number of the fixed suction device and the movable suction device as the number of the molds are provided.

7. The equipment for manufacturing a cast-iron casting according to claim 5 or 6, further comprising:

a temperature sensor that measures the product surface temperature of the casting; and
a control device that controls such that the fixed suction device is separated from the mold and a decompressed
state is released when the product surface temperature of the casting has reached or fallen below the A1
transformation point.

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8. The equipment for manufacturing a cast-iron casting according to claim 7, wherein the temperature sensor is inserted
inside of the mold so as to contact the thickest area of the casting inside of the mold.
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9. The equipment for manufacturing a cast-iron casting according to claim 7 or 8, further comprising a warning light
that lights due to an instruction of the control device.
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10. A cast-iron casting manufactured by decompressing the inside of a mold until the casting temperature inside of the
mold after a melt has been poured falls to or below an A1 transformation point in a mold-molding method that
decompresses molding sand and pours a melt into the mold that has been molded.

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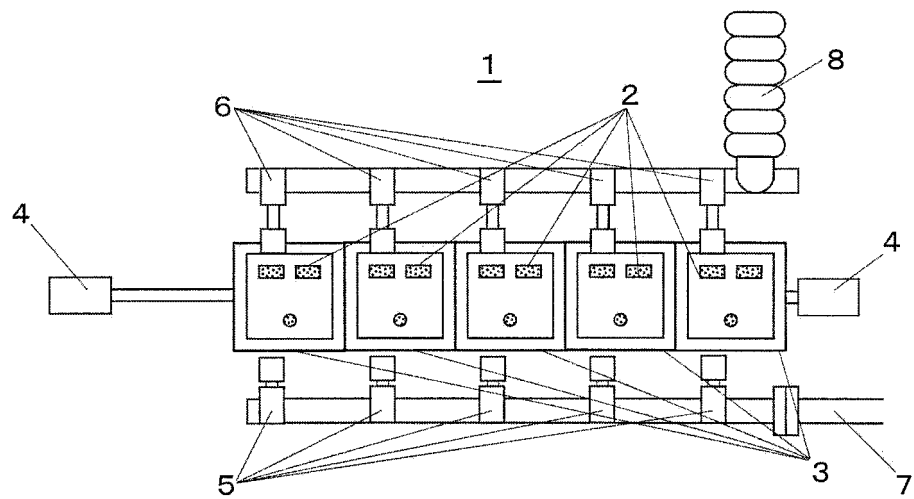
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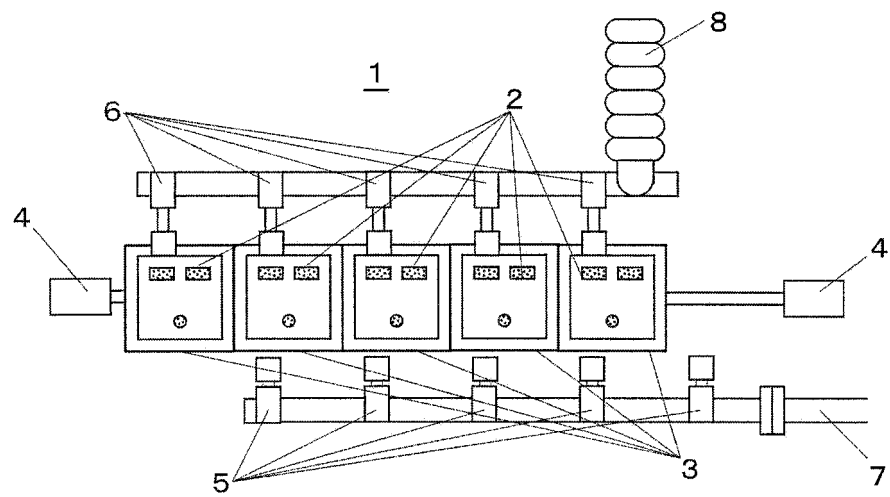
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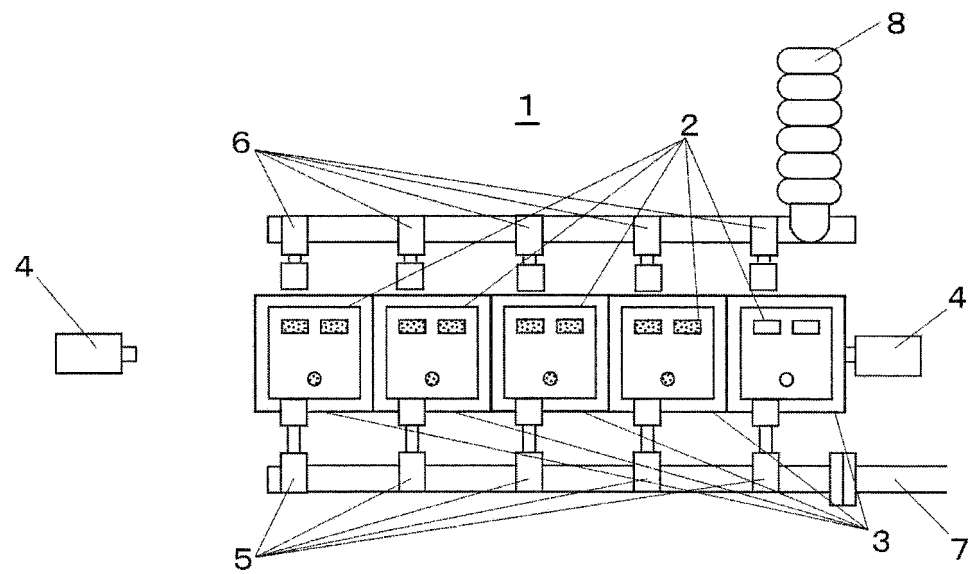
[FIG. 1]



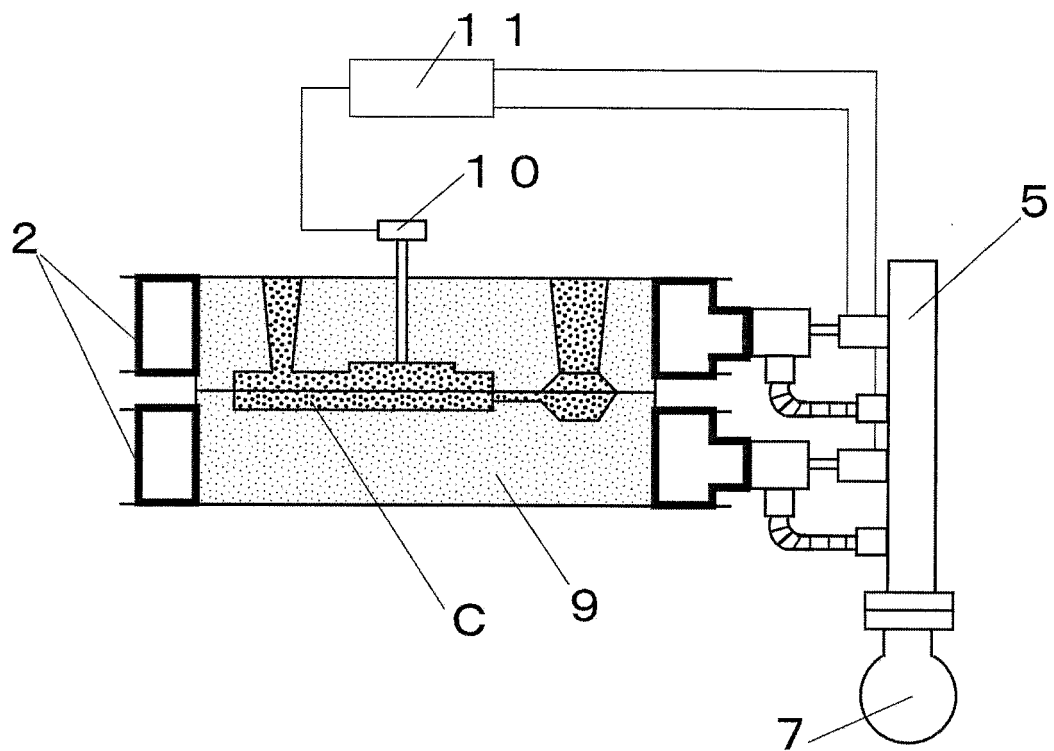
[FIG. 2]



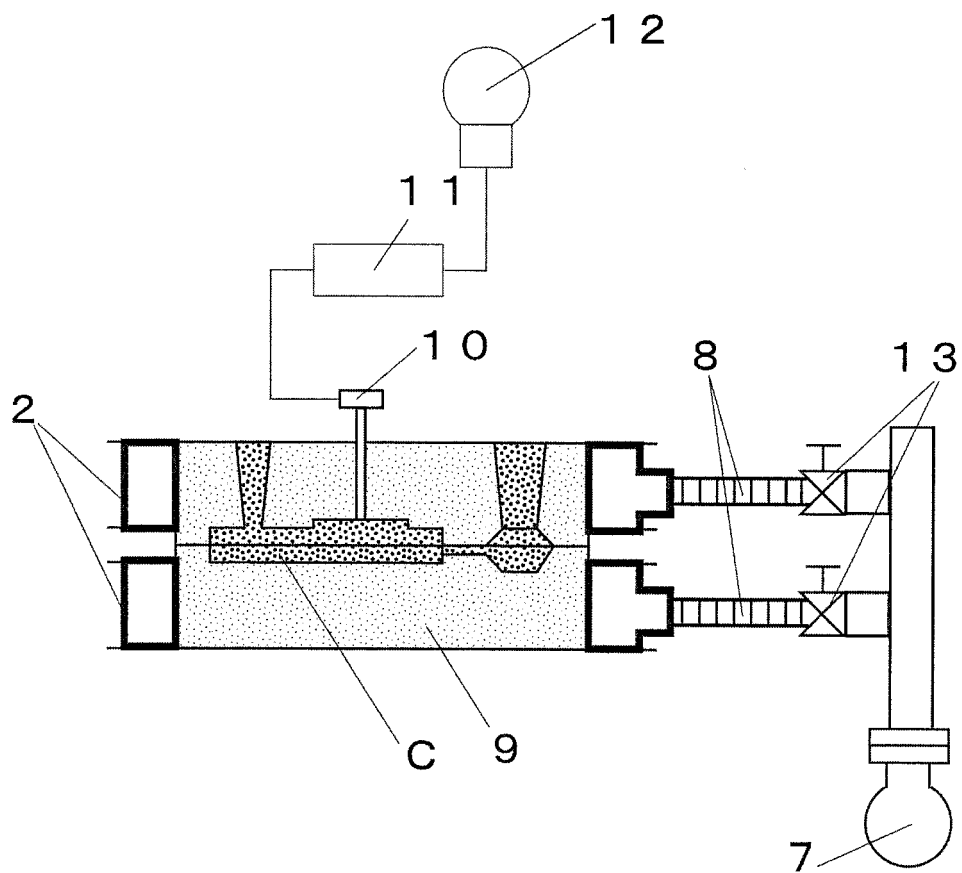
[FIG. 3]



[FIG. 4]



[FIG. 5]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/083213

A. CLASSIFICATION OF SUBJECT MATTER

B22C9/03(2006.01)i, B22D27/20(2006.01)i, B22D30/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22C9/03, B22D27/20, B22D30/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-42775 A (Iwate University), 05 March 2015 (05.03.2015), claims; paragraphs [0001] to [0007] (Family: none)	1-10
A	JP 2012-35270 A (Sinto Kogyo Ltd.), 23 February 2012 (23.02.2012), entire text & CN 102343435 A	1-10
A	JP 58-224066 A (Nippon Kokan Keishu Kabushiki Kaisha), 26 December 1983 (26.12.1983), claims; page 1, lower right column, line 8 to page 2, upper right column, line 11 (Family: none)	1-10

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
04 February 2016 (04.02.16)Date of mailing of the international search report
16 February 2016 (16.02.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/083213

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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REFERENCES CITED IN THE DESCRIPTION

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- **YONEKURA ; ISAO.** Color enameling techniques for cast-iron kitchenware. *Iwate Industrial Research Institute: Research Report No. 10*, 2003 [0016]
- **YONEKURA ; ISAO ; SAITOH ; HIROYUKI.** Influence of the properties of base castings and surface treatment on the quality of colored enamel film. *Iwate Industrial Research Institute: Research Report No. 11*, 2004 [0016]