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(54) **POWDER FEEDING DEVICE AND POWDER TRANSFER METHOD**

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(57) **ABSTRACT**

Powder feeding device and powder transfer method are disclosed. The powder feeding device includes a container including a container body forming a storage space therein; a hopper including a hopper body forming an accommodation space therein; a chamber unit including a chamber housing forming a hollow portion and coupled to the hopper body; a pipe assembly including a container pipe unit which extends from the container and is opened or closed, a hopper pipe unit which is branched from the container pipe unit, is connected to the hopper body, and is opened or closed, and a chamber pipe unit which is branched from the container pipe unit, is connected to the chamber housing, and is opened or closed; and a valve assembly including a coupling valve which is coupled to at least one of the chamber housing and the hopper body and connects/disconnects the storage space to/from the hollow portion.

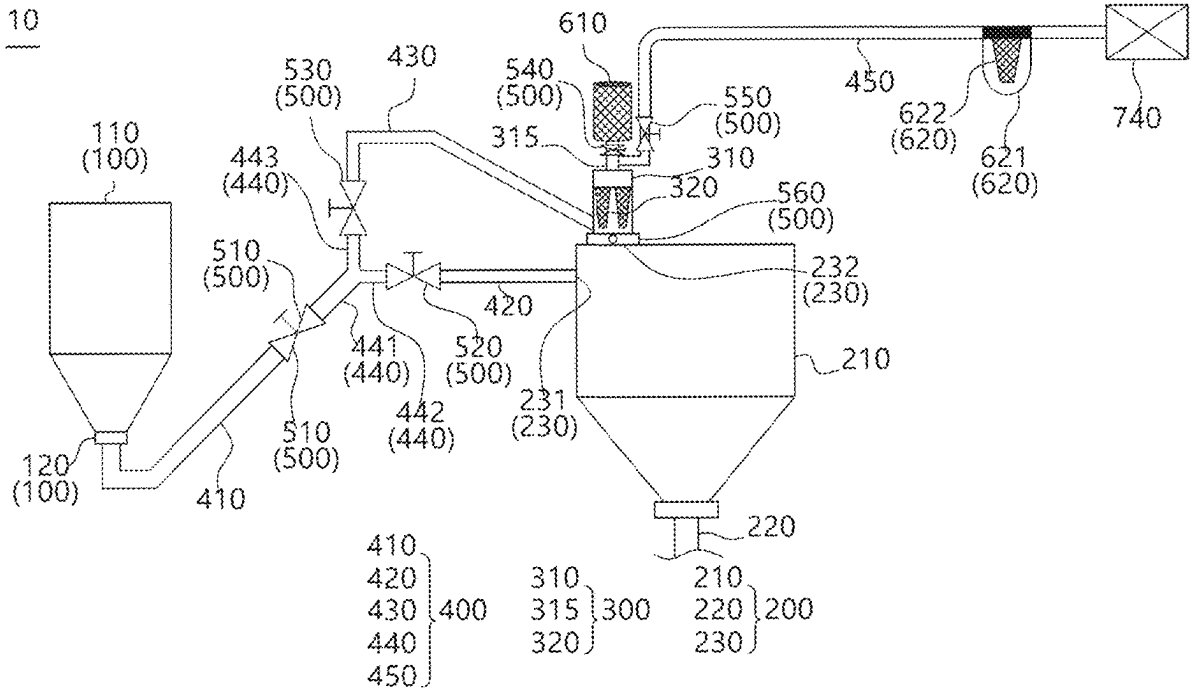


FIG. 1

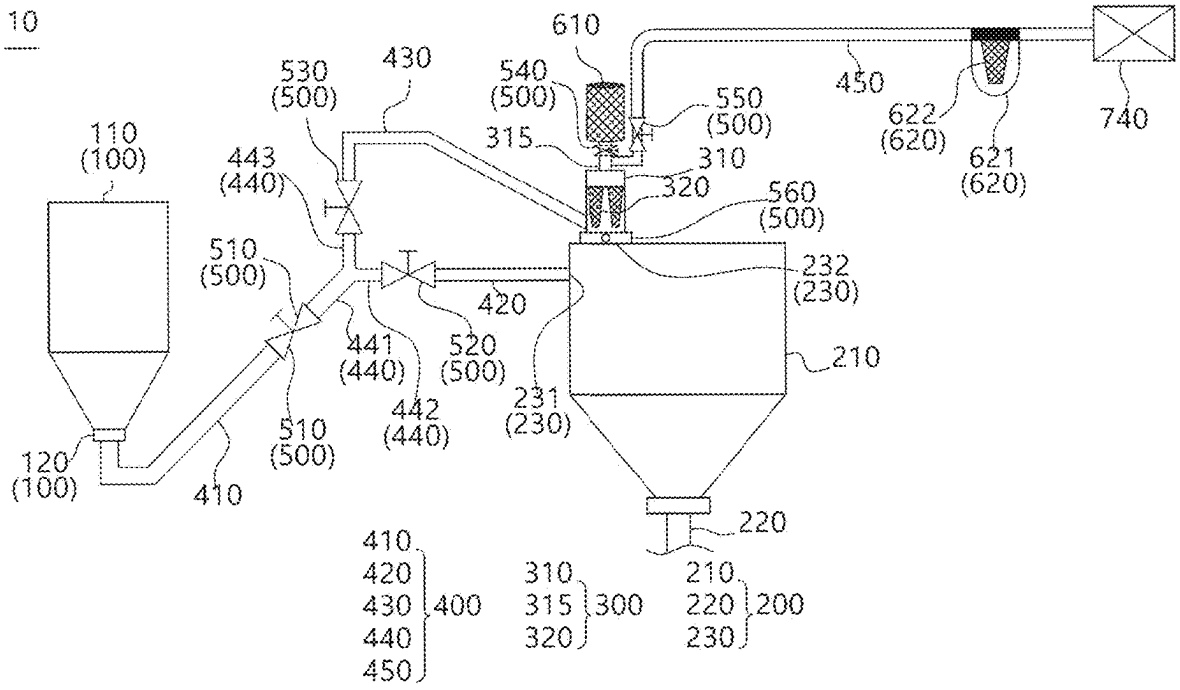

10
610
530 (500)
430
540 (500)
550 (500)
450
622 (620)
621 (620)
740
110 (100)
443 (440)
315
310
320
560 (500)
510 (500)
232 (230)
420
441 (440)
520 (500)
210
231 (230)
442 (440)
510 (500)
120 (100)
410
220
410
420
430
440
450
400
310
315
320
300
210
220
230
200

FIG. 2

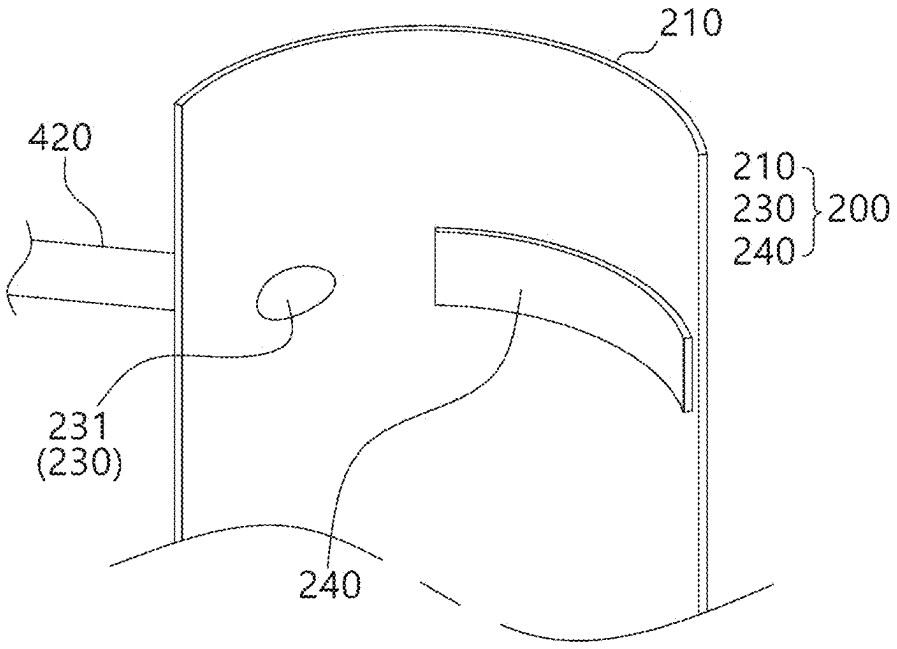

210
420
210
230
240
200
231
(230)
240

FIG. 3

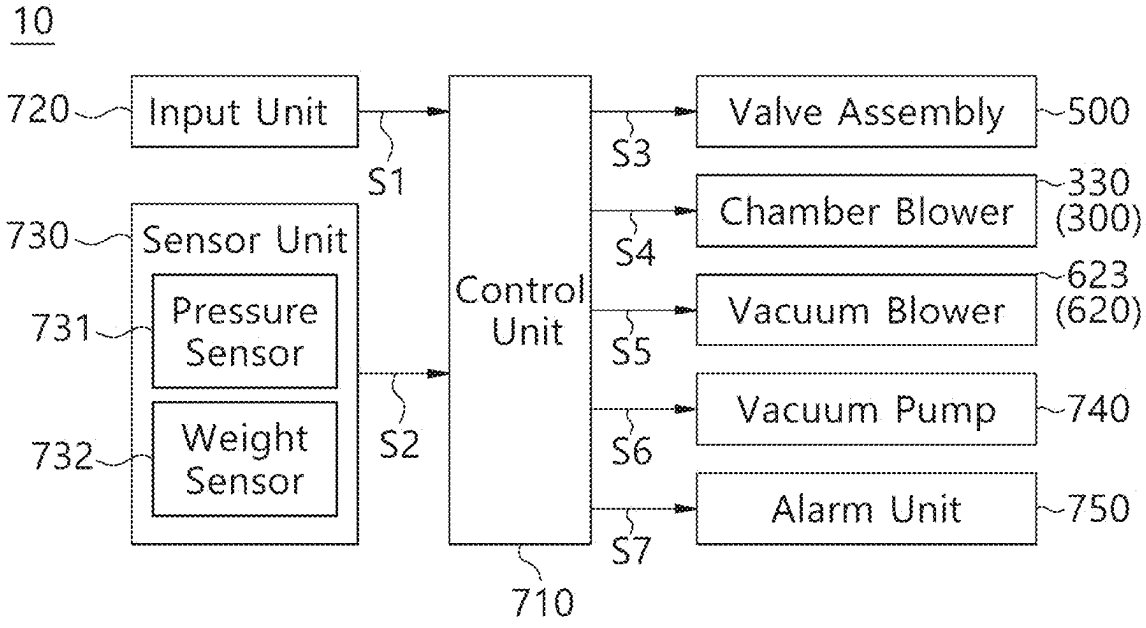

10
720
Input Unit
S1
730
Sensor Unit
731
Pressure Sensor
732
Weight Sensor
S2
Control Unit
710
S3
S4
S5
S6
S7
Valve Assembly
500
Chamber Blower
330
(300)
Vacuum Blower
623
(620)
Vacuum Pump
740
Alarm Unit
750

FIG. 4

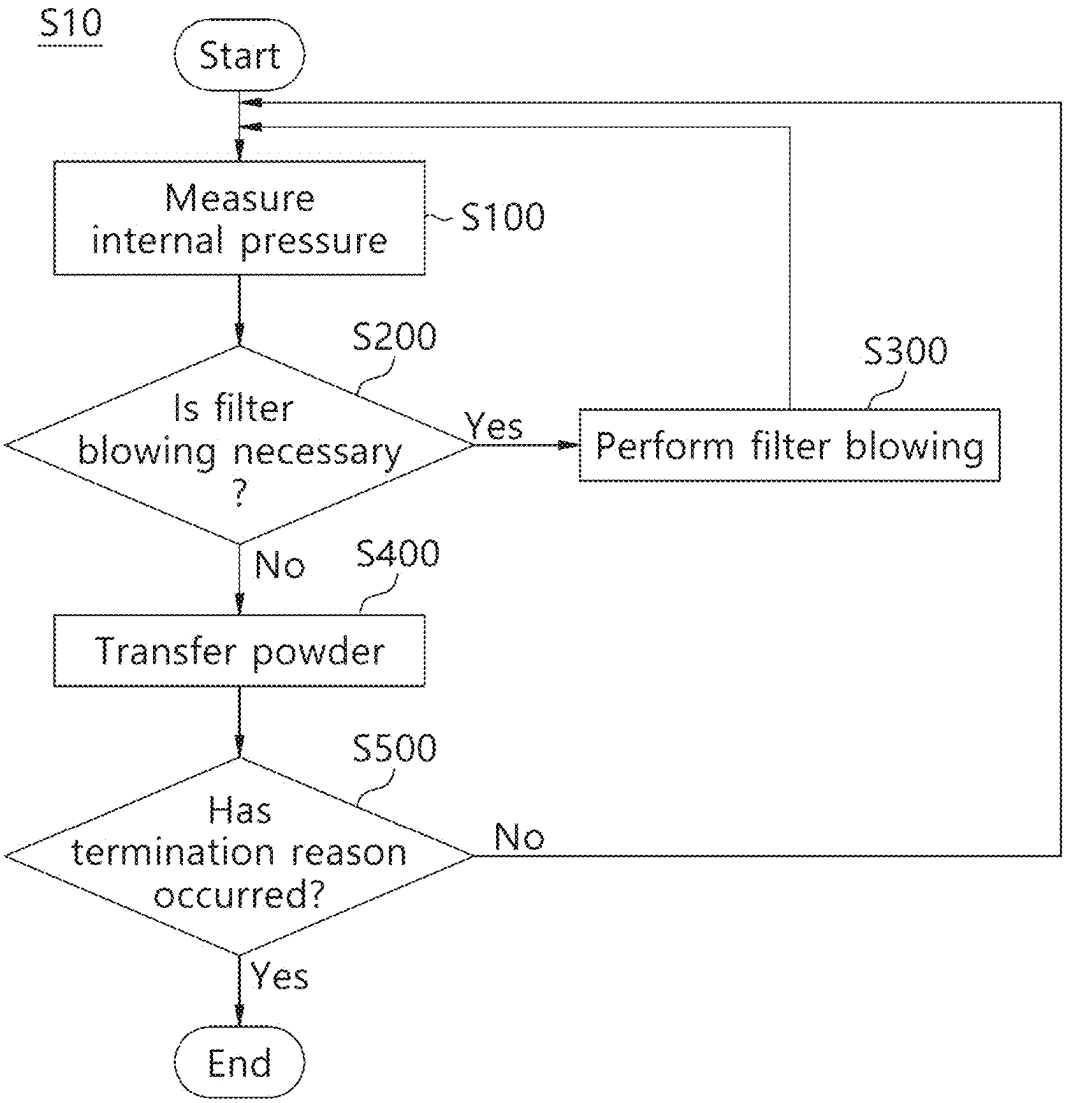

S10
Start
Measure internal pressure
S100
S200
Is filter blowing necessary ?
Yes
S300
Perform filter blowing
No
S400
Transfer powder
S500
Has termination reason occurred?
No
Yes
End

FIG. 5

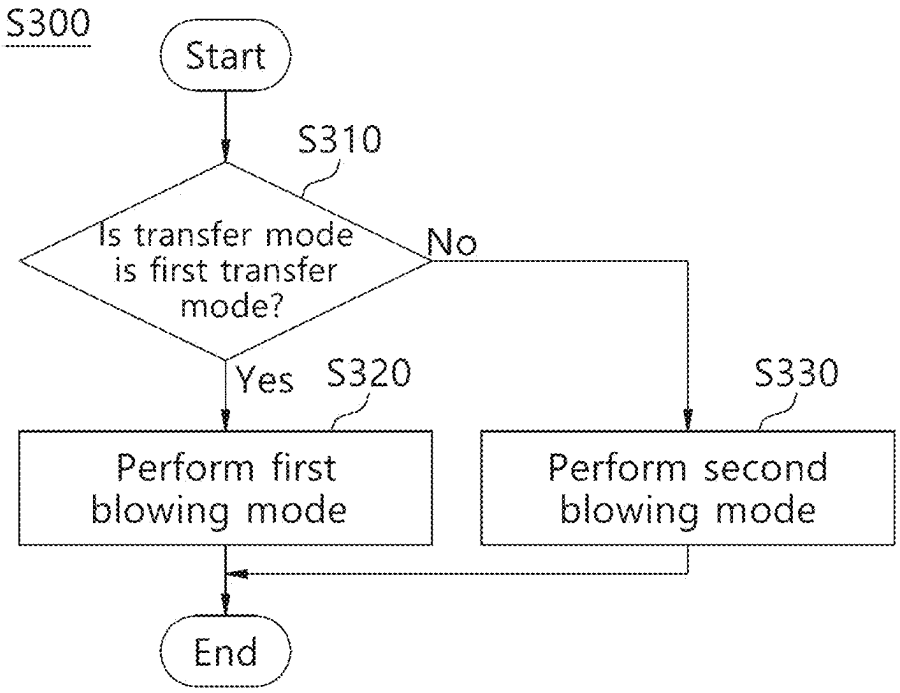

S300
Start
S310
Is transfer mode is first transfer mode?
No
Yes
S320
S330
Perform first blowing mode
Perform second blowing mode
End

FIG. 6

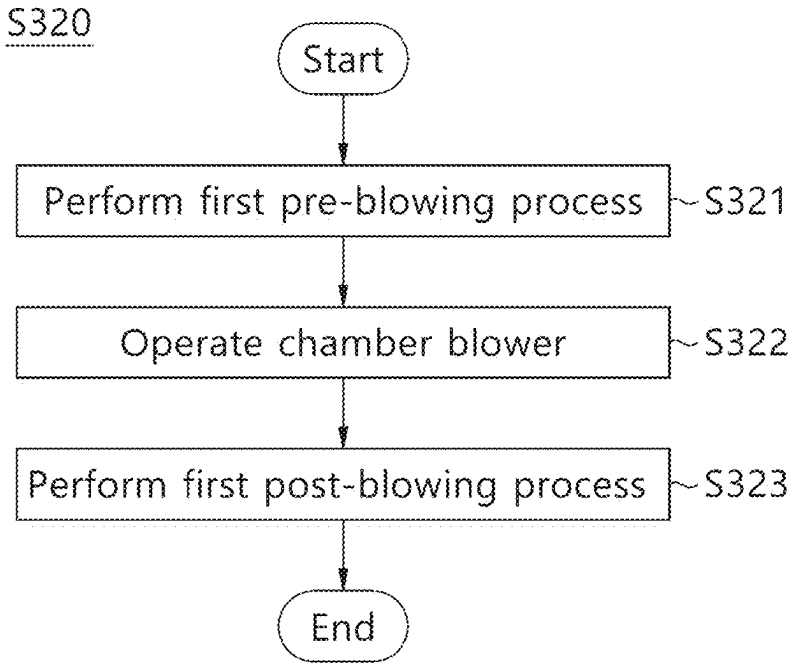

S320
Start
Perform first pre-blowing process
S321
Operate chamber blower
S322
Perform first post-blowing process
S323
End

FIG. 7

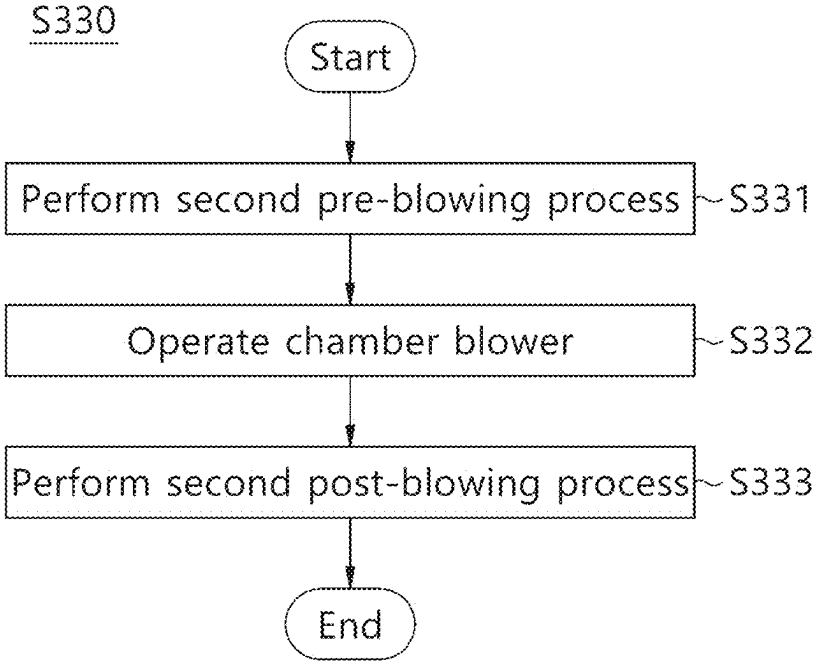
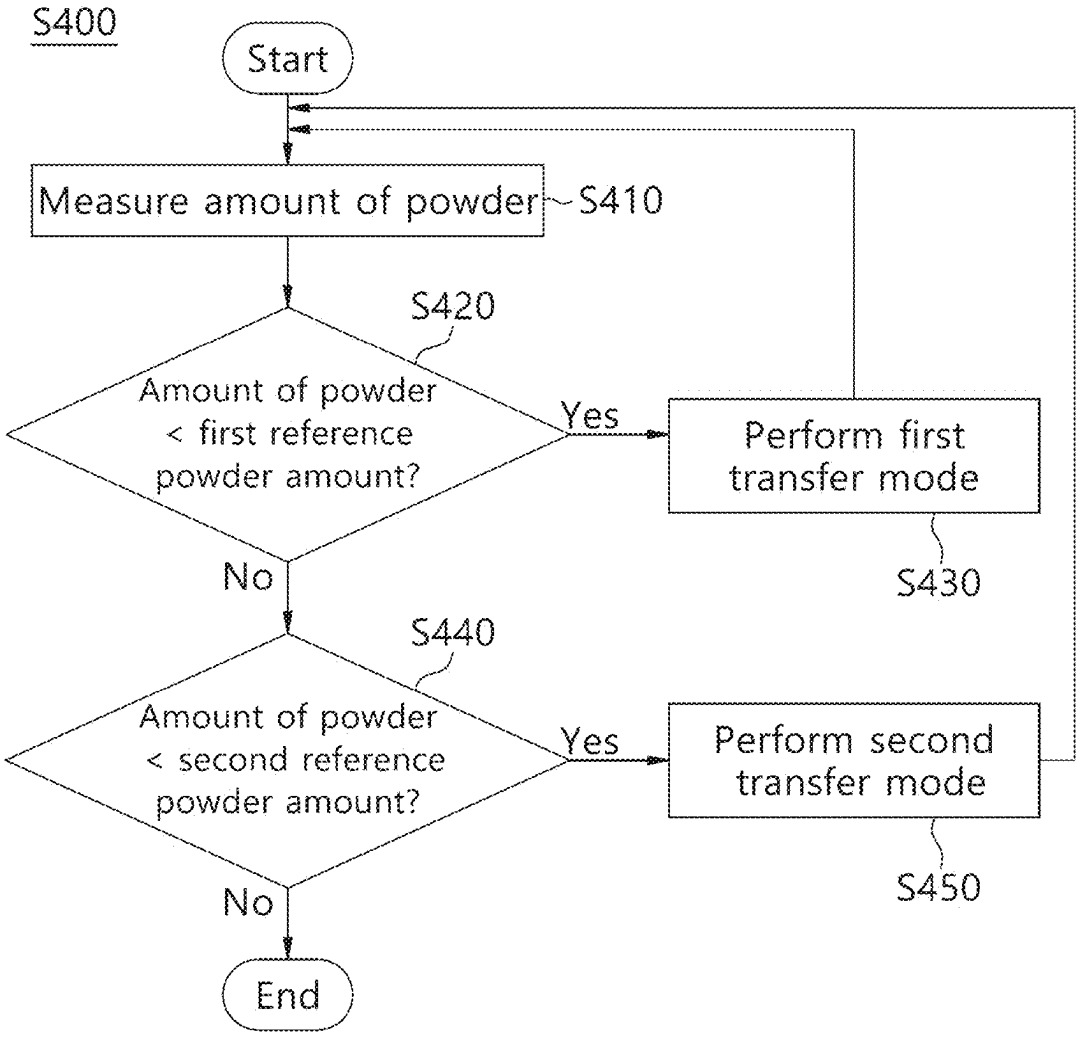

S330
Start
Perform second pre-blowing process
S331
Operate chamber blower
S332
Perform second post-blowing process
S333
End

FIG. 8


S400
Start
Measure amount of powder
S410
S420
Amount of powder < first reference powder amount?
Yes
Perform first transfer mode
S430
No
S440
Amount of powder < second reference powder amount?
Yes
Perform second transfer mode
S450
No
End

POWDER FEEDING DEVICE AND POWDER TRANSFER METHOD

CROSS-REFERENCE TO RELATED APPLICATION AND CLAIM OF PRIORITY

[0001] This application claims priority to Korean Patent Application No. 10-2024-0019593 filed on Feb. 8, 2024 in the Korean Intellectual Property Office (KIPO), the entire disclosure of which is incorporated by reference herein.

TECHNICAL FIELD

[0002] Embodiments of the disclosure relate to a powder feeding device and a powder transfer method.

BACKGROUND

[0003] For powder used in secondary batteries, etc., accurate weighing may be important. In addition, there is a need to increase process efficiency by quickly transferring the powder. A device and method capable of accurately and quickly transferring the powder are required.

SUMMARY

[0004] An object of embodiments of the disclosure is to provide a powder feeding device and a powder transfer method that vary a transfer mode based on an amount of transferred powder.

[0005] A powder feeding device according to an embodiment of the disclosure may comprise a container including a container body forming a storage space inside the container body; a hopper including a hopper body forming an accommodation space inside the hopper body; a chamber unit including a chamber housing, the chamber housing forming a hollow portion and coupled to the hopper body; a pipe assembly including a container pipe unit which extends from the container and is opened or closed, a hopper pipe unit which is branched from the container pipe unit, is connected to the hopper body, and is opened or closed, and a chamber pipe unit which is branched from the container pipe unit, is connected to the chamber housing, and is opened or closed; and a valve assembly including a coupling valve which is coupled to at least one of the chamber housing and the hopper body and connects or disconnects the storage space with the hollow portion.

[0006] The valve assembly may further include a container valve which is coupled to the container pipe unit and opens or closes the container pipe unit, a hopper valve which is coupled to the hopper pipe unit and opens or closes the hopper pipe unit, and a chamber valve which is coupled to the chamber pipe unit and opens or closes the chamber pipe unit.

[0007] The chamber unit may further include a chamber port extending from the chamber housing. The pipe assembly may further include a pump pipe, and an end of the pump pipe extends from the chamber port and another end of the pump pipe leads to a vacuum pump.

[0008] The valve assembly may further include a vacuum line valve which is coupled to the pump pipe and opens or closes the pump pipe.

[0009] The valve assembly may further include a vacuum release valve which is coupled to the chamber port and opens or closes the chamber port.

[0010] The end of the pump pipe may be located between the vacuum release valve and the chamber housing.

[0011] The chamber unit may further include a chamber filter which is located in the hollow portion of the chamber housing and performs a filter function.

[0012] The chamber unit may further include a chamber blower spraying a gas into the chamber filter.

[0013] The powder feeding device may further comprise a pressure sensor measuring an internal atmospheric pressure of the chamber housing, and a control unit connected to the pressure sensor and receiving a second signal from the pressure sensor. The control unit may operate the chamber blower when the internal atmospheric pressure of the chamber housing from the second signal is greater than or equal to a reference chamber internal pressure.

[0014] The powder feeding device may further comprise a vacuum pump and a vacuum filter unit. The pipe assembly may further include a pump pipe, and an end of the pump pipe extends from the chamber unit and another end of the pump pipe leads to the vacuum pump. The vacuum filter unit may include a vacuum filter housing coupled to the pump pipe, and a vacuum filter located in the vacuum filter housing.

[0015] The powder feeding device may further comprise a weight sensor connected to the hopper body and measuring a weight applied to the weight sensor, and a control unit connected to the weight sensor and receiving a second signal from the weight sensor. The control unit may open the container pipe unit and the hopper pipe unit and close the chamber pipe unit when an increase amount of a weight measured by the weight sensor from the second signal is less than or equal to a first reference powder amount.

[0016] The control unit may open the container pipe unit and the chamber pipe unit and close the hopper pipe unit when the increase amount of the weight from the second signal is greater than or equal to the first reference powder amount and is less than a second reference powder amount.

[0017] A powder transfer method of transferring a powder stored in a container to one of a hopper and a chamber unit may comprise measuring an internal pressure of a chamber housing included in the chamber unit; comparing the measured internal pressure with a reference chamber internal pressure; and spraying a gas into a chamber filter included in the chamber housing when the measured internal pressure is greater than or equal to the reference chamber internal pressure, or transferring the powder stored in the container to one of the hopper and the chamber unit when the measured internal pressure is less than the reference chamber internal pressure. Transferring the powder may be performed in parallel with measuring the internal pressure.

[0018] Spraying the gas into the chamber filter may comprise determining whether a transfer mode is a first transfer mode, performing a first blowing mode when the transfer mode is the first transfer mode, and performing a second blowing mode when the transfer mode is not the first transfer mode.

[0019] When an amount of the powder introduced into the hopper and the chamber unit is less than a first reference powder amount, the transfer mode may be the first transfer mode. When the amount of the powder introduced into the hopper and the chamber unit is greater than or equal to the first reference powder amount and is less than a second reference powder amount, the transfer mode may be a second transfer mode.

[0020] Performing the first blowing mode may comprise performing a first pre-blowing process of blocking the

hopper and the container from communicating with the chamber housing and exposing the chamber housing to an outside air, spraying the gas into the chamber filter, and performing a first post-blowing process of blocking the chamber housing from the outside air and communicating the chamber housing with the hopper and the container.

[0021] Performing the second blowing mode may comprise performing a second pre-blowing process of blocking the hopper and the container from communicating with the chamber housing and exposing the chamber housing to an outside air, spraying the gas into the chamber filter, and performing a second post-blowing process of blocking the chamber housing from the outside air and communicating the chamber housing with the container.

[0022] Transferring the powder may comprise measuring an amount of the powder introduced into the hopper and the chamber unit, comparing the measured amount of the powder with a first reference powder amount, and performing a first transfer mode when the measured amount of the powder is less than the first reference powder amount.

[0023] Transferring the powder may comprise comparing the measured amount of the powder with a second reference powder amount when the measured amount of the powder is greater than or equal to the first reference powder amount, and performing a second transfer mode when the measured amount of the powder is less than the second reference powder amount. In performing the first transfer mode, the powder stored in the container may be transferred to the hopper. In performing the second transfer mode, the powder stored in the container may be transferred to the chamber housing,

[0024] Performing the first transfer mode may be performed in parallel with measuring the amount of the powder, and performing the second transfer mode may be performed in parallel with measuring the amount of the powder.

[0025] According to an embodiment of the disclosure, a powder feeding device and a powder transfer method that vary a transfer mode based on an amount of transferred powder can be provided.

[0026] A powder feeding device and a powder transfer method according to some embodiments of the disclosure can be used in eco-friendly electric vehicles, hybrid vehicles, etc. to prevent climate change by suppressing air pollution and greenhouse gas emissions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of the disclosure, illustrate embodiments of the disclosure and together with the description serve to explain the principle of the disclosure.

[0028] FIG. **1** illustrates a powder feeding device according to an embodiment of the disclosure.

[0029] FIG. **2** illustrates a cut-away view of a part of a hopper illustrated in FIG. **1**.

[0030] FIG. **3** is a block diagram of a powder feeding device according to an embodiment of the disclosure.

[0031] FIG. **4** is a flow chart illustrating a powder transfer method according to an embodiment of the disclosure.

[0032] FIG. **5** is a flowchart illustrating a filter blowing step.

[0033] FIG. **6** is a flowchart illustrating a step of performing a first blowing mode.

[0034] FIG. **7** is a flowchart illustrating a step of performing a second blowing mode.

[0035] FIG. **8** is a flowchart illustrating a powder transfer step.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0036] Reference will now be made in detail to embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. However, the following description is merely an example and does not intend to limit the disclosure to a specific implementation.

[0037] FIG. **1** illustrates a powder feeding device according to an embodiment of the disclosure. A powder feeding device **10** may be schematically illustrated in FIG. **1**.

[0038] Referring to FIG. **1**, the powder feeding device **10** may include a container **100**. The container **100** may include a container body **110**. The container body **110** may form a storage space therein.

[0039] For example, the container body **110** may accommodate powder. For example, the powder may be located in the storage space formed in the container body **110**.

[0040] The powder accommodated in the container body **110** may be, for example, a component of a secondary battery. For example, the powder accommodated in the container body **110** may be a material forming an active material of the secondary battery.

[0041] The container **100** may include a container outlet **120**. The container outlet **120** may be formed, coupled, or connected to the container body **110**.

[0042] For example, the container outlet **120** may extend from an end of the container body **110**. For example, the container outlet **120** may extend downward from a lower end of the container body **110**.

[0043] The container outlet **120** may communicate with the container body **110**. For example, the powder contained in the container body **110** may be discharged to the outside of the container **100** through the container outlet **120**.

[0044] The powder feeding device **10** may include a pipe assembly **400**. The pipe assembly **400** may include a container pipe **410**. The container pipe **410** may form a shape of a pipe or a tube.

[0045] The container pipe **410** may be connected or coupled to the container **100**. For example, the container pipe **410** may be connected or coupled to the container outlet **120**. For example, the container pipe **410** may connect the container outlet **120** to a container valve **510**.

[0046] For example, the container pipe **410** may communicate with the container outlet **120**. For example, at least a portion of the powder accommodated in the container body **110** may be transferred to the container pipe **410** via the container outlet **120**.

[0047] The powder feeding device **10** may include a hopper **200**. The hopper **200** may include a hopper body **210**. The hopper body **210** may form an accommodation space therein. For example, at least a portion of the powder located in the container pipe **410** may be transferred and located in the accommodation space formed in the hopper body **210**.

[0048] The hopper **200** may include a hopper inlet **230**. The hopper inlet **230** may be formed, connected, or coupled to the hopper body **210**. For example, the hopper inlet **230** may be connected to or communicate with the accommo-

dation space formed in the hopper body **210**. For example, the hopper inlet **230** may be located at the upper end of the hopper body **210**.

[0049] A plurality of hopper inlets **230** may be provided. For example, the hopper **200** may include a plurality of hopper inlets **230**. For example, the hopper **200** may include a hopper pipe inlet **231** and a hopper chamber inlet **232**. The hopper inlet **230** may include or indicate at least one of the hopper pipe inlet **231** and the hopper chamber inlet **232**.

[0050] For example, the hopper pipe inlet **231** may be located at an upper end of a side of the hopper body **210**. For example, the hopper chamber inlet **232** may be located on a top face of the hopper body **210**. The hopper inlet **230** may be located above a hopper outlet **220**.

[0051] The hopper inlet **230** may be connected or coupled to the pipe assembly **400**. For example, the hopper pipe inlet **231** may be connected or coupled to a hopper pipe **420**. For example, the hopper chamber inlet **232** may be connected or coupled to a coupling valve **560**.

[0052] The hopper **200** may include the hopper outlet **220**. The hopper outlet **220** may be connected or coupled to the hopper body **210**. For example, the hopper outlet **220** may be connected or coupled to a lower end of the hopper body **210**.

[0053] For example, the hopper outlet **220** may form a shape extending downward from the lower end of the hopper body **210**. At least a portion of the powder contained in the hopper body **210** may pass through the hopper outlet **220** and be discharged to the outside of the hopper **200**.

[0054] The powder feeding device **10** may include a chamber unit **300**. The chamber unit **300** may include a chamber housing **310**. The chamber housing **310** may be connected or coupled to the hopper body **210**. For example, the chamber housing **310** may be connected to the hopper body **210** through the coupling valve **560**.

[0055] The chamber housing **310** may be located above the hopper body **210**. For example, the coupling valve **560** may be located, connected, or coupled to the hopper chamber inlet **232**, and the chamber housing **310** may be connected or coupled to the coupling valve **560**.

[0056] The chamber housing **310** may form a hollow portion. A size of the hollow portion formed in the chamber housing **310** may be less than a size of the accommodation space formed in the hopper body **210**.

[0057] An internal pressure of the chamber housing **310** may be controlled. For example, the internal pressure (or atmospheric pressure) of the chamber housing **310** may be maintained lower than an external pressure of the chamber housing **310**. For example, the internal pressure (or atmospheric pressure) of the chamber housing **310** may be maintained lower than an internal pressure (or atmospheric pressure) of the container body **110**.

[0058] The chamber unit **300** may include a chamber port **315**. The chamber port **315** may be connected or coupled to the chamber housing **310**. For example, the chamber port **315** may form a shape extending from the chamber housing **310**. For example, the chamber port **315** may be formed integrally with the chamber housing **310**.

[0059] A hollow portion may be formed inside the chamber port **315**. For example, the chamber port **315** may form a shape of a cylinder bore. For example, the hollow portion formed in the chamber port **315** may communicate with the chamber housing **310**.

[0060] The chamber port **315** may be connected or coupled to a vacuum release valve **540**. For example, the vacuum release valve **540** may be installed in the chamber port **315**.

[0061] The chamber unit **300** may include a chamber filter **320**. The chamber filter **320** may have a filtering function. For example, at least a portion of the powder applied to the chamber filter **320** may be blocked by the chamber filter **320**, and thus movement of the powder may be suppressed.

[0062] The chamber filter **320** may be located in the chamber housing **310**. For example, the chamber filter **320** may be installed, coupled, or connected to the chamber housing **310**.

[0063] The chamber filter **320** may partition the chamber housing **310** and the chamber port **315**. For example, the hollow portion formed in the chamber housing **310** and the hollow portion formed in the chamber port **315** by the chamber filter **320** may be partitioned or separated by the chamber filter **320**. For example, gas (or air) incident on an external face of the chamber filter **320** may pass through the chamber filter **320** and flow into the chamber port **315**.

[0064] The powder feeding device **10** may include a vacuum pump **740**. The vacuum pump **740** may be connected to the chamber unit **300** through a pump pipe **450**.

[0065] For example, the vacuum pump **740** may maintain the internal pressure (or atmospheric pressure) of the chamber housing **310** and the chamber port **315** to be lower than an external pressure (or atmospheric pressure) of the chamber unit **300**.

[0066] The powder feeding device **10** may include a valve assembly **500**. The valve assembly **500** may include the coupling valve **560**. The coupling valve **560** may connect the hopper body **210** to the chamber housing **310**. For example, the coupling valve **560** may be connected, coupled, or installed to at least one of the hopper body **210** and the chamber housing **310**.

[0067] The coupling valve **560** may connect or disconnect the accommodation space formed in the hopper body **210** with the hollow portion formed in the chamber housing **310**. In other words, the coupling valve **560** may connect or disconnect the accommodation space formed in the hopper body **210** with the hollow portion formed in the chamber housing **310**.

[0068] For example, in a state in which the coupling valve **560** is open, the hopper body **210** and the chamber housing **310** may communicate with each other. In a state in which the coupling valve **560** is open, at least a portion of the powder located in the chamber housing **310** may fall and move to the inside of the hopper body **210**.

[0069] For example, in a state in which the coupling valve **560** is closed, the hollow portion formed in the hopper body **210** and the hollow portion formed in the chamber housing **310** may be separated from each other. In a state in which the coupling valve **560** is closed, an internal pressure (or atmospheric pressure) of the hopper body **210** may be maintained differently from an internal pressure (or atmospheric pressure) of the chamber housing **310**.

[0070] The valve assembly **500** may include the vacuum release valve **540**. The vacuum release valve **540** may be connected, coupled, or installed to the chamber port **315**. The vacuum release valve **540** may, for example, open or/and close the hollow portion formed in the chamber port **315**.

[0071] In a state in which the vacuum release valve **540** is open, the internal pressure (or atmospheric pressure) of the chamber port **315** and the internal pressure (or atmospheric pressure) of the chamber housing **310** may be substantially the same as the external pressure (or atmospheric pressure) of the chamber unit **300**.

[0072] In a state in which the vacuum release valve **540** is closed, the internal pressure (or atmospheric pressure) of the chamber port **315** and the internal pressure (or atmospheric pressure) of the chamber housing **310** may be maintained lower than the external pressure (or atmospheric pressure) of the chamber unit **300**.

[0073] The pipe assembly **400** may include the pump pipe **450**. The pump pipe **450** may form a shape of a pipe or a tube. The pump pipe **450** may connect the vacuum pump **740** and the chamber unit **300**.

[0074] For example, the pump pipe **450** may extend from the vacuum pump **740** and lead to the chamber unit **300**. For example, the pump pipe **450** may extend from an end of the pump pipe **450** and lead to another end of the pump pipe **450**.

[0075] For example, the end of the pump pipe **450** may be connected to the vacuum pump **740**. The pump pipe **450** may communicate with the chamber port **315**. For example, the other end of the pump pipe **450** may be connected to the chamber port **315**. For example, the other end of the pump pipe **450** may be located between the chamber housing **310** and the vacuum release valve **540**.

[0076] The valve assembly **500** may include a vacuum line valve **550**. The vacuum line valve **550** may be located, connected, or coupled to the pump pipe **450**.

[0077] For example, the vacuum line valve **550** may be installed in the pump pipe **450**. For example, the vacuum line valve **1'550** may be located on the pump pipe **450** and between the end of the pump pipe **450** and the other end of the pump pipe **450**.

[0078] When the vacuum pump **740** operates in a state in which the vacuum line valve **550** is open, at least a portion of the gas (or air) located in the chamber housing **310** may reach the vacuum pump **740** via the chamber port **315** and the pump pipe **450**.

[0079] In a state in which the vacuum line valve **550** is closed, the hollow portion formed in the chamber unit **300** may be separated from the vacuum pump **740** without communicating with the vacuum pump **740**. Therefore, even if the vacuum pump **740** operates in a state in which the vacuum line valve **550** is closed, the vacuum line valve **550** can prevent the gas (or air) located in the chamber housing **310** from reaching the vacuum pump **740**.

[0080] The pipe assembly **400** may include the hopper pipe **420**. The hopper pipe **420** may form a shape of a pipe or a tube. The hopper pipe **420** may be connected or coupled to the hopper **200**.

[0081] For example, an end of the hopper pipe **420** may be connected to the hopper inlet **230**. For example, the end of the hopper pipe **420** may be connected to the hopper pipe inlet **231**.

[0082] The pipe assembly **400** may include a chamber pipe **430**. The chamber pipe **430** may form a shape of a pipe or a tube. The chamber pipe **430** may be connected or coupled to a chamber unit **300**.

[0083] For example, an end of the chamber pipe **430** may be connected to the chamber housing **310**. For example, the end of the chamber pipe **430** may be connected to a lower end of the chamber housing **310**. For example, the end of the chamber pipe **430** may be located below the chamber port **315**.

[0084] The pipe assembly **400** may include a branch pipe **440**. The branch pipe **440** may connect the container pipe **410**, the hopper pipe **420**, and the chamber pipe **430** to each other.

[0085] For example, the branch pipe **440** may connect the container pipe **410**, the hopper pipe **420**, and the chamber pipe **430** to each other through the valve assembly **500**.

[0086] For example, the branch pipe **440** may include a container branch portion **441**. The container branch portion **441** may form a shape of a pipe or a tube.

[0087] For example, the valve assembly **500** may include the container valve **510**. For example, the container valve **510** may connect the container branch portion **441** and the container pipe **410**.

[0088] For example, in a state in which the container valve **510** is opened, the container branch portion **441** and the container pipe **410** may communicate with each other. For example, in a state in which the container valve **510** is closed, an internal space of the container branch portion **441** may be separated from an internal space of the container pipe **410**.

[0089] For example, the branch pipe **440** may include a hopper branch portion **442**. The hopper branch portion **442** may form a shape of a pipe or a tube.

[0090] For example, the valve assembly **500** may include a hopper valve **520**. For example, the hopper valve **520** may connect the hopper branch portion **442** and the hopper pipe **420**.

[0091] For example, in a state in which the hopper valve **520** is opened, the hopper branch portion **442** and the hopper pipe **420** may communicate with each other. For example, in a state in which the hopper valve **520** is closed, an internal space of the hopper branch portion **442** may be separated from an internal space of the hopper pipe **420**.

[0092] For example, the branch pipe **440** may include a chamber branch portion **443**. The chamber branch portion **443** may form a shape of a pipe or a tube.

[0093] For example, the valve assembly **500** may include a chamber valve **530**. For example, the chamber valve **530** may connect the chamber branch portion **443** and the chamber pipe **430**.

[0094] For example, in a state in which the chamber valve **530** is opened, the chamber branch portion **443** and the chamber pipe **430** may communicate with each other. For example, in a state in which the chamber valve **530** is closed, an internal space of the chamber branch portion **443** may be separated from an internal space of the chamber pipe **430**.

[0095] The container branch portion **441**, the hopper branch portion **442**, and the chamber branch portion **443** may be connected to each other. For example, an end of the container branch portion **441**, an end of the hopper branch portion **442**, and an end of the chamber branch portion **443** may be connected and communicate with each other at a point.

[0096] For example, another end of the container branch portion **441** may be connected to the container valve **510**. For example, another end of the hopper branch portion **442** may be connected to the hopper valve **520**. For example, another end of the chamber branch portion **443** may be connected to the chamber valve **530**.

[0097] The powder feeding device **10** may include an outer filter **610**. The outer filter **610** may be connected to at least one of the chamber port **315** and the vacuum release valve **540**. For example, the outer filter **610** may be connected or coupled to the chamber port **315**.

[0098] In a state in which the vacuum release valve **540** is closed, the internal pressure (or atmospheric pressure) of the chamber housing **310** may be lower than the external pressure (or atmospheric pressure) of the chamber unit **300**.

[0099] In this state, when the vacuum release valve **540** is opened, gas (or air) located outside the chamber unit **300** may flow into the inside of the chamber unit **300**. The outer filter **610** may prevent foreign substances (e.g., dust, etc.) mixed in the gas (or air) located outside the chamber unit **300** from being introduced into the inside of the chamber unit **300**.

[0100] The powder feeding device **10** may include a vacuum filter unit **620**. The vacuum filter unit **620** may include a vacuum filter housing **621**. The vacuum filter housing **621** may be located or installed in the pump pipe **450**. For example, the vacuum filter housing **621** may be located on the pump pipe **450** and between the vacuum line valve **550** and the vacuum pump **740**.

[0101] The vacuum filter unit **620** may include a vacuum filter **622**. The vacuum filter **622** may be located in the vacuum filter housing **621**. The vacuum filter **622** may prevent foreign substances (e.g., dust, powder, etc.) located inside the pump pipe **450** from being introduced into the vacuum pump **740**.

[0102] For example, gas (or air) located in the chamber unit **300** may flow into the pump pipe **450** and may be incident on a face of the vacuum filter **622**. At least a portion of the gas (or air) incident on the face of the vacuum filter **622** may pass through the vacuum filter **622** and flow toward the vacuum pump **740**.

[0103] In this process, the vacuum filter **622** can prevent at least a portion of the foreign substances mixed in the gas (or air) located in the chamber unit **300** from being introduced into the vacuum pump **740**.

[0104] FIG. **2** illustrates a cut-away view of a part of a hopper illustrated in FIG. **1**.

[0105] Referring to FIG. **2**, the hopper **200** may include a wear prevention plate **240**. The wear-resistant plate **240** may be located inside the hopper body **210**. For example, the wear prevention plate **240** may be installed inside the hopper body **210**.

[0106] The hopper pipe **420** may be connected to the hopper pipe inlet **231**. For example, at least a portion of the powder located in the hopper pipe **420** may pass through the hopper pipe inlet **231** and flow into the inside of the hopper body **210**.

[0107] The wear prevention plate **240** may face the hopper pipe inlet **231**. For example, at least a portion of the powder that passes through the hopper pipe inlet **231** and flows into the inside of the hopper body **210** may be incident on the wear prevention plate **240**. Accordingly, the wear prevention plate **240** can prevent an impact applied to the hopper body **210** by the powder incident on the hopper body **210**.

[0108] FIG. **3** is a block diagram of a powder feeding device according to an embodiment of the disclosure.

[0109] Referring to FIGS. **1** to **3**, the powder feeding device **10** may include a control unit **710**. The control unit **710** may process signals. For example, the control unit **710** may perform calculations.

[0110] For example, the control unit **710** may be implemented through at least one of a processor, a computer, a server, an electric circuit, or a circuit board.

[0111] The powder feeding device **10** may include an input unit **720**. The input unit **720** may obtain an input from a user, etc. The input unit **720** may generate a first signal S**1** and transmit the first signal S**1** to the control unit **710**.

[0112] The first signal S**1** may include information on the input. For example, the first signal S**1** may include command information about an operation of at least one of the valve assembly **500**, a chamber blower **330**, a vacuum blower **623**, or the vacuum pump **740**.

[0113] The powder feeding device **10** may include a sensor unit **730**. The sensor unit **730** may include a pressure sensor **731**. A plurality of pressure sensors **731** may be provided.

[0114] For example, the pressure sensor **731** may be coupled to the chamber unit **300**. For example, the pressure sensor **731** may measure the internal pressure (or atmospheric pressure) of the chamber unit **300**. For example, the pressure sensor **731** may measure an internal atmospheric pressure of the chamber housing **310** or/and an internal atmospheric pressure of the chamber port **315**. A second signal S**2** may include information on the internal atmospheric pressure of the chamber housing **310** or the internal atmospheric pressure of the chamber port **315**.

[0115] When a relatively large amount of foreign substances are attached to the chamber filter **320**, the internal pressure (or atmospheric pressure) of the chamber unit **300** may be relatively high. When the internal pressure (or atmospheric pressure) of the chamber unit **300** is relatively high, the control unit **710** may determine that the relatively large amount of foreign substances are attached to the chamber filter **320**.

[0116] If it is determined that the relatively large amount of foreign substances are attached to the chamber filter **320**, the control unit **710** may generate at least one of a fourth signal S**4** and a seventh signal S**7**.

[0117] The fourth signal S**4** may include information on an operation command of the chamber blower **330** and may be transmitted to the chamber blower **330**. The seventh signal S**7** may include alarm information on an abnormality of the chamber filter **320** and may be transmitted to an alarm unit **750**.

[0118] For example, the pressure sensor **731** may be coupled to the vacuum filter housing **621**. For example, the pressure sensor **731** may measure an internal pressure of the vacuum filter housing **621**.

[0119] For example, the pressure sensor **731** may measure a pressure difference between two different points. For example, the pressure sensor **731** may measure a difference between a pressure at a point facing a face of the vacuum filter **622** and a pressure at a point facing another face of the vacuum filter **622**.

[0120] The "pressure difference" refer to a difference between a pressure at a point facing a face of the vacuum filter **622** and a pressure at a point facing another face of the vacuum filter **622**.

[0121] The second signal S**2** may include information on the difference between the pressure at the point facing the face of the vacuum filter **622** and the pressure at the point facing the other face of the vacuum filter **622**. That is, the second signal S**2** may include information on the pressure difference.

[0122] If the difference between the pressure at the point facing the face of the vacuum filter **622** and the pressure at the point facing the other face of the vacuum filter **622** is relatively large, the control unit **710** may determine that a relatively large amount of foreign substances are attached to the vacuum filter **622**.

[0123] If it is determined that the relatively large amount of foreign substances are attached to the vacuum filter **622**, the control unit **710** may generate at least one of a fifth signal S**5** and the seventh signal S**7**.

[0124] The fifth signal S**5** may include information on an operation command of the vacuum blower **623** and may be transmitted to the vacuum blower **623**. The seventh signal S**7** may include alarm information on an abnormality of the vacuum filter unit **620** and may be transmitted to the alarm unit **750**.

[0125] The sensor unit **730** may include a weight sensor **732**. The weight sensor **732** may be coupled to the hopper **200**. For example, the weight sensor **732** may be coupled or connected to the hopper body **210**. For example, the weight sensor **732** may include a load cell.

[0126] For example, the weight sensor **732** may measure a weight of the hopper body **210**. The weight of the hopper body **210** may vary depending on an amount of powder accommodated in the hopper body **210**. Therefore, the weight sensor **732** may measure the weight of the powder accommodated in the hopper body **210**.

[0127] For example, the weight sensor **732** may measure the weights of the hopper body **210** and the chamber unit **300**. The weight of the hopper body **210** may vary depending on the amount of powder accommodated in the hopper body **210**. The weight of the chamber unit **300** may vary depending on an amount of powder accommodated in the chamber housing **310**. Therefore, the weight sensor **732** may measure the weight of the powder accommodated in the hopper body **210** and the chamber housing **310**.

[0128] The sensor unit **730** may generate the second signal S**2** and transmit the second signal S**2** to the control unit **710**. The second signal S**2** may include at least one of information on the internal atmospheric pressure of the chamber unit **300** and information on the weight of the powder accommodated in the hopper body **210**.

[0129] The control unit **710** may generate output signals S**3**, S**4**, S**5**, S**6**, and S**7** based on input signals S**1** and S**2**. For example, the input signals S**1** and S**2** may include at least one of the first signal S**1** and the second signal S**2**. For example, the output signals S**3**, S**4**, S**5**, S**6**, and S**7** may include at least one of the third signal S**3**, the fourth signal S**4**, the fifth signal S**5**, the sixth signal S**6**, or the seventh signal S**7**.

[0130] The valve assembly **500** may receive the third signal S**3**. The third signal S**3** may include information on an operation command of the valve assembly **500**. The valve assembly **500** may operate in response to the third signal S**3**.

[0131] The chamber unit **300** may include the chamber blower **330**. The chamber blower **330** may be connected or coupled to at least one of the chamber housing **310** and the chamber port **315**. For example, the chamber blower **330** may be connected or coupled to the chamber housing **310**. The chamber blower **330** may receive the fourth signal S**4** and operate in response to the fourth signal S**4**.

[0132] The chamber blower **330** may provide gas (or air) to the chamber filter **320**. For example, the chamber blower **330** may spray gas (or air) into the chamber filter **320**. Hence, at least a portion of the foreign substances attached to the chamber filter **320** can be separated from the chamber filter **320**.

[0133] The vacuum filter unit **620** may include the vacuum blower **623**. The vacuum blower **623** may be connected or coupled to the vacuum filter housing **621**. The vacuum blower **623** may receive the fifth signal S**5** and operate in response to the fifth signal S**5**.

[0134] The vacuum blower **623** may provide gas (or air) to the vacuum filter **622**. For example, the vacuum blower **623** may spray gas (or air) into the vacuum filter **622**. Hence, at least a portion of the foreign substances attached to the vacuum filter **622** can be separated from the vacuum filter **622**.

[0135] The vacuum pump **740** may operate in response to the sixth signal S**6**. The vacuum pump **740** may suck gas (or air) located in the pump pipe **450**. Hence, the vacuum pump **740** may maintain an internal atmospheric pressure of the pump pipe **450** to be lower than an external atmospheric pressure of the vacuum pump **740**.

[0136] The powder feeding device **10** may include the alarm unit **750**. The alarm unit **750** may receive the seventh signal S**7** and operate in response to the seventh signal S**7**.

[0137] The alarm unit **750** may include a display. The alarm unit **750** may provide information on a state of the filters **320** and **622** to an operator.

[0138] For example, the alarm unit **750** may display an alarm about the abnormality of the filters **320** and **622**. For example, the alarm unit **750** may include a speaker. For example, the alarm unit **750** may express the alarm about the abnormality of the filters **320** and **622** as an auditory signal.

[0139] The operation of the powder feeding device **10** is described. The powder stored in the container **100** may be transferred to the inside of the hopper body **210**. For example, at least a portion of the powder stored in the container **100** may be transferred to the inside of the hopper body **210** due to a difference in the atmospheric pressure (or pressure).

[0140] For example, a method of transferring the powder stored in the container **100** to the inside of the hopper body **210** may be divided into two transfer modes. For example, a first transfer mode may indicate a transfer method in which a relatively large amount of powder is transferred from the container **100** to the hopper **200**. For example, a second transfer mode may indicate a transfer method in which a relatively small amount of powder is transferred from the container **100** to the hopper **200**.

[0141] For example, in the first transfer mode, at least a portion of the powder stored in the container **100** may sequentially pass through the container pipe **410** and the hopper pipe **420** and may be transferred to the inside of the hopper body **210**.

[0142] For example, in the second transfer mode, at least a portion of the powder stored in the container **100** may sequentially pass through the container pipe **410**, the chamber pipe **430**, and the chamber unit **300** and may be transferred to the inside of the hopper body **210**.

[0143] The process of transferring the powder stored in the container **100** to the inside of the hopper body **210** may be divided in time series. For example, 80% to 90% of the powder to be transferred to the inside of the hopper body **210** may be transferred from the container **100** to the hopper **200**

in the first transfer mode, and then the remaining powder may be transferred from the container **100** to the hopper **200** in the second transfer mode.

[0144] The operation of the valve assembly **500** may vary depending on the transfer mode.

[0145] For example, in the first transfer mode, the container valve **510**, the hopper valve **520**, the vacuum line valve **550**, and the coupling valve **560** may be maintained in an open state. For example, in the first transfer mode, the chamber valve **530** and the vacuum release valve **540** may be maintained in a closed state.

[0146] In the first transfer mode, the vacuum pump **740** may operate. When the vacuum pump **740** operates, the internal atmospheric pressure (or pressure) of the pump pipe **450** may be lower than the external atmospheric pressure.

[0147] When the internal atmospheric pressure (or pressure) of the pump pipe **450** is lower than the external atmospheric pressure, the internal atmospheric pressure of the chamber port **315** and the chamber housing **310** may be lower than the external atmospheric pressure.

[0148] When the internal atmospheric pressure of the chamber port **315** and the chamber housing **310** is lower than the external atmospheric pressure, the internal pressure of the hopper body **210** may be lower than the external atmospheric pressure. For example, the internal pressure of the hopper body **210** may be lower than the internal atmospheric pressure of the container body **110**.

[0149] When the internal pressure of the hopper body **210** is lower than the internal atmospheric pressure of the container body **110**, at least a portion of the powder accommodated in the hopper body **210** may sequentially pass through the container pipe **410** and the hopper pipe **420** and flow into the inside of the hopper body **210**.

[0150] As the powder flows into the hopper body **210** in the first transfer mode, the amount of powder measured by the weight sensor **732** may vary. If the amount of powder measured by the weight sensor **732** is less than a first reference powder amount, the first transfer mode may be maintained. If the amount of powder measured by the weight sensor **732** is greater than or equal to the first reference powder amount, the first transfer mode may be terminated and the second transfer mode may be started.

[0151] In the second transfer mode, the container valve **510**, the chamber valve **530**, and the vacuum line valve **550** may be maintained in an open state. In the second transfer mode, the hopper valve **520**, the vacuum release valve **540**, and the coupling valve **560** may be maintained in a closed state.

[0152] In the second transfer mode, at least a portion of the powder contained in the container **100** may sequentially pass through the container pipe **410** and the hopper pipe **430** due to a difference in the atmospheric pressure and be introduced into the inside of the chamber housing **310**. When the coupling valve **560** is opened, at least a portion of the powder located in the chamber housing **310** may pass through the coupling valve **560** and be introduced into the inside of the hopper body **210**.

[0153] As the powder is introduced into the hopper body **210** in the second transfer mode, the amount of powder measured by the weight sensor **732** may vary. If the amount of powder measured by the weight sensor **732** is less than a second reference powder amount, the second transfer mode may be maintained. If the amount of powder measured by the weight sensor **732** is greater than or equal to the second reference powder amount, the second transfer mode may be terminated.

[0154] The second reference powder amount may be greater than the first reference powder amount. For example, the first reference powder amount may be 80% to 90% of the second reference powder amount.

[0155] For example, powder as much as the first reference powder amount may be transferred in the first transfer mode, and powder by subtracting the first reference powder amount from the second reference powder amount may be transferred in the second transfer mode.

[0156] In the second transfer mode, at least one of the container valve **510** and the chamber valve **530** may be opened or closed in order to precisely measure the transferred powder. For example, in the second transfer mode, at least one of the container valve **510** and the chamber valve **530** may be opened or closed one or more times.

[0157] As a result, powder as much as the second reference powder amount can be transferred more accurately and quickly from the inside of the container **100** to the inside of the hopper body **210**.

[0158] In the process of transferring the powder stored in the container **100** to the inside of the hopper body **210**, the internal atmospheric pressure of the hopper body **210** may be maintained lower than the internal atmospheric pressure of the container **100**.

[0159] In order for the internal atmospheric pressure of the hopper body **210** to be maintained lower than the internal atmospheric pressure of the container **100**, the gas (or air) located inside the hopper body **210** may pass through the filters **320** and **622**. The filter (**320**, **622**) may include or indicate at least one of the chamber filter **320** and the vacuum filter **622**.

[0160] In the process of the gas (or air) passing through the filters **320** and **622**, foreign substances (e.g., dust or powder, etc.) mixed in the gas (or air) may be attached to the filters **320** and **622**.

[0161] The foreign substances (e.g., dust or powder, etc.) attached to the filters **320** and **622** can prevent the internal atmospheric pressure of the hopper body **210** from forming a negative pressure.

[0162] The negative pressure may refer to a pressure when a value by subtracting the internal atmospheric pressure of the container body **110** from the internal atmospheric pressure of the hopper body **210** is a negative value.

[0163] That is, the foreign substances (e.g., dust or powder, etc.) attached to the filters **320** and **622** can prevent the powder from being transferred from the container **100** to the inside of the hopper body **210**. A reference chamber internal pressure may be, for example, less than 1 atmosphere (atm). For example, the reference chamber internal pressure may be 0.5 atm.

[0164] For example, if the internal atmospheric pressure of the chamber housing **310** is greater than or equal to the reference chamber internal pressure, the foreign substances (e.g., dust or powder, etc.) attached to the filters **320** and **622** need to be separated from the filters **320** and **622**. The chamber unit **300** may be referred to as a "chamber."

[0165] A process of separating the foreign substances attached to the chamber filter **320** from the chamber filter **320** may be described. The process of separating the foreign

substances attached to the chamber filter **320** from the chamber filter **320** may vary depending on the transfer mode.

[0166] For example, a process of separating the foreign substances attached to the chamber filter **320** from the chamber filter **320** in the first transfer mode may be referred to as a "first blowing mode."

[0167] In the first blowing mode, the vacuum line valve **550** and the coupling valve **560** may be closed, and the vacuum release valve **540** may be opened. In the first blowing mode, after the chamber blower **330** operates, the vacuum line valve **550** and the coupling valve **560** may be opened and the vacuum release valve **540** may be closed.

[0168] For example, a process of separating the foreign substances attached to the chamber filter **320** from the chamber filter **320** in the second transfer mode may be referred to as a "second blowing mode."

[0169] In the second blowing mode, the chamber valve **530** and the vacuum line valve **550** may be closed, and the vacuum release valve **540** may be opened. In the second blowing mode, after the chamber blower **330** operates, the chamber valve **530** and the vacuum line valve **550** may be opened, and the vacuum release valve **540** may be closed.

[0170] In the first blowing mode and the second blowing mode, the chamber blower **330** may spray gas (or air) toward the chamber filter **320**. When the chamber blower **330** sprays gas (or air) toward the chamber filter **320**, the foreign substances attached to the chamber filter **320** may be separated from the chamber filter **320**.

[0171] In a state in which the coupling valve **560**, the chamber valve **530**, and the vacuum line valve **550** are closed, the internal atmospheric pressure of the chamber housing **310** may be lower than an external atmospheric pressure of the chamber housing **310**.

[0172] When the vacuum release valve **540** is opened in a state in which the internal atmospheric pressure of the chamber housing **310** is lower than the external atmospheