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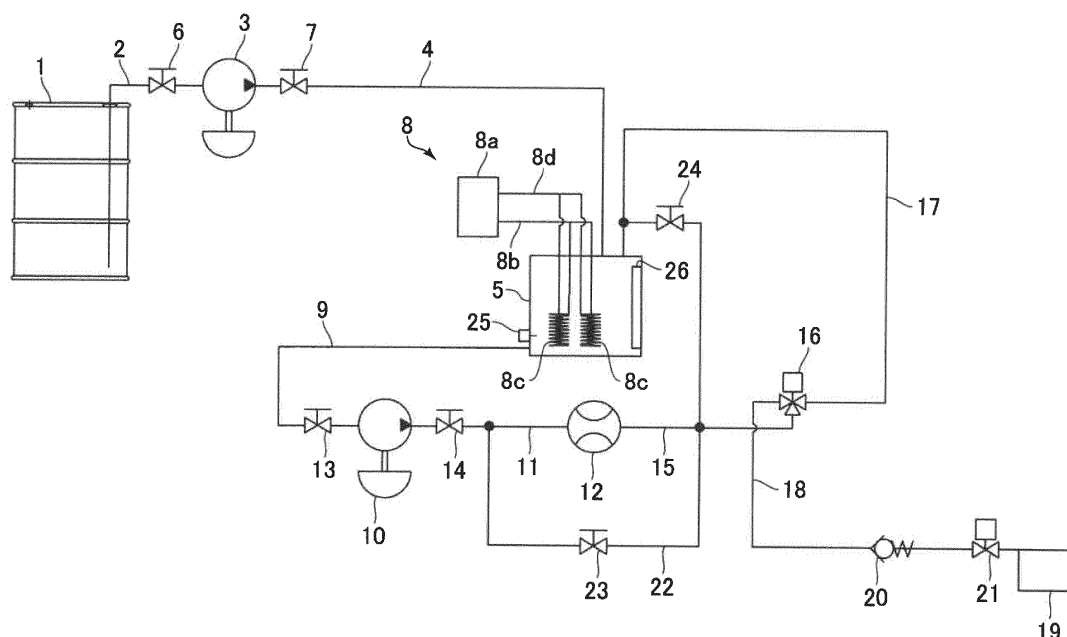
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(54) **FOUNDRY SAND BINDER SUPPLY DEVICE AND BINDER SUPPLY METHOD**

(57) Disclosed is a binder supply apparatus for supplying a liquid binder to foundry sand. The binder supply apparatus comprises: a reservoir tank for reserving the binder therein; a first pump for supplying the binder to the reservoir tank; a temperature adjusting device for adjusting the temperature of the binder in the reservoir tank

to a given temperature; a second pump for circulating the binder such that the binder is discharged from the reservoir tank to a circulation passage and then re-supplied to the reservoir tank; a flowmeter for measuring the flow rate of the binder flowing through the circulation passage; and a binder ejection port for ejecting the binder.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a binder supply apparatus and a binder supply method for supplying a liquid binder to foundry sand.

BACKGROUND ART

[0002] Heretofore, a binder supply apparatus for supplying a liquid binder to foundry sand has been known from, e.g., the following Patent Document 1.

CITATION LIST

[Parent Document]

[0003] Patent Document 1: JP H08-976A

SUMMARY OF INVENTION

[Technical Problem]

[0004] Conventionally, in a liquid binder supply apparatus, a flow rate of a liquid binder flowing through a flow passage is measured by a flowmeter. However, because, in a space whose temperature varies, an error in measured flow rate increases every time a liquid temperature (the temperature of the liquid binder) is changed, there was a problem of being unable to measure the flow rate with a high degree of accuracy.

[0005] Therefore, the present invention has been made to solve the above problem, and an object thereof is to provide a binder supply apparatus and a binder supply method for foundry sand, capable of keeping a liquid temperature constant to reduce an error in measured flow rate to thereby perform a highly-accurate flow rate measurement.

[Solution to Technical Problem]

[0006] In order to achieve the above object, according to one aspect of the present invention, there is provided a binder supply apparatus for supplying a liquid binder to foundry sand. The binder supply apparatus comprises: a reservoir tank for reserving the binder therein; a first pump for supplying the binder to the reservoir tank; a temperature adjusting device to adjust a temperature of the binder in the reservoir tank to a given temperature; a second pump for circulating the binder such that the binder is discharged from the reservoir tank to a circulation passage and then re-supplied to the reservoir tank; a flowmeter for measuring a flow rate of the binder flowing through the circulation passage; and a binder ejection port for ejecting the binder to allow the binder to be kneaded with the foundry sand.

[0007] Preferably, in the binder supply apparatus of

the present invention, the flowmeter is installed in the circulation passage at a position downstream of the second pump, wherein the binder supply apparatus further comprises a three-way valve installed in the circulation passage at a position downstream of the flowmeter, and configured to switch a flow direction of the binder supplied from the second pump, between toward a first side allowing the binder to be supplied to the reservoir tank and toward a second side allowing the binder to be supplied to the binder ejection port.

[0008] Preferably, the binder supply apparatus of the present invention further comprises a bypass passage for removing air entrained in the binder, the bypass passage being communicably connected to the circulation passage at a position downstream of the second pump, and the reservoir tank, while bypassing the flowmeter.

[0009] Preferably, the binder supply apparatus of the present invention further comprises an opening-closing valve installed adjacent to and upstream of the binder eject port.

[0010] Preferably, in the binder supply apparatus of the present invention, the foundry sand is core sand for making a core.

[0011] In the above binder supply apparatus, the core sand may be core sand for making an inorganic core.

[0012] According to another aspect of the present invention, there is provided a binder supply method for supplying a liquid binder to foundry sand. The binder supply method comprises the steps of: supplying, by a first pump, the binder to a reservoir tank; circulating, by a second pump, the binder such that the binder is discharged from the reservoir tank to a circulation passage and then re-supplied to the reservoir tank; adjusting, by a temperature adjusting device, a temperature of the binder in the reservoir tank to a given temperature; and measuring, by a flowmeter, a flow rate of the binder flowing through the circulation passage.

[0013] Preferably, the binder supply method of the present invention further comprises a step of switching, by a three-way valve installed in the circulation passage at a position downstream of the second pump via the flowmeter, a flow direction of the binder supplied from the second pump, between toward a first side allowing the binder to be supplied to the reservoir tank and toward a second side allowing the binder to be supplied to a binder ejection port.

[0014] More preferably, in the above binder supply method, during a time period during which the binder supplied from the second pump is ejected from the binder ejection port, the flow rate of the binder being supplied from the second pump is measured by the flowmeter to figure out an amount of the binder to be ejected from the binder ejection port, and, in response to ascertaining that the amount of the binder to be ejected reaches a setup amount set to a value less than a target ejection amount, the second pump is changed to be operated on a pulse-by-pulse basis.

[0015] More preferably, in the above binder supply

method, during any time period except for a time period during which the binder supplied from the second pump is ejected from the binder ejection port, the binder supplied from the second pump is circulatingly supplied to the reservoir tank.

[0016] Preferably, in the binder supply method of the present invention, the second pump is operated on a pulse-by-pulse basis, wherein a pulse period is adjusted to reduce a flow rate per pulse of the binder to be supplied from the second pump.

[Effect of Invention]

[0017] The binder supply apparatus and the binder supply method of the present invention make it possible to keep the temperature of the binder constant, even in a space whose temperature varies. This brings out various advantageous effects such as an effect of being able to reduce an error in measured flow rate to thereby perform a highly-accurate flow rate measurement.

BRIEF DESCRIPTION OF DRAWINGS

[0018] FIG. 1 is an overall configuration diagram depicting a binder supply apparatus according to one embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0019] With reference to the drawings, a binder supply apparatus according to one embodiment of the present invention and a binder supply method for use with the binder supply apparatus will now be described. This embodiment will be described based on an example in which core sand (in this embodiment, artificial sand) for making an inorganic core is used as foundry sand, and a liquid binder (in this embodiment, liquid glass) is supplied to the core sand. In FIG. 1, the reference sign 1 denotes a storage container (in this embodiment, a metal drum) storing a liquid binder therein.

[0020] The storage container 1 is communicably connected to a first pump 3 (in this embodiment, a pneumatic diaphragm pump) via a pipe 2. The first pump 3 is communicably connected to an inlet side of a reservoir tank 5 via a pipe 4. Upon activation of the first pump 3, the binder stored in the storage container 1 is supplied to the reservoir tank 5. Two opening and closing valves 6, 7 are installed, respectively, in the pipes 2, 4 at positions upstream and downstream of the first pump 3. A thermometer 25 (in this embodiment, a thermocouple) is mounted to a sidewall of the reservoir tank 5. This thermometer 25 is operable to measure the temperature of the binder in the reservoir tank 5. Further, a level switch 26 is attached inside the reservoir tank 5. This level switch 26 is operable to detect an "empty state" and a "full state" in the inside of the reservoir tank 5.

[0021] The binder supply apparatus according to this embodiment is equipped with a temperature adjusting

device 8 for adjusting the temperature of the binder in the reservoir tank 5 to a given temperature. This temperature adjusting device 8 comprises a liquid circulation unit 8a, an inlet-side pipe 8b, two stainless steel corrugated tubes 8c housed in the reservoir tank 5, and an outlet-side pipe 8b, wherein a circulating liquid discharged from the liquid circulation unit 8a is supplied to the corrugated tubes 8c via the inlet-side pipe 8b, and, after passing through the corrugated tubes 8c, returned to the liquid circulation unit 8a via the outlet-side pipe 8b. By repeating such circulation of the binder, the temperature of the binder can be adjusted through heat exchange conducted in a region of the corrugated tubes 8c.

[0022] Further, an outlet side of the reservoir tank 5 is communicably connected to a second pump 10 (in this embodiment, an electromagnetic diaphragm pump) via a pipe 9. The second pump 10 is communicably connected to a flowmeter 12 (in this embodiment, a Coriolis flowmeter) via a pipe 11. Upon activation of the second pump 10, the binder is discharged from the reservoir tank 5. Two opening and closing valves 13, 14 are installed, respectively, in the pipes 9, 11 at positions upstream and downstream of the second pump 10.

[0023] The flow meter 12 is communicably connected to an inlet side of a three-way valve 16 via a pipe 15. A first one of two outlets of the three-way valve 16 is communicably connected to the inlet side of the reservoir tank 5 via a pipe 17. The other, second, outlet of the three-way valve 16 is communicably connected to a binder ejection port 19 via a pipe 18 forming an ejection passage. The three-way valve 16 is a pneumatically-operated three-way valve. Specifically, the three-way valve 16 is configured such that, in response to pilot air supplied from a non-depicted solenoid valve to the three-way valve 16, a flow direction of the binder supplied from the second pump 10 is switched between toward a first side (the side of the pipe 17) allowing the binder to be supplied to the reservoir tank 5 and toward a second side (the side of the pipe 18) allowing the binder to be supplied to the binder ejection port 19.

[0024] A check valve 20 and an opening and closing valve 21 are installed in the pipe 18. The opening and closing valve 21 is installed at a position adjacent to and upstream of the binder ejection port 19. The opening and closing valve 21 is configured to be normally closed, and opened in response to the pilot air supplied from a non-depicted solenoid valve thereto.

[0025] A pipe 22 branching from the pipe 11 to allow the binder to flow parallel to the flowmeter 12, i.e., to bypass the flowmeter 12 is communicably connected to the inlet side of the reservoir tank 5. This pipe 22 forms a bypass passage for removing air entrained in the binder. In the pipe 22, an opening and closing valve 23 is installed in an upstream-side sub-pipe through which the binder flows parallel to the flowmeter 12, and an opening and closing valve 24 is installed in a downstream-side sub-pipe at a position adjacent to the inlet side of the reservoir tank 5.

[0026] Next, the operation of the binder supply apparatus according to the above embodiment and a binder supply apparatus for use with this binder supply apparatus will be described. At start of operation of the binder supply apparatus, the opening and closing valves 6, 7, 13, 14 are opened, and the opening and closing valves 23, 24 are closed. The three-way valve 16 is set such that the flow direction of the binder is switched toward the first side allowing the binder to be supplied to the reservoir tank 5.

[0027] When the level switch 26 detects that the inside of the reservoir 5 is in the "empty state", the first pump 3 is activated to supply the binder in the storage container 1 to the reservoir tank 5. On the other hand, when the level switch 26 detects that the inside of the reservoir 5 is in the "full state", the first pump 3 is deactivated.

[0028] Subsequently, the second pump 10 is activated. Thus, the binder is discharged from the reservoir tank 5, and re-supplied to the reservoir tank 5 via the pipe 17. The binder is circulated in this manner, and this circulation will be repeated.

[0029] During the circulation of the binder, the liquid circulation unit 8a is operated to conduct heat exchange in the corrugated tubes 8c. In this way, the temperature of the binder in the reservoir tank 5 is adjusted to a given temperature. The binder is continuously circulated during the adjustment, so that it is possible to keep constant the temperature of the binder in the reservoir tank 5 and the pipes 9, 11, 15, 17 forming a circulation passage.

[0030] Subsequently, the three-way valve 16 is controlled such that the flow direction of the binder is switched toward the second side allowing the binder to be supplied to the binder ejection port 19. Then, the opening and closing valve 21 is opened. Thus, the binder is sent to the binder ejection port 19 via the pipe 18, and ejected from the binder ejection port 19. The ejected binder is supplied to a non-depicted kneader.

[0031] During a time period during which the binder supplied from the second pump 10 is ejected from the binder ejection port 19, the flow rate of the binder being supplied from the second pump 10 is measured by the flowmeter 12. In this way, the amount of the binder to be ejected from the binder ejection port 19 is figured out. Then, in response to ascertaining that the amount of the binder to be ejected reaches a setup amount set to a value less than a target ejection amount, the second pump 10 is changed to be operated on a pulse-by-pulse basis. This makes it possible to finely adjust the amount of binder to be ejected from the binder ejection port 19 to eject the binder with a high degree of accuracy. Here, the term "operating the second pump 10 on a pulse-by-pulse basis" means that supply and supply stop of the binder from the second pump 10, i.e., discharge and suction of the second pump 10, are alternately repeated every a given pulse period (given time period).

[0032] Subsequently, when the amount of binder to be ejected reaches the target ejection amount, the opening and closing valve 21 is closed. Then, the three-way valve

16 is controlled such that the flow direction of the binder is switched toward the first side allowing the binder to be supplied to the reservoir tank 5. Thus, until ejection of the binder from the binder ejection port 19 is performed next, the binder supplied from the second pump 10 is circulated again to keep constant the temperature of the binder in the reservoir tank 5 and the pipes forming the circulation passage.

[0033] Here, the binder supplied to the non-depicted kneader is kneaded together with foundry sand, a powdered binder and others in the kneader, and formed into wet sand. Using this wet sand, an inorganic core is made by a non-depicted inorganic core-making machine.

[0034] The binder supply apparatus according to this embodiment comprises the pipe 22 serving as a bypass passage for removing air entrained in the binder, as mentioned above. In the binder supply apparatus according to this embodiment, the binder can be circulated via the pipe 22 at a high speed, so that it is possible to obtain an advantage of being able to remove air entrained in the binder, at a high speed. During this removal of the air, the opening and closing valves 23, 24 are opened. Thus, the binder is supplied to the inlet side of the reservoir tank 5 via the pipe 22, without restriction on the flow rate thereof due to the flowmeter 12. During the course of the supply of the binder, air entrained in the binder within the reservoir tank 5 will be removed.

[0035] Further, the binder supply apparatus according to this embodiment may be configured such that the second pump 10 is operated on a pulse-by-pulse basis, wherein the pulse period is adjusted to be shortened, to thereby reduce a flow rate per pulse of the binder to be supplied from the second pump 10. In this case, the amount of the binder to be restricted by a relatively narrow passage in the flowmeter 12 can be reduced, so that it is possible to obtain an advantage of being able to improve efficiency of the second pump 10. Here, the term "pulse period" means an elapsed time from start of a certain pulse through until start of the next pulse.

[0036] More specifically, when the pulse period of the second pump 10 becomes longer, the flow rate per pulse period of the second pump 10 becomes larger. Thus, the amount of the binder to be restricted by the relatively narrow passage in the flowmeter 12 is increased, leading to deterioration in efficiency of the second pump 10. Therefore, the second pump 10 is specifically adjusted to shorten the pulse period of the second pump 10. In this case, the flow rate per pulse period of the second pump 10 can be reduced, so that the amount of the binder to be restricted by the relatively narrow passage in the flowmeter 12 can also be reduced. As a result, it is possible to improve efficiency of the second pump 10.

[0037] In this embodiment, the flowmeter 12 is installed in the circulation passage at a position downstream of the second pump 10, and the three-way valve 16 is installed in the circulation passage at a position downstream of the flowmeter 12, wherein the three-way valve 16 is configured to switch the flow direction of the binder

supplied from the second pump 10, between toward the first side allowing the binder to be supplied to the reservoir tank 5 and toward the second side allowing the binder to be supplied to the binder ejection port 19. This configuration has the advantage that the binder supplied from the second pump 10 can be circulatingly supplied to the reservoir tank 5, during any time period except for a time period during which the binder supplied from the second pump 10 is ejected from the binder ejection port 19.

[0038] Further, the binder is continuously circulated during any time period except for the time period during which the binder is ejected from the binder ejection port 19, so that there is an advantage of being able to keep constant the temperature of the binder in the reservoir tank 5 and the pipes forming the circulation passage, without additionally installing a stirrer or the like.

[0039] In this embodiment, the opening-closing valve 21 is installed adjacent to and upstream of the binder eject port 19, so that there is an advantage of being able to suppress dripping from the binder eject port 19.

[0040] In the binder supply apparatus according to this embodiment, a material, structure, etc., of each of the pipes is not particularly limited, as long as it forms a flow passage of the binder. For example, it may be a tube or duct member, a hose or the like.

[0041] In the above embodiment, when removing air entrained in the binder, both the opening and closing valves 23, 24 are opened. However, the present invention is not limited thereto. That is, only one of the opening and closing valves 23, 24 may be opened.

[0042] Further, although the above embodiment has been described based on an example in which the binder is supplied to core sand for making an inorganic core, the present invention is not limited thereto. For example, the present invention may be applied to a process of making any type of core other than an inorganic core, as long as the process needs to supply a binder to core sand. Further, the present invention may be applied to a process of making a mold using green sand, as long as the process needs to supply a binder to the green sand. Further, the present invention may be applied to a process of making a self-hardening mold, as long as the process needs to supply a binder to self-hardening foundry sand.

LIST OF REFERENCE SIGNS

[0043]

- 3: first pump
- 5: reservoir tank
- 8: temperature adjusting device
- 10: second pump
- 12: flowmeter
- 16: three-way valve
- 19: binder ejection port
- 21: opening and closing valve
- 22: pipe (bypass passage)

Claims

1. A binder supply apparatus for supplying a liquid binder to foundry sand, comprising:

a reservoir tank for reserving the binder therein;
 a first pump for supplying the binder to the reservoir tank;
 a temperature adjusting device to adjust a temperature of the binder in the reservoir tank to a given temperature;
 a second pump for circulating the binder such that the binder is discharged from the reservoir tank to a circulation passage and then re-supplied to the reservoir tank;
 a flowmeter for measuring a flow rate of the binder flowing through the circulation passage; and
 a binder ejection port for ejecting the binder to allow the binder to be kneaded with the foundry sand.

2. The binder supply apparatus according to claim 1, wherein the flowmeter is installed in the circulation passage at a position downstream of the second pump, and wherein the binder supply apparatus further comprises a three-way valve installed in the circulation passage at a position downstream of the flowmeter, and configured to switch a flow direction of the binder supplied from the second pump, between toward a first side allowing the binder to be supplied to the reservoir tank and toward a second side allowing the binder to be supplied to the binder ejection port.

3. The binder supply apparatus according to claim 1 or 2, wherein the binder supply apparatus further comprises a bypass passage for removing air entrained in the binder, the bypass passage being communicably connected to the circulation passage at a position downstream of the second pump, and the reservoir tank, while bypassing the flowmeter.

4. The binder supply apparatus according to claim 1 or 2, wherein the binder supply apparatus further comprises an opening-closing valve installed adjacent to and upstream of the binder eject port.

5. The binder supply apparatus according to claim 1 or 2, wherein the foundry sand is core sand for making a core.

6. The binder supply apparatus according to claim 5, wherein the core sand is core sand for making an inorganic core.

7. A binder supply method for supplying a liquid binder to foundry sand, comprising the steps of:

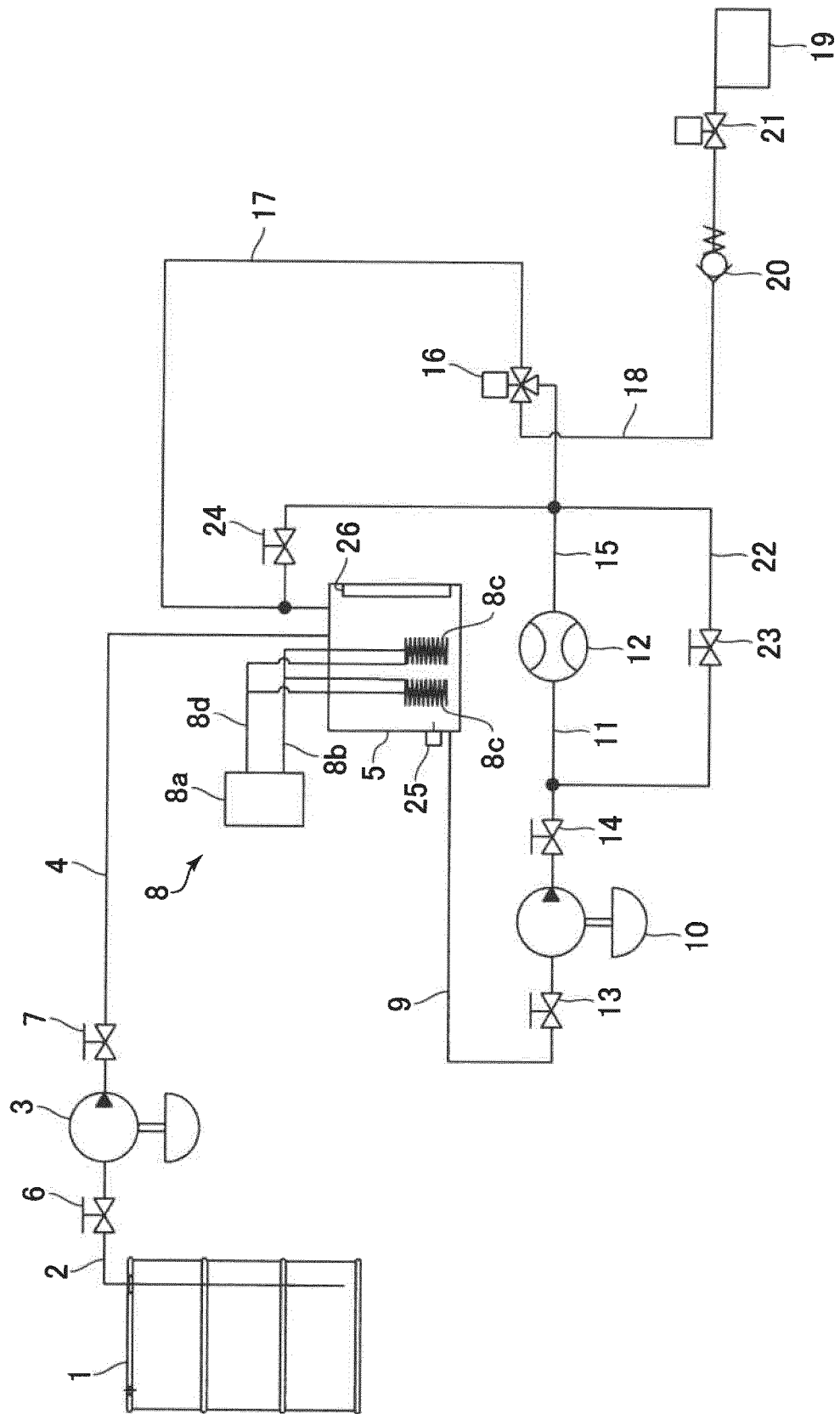
supplying, by a first pump, the binder to a reservoir tank;
circulating, by a second pump, the binder such that the binder is discharged from the reservoir tank to a circulation passage and then re-supplied to the reservoir tank;
adjusting, by a temperature adjusting device, a temperature of the binder in the reservoir tank to a given temperature; and
measuring, by a flowmeter, a flow rate of the binder flowing through the circulation passage.

8. The binder supply method as recited in claim 7, wherein the binder supply method further comprises a step of switching, by a three-way valve installed in the circulation passage at a position downstream of the second pump via the flowmeter, a flow direction of the binder supplied from the second pump, between toward a first side allowing the binder to be supplied to the reservoir tank and toward a second side allowing the binder to be supplied to a binder ejection port.
9. The binder supply method according to claim 8, wherein, during a time period during which the binder supplied from the second pump is ejected from the binder ejection port, the flow rate of the binder being supplied from the second pump is measured by the flowmeter to figure out an amount of the binder to be ejected from the binder ejection port, and, in response to ascertaining that the amount of the binder to be ejected reaches a setup amount set to a value less than a target ejection amount, the second pump is changed to be operated on a pulse-by-pulse basis.
10. The binder supply method according to claim 8, wherein, during any time period except for a time period during which the binder supplied from the second pump is ejected from the binder ejection port, the binder supplied from the second pump is circulatingly supplied to the reservoir tank.
11. The binder supply method according to claim 7 or 8, wherein the second pump is operated on a pulse-by-pulse basis, and wherein a pulse period is adjusted to reduce a flow rate per pulse of the binder to be supplied from the second pump.

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FIG.1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/047210

A. CLASSIFICATION OF SUBJECT MATTER

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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)

Int.Cl. B22C5/18, B22D45/00

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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 10-80745 A (SINTOKOGIO, LTD.) 31 March 1998 (Family: none)	1-11

☐

Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents:

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document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

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17 January 2018 (17.01.2018)

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Japan Patent Office
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H08976 A [0003]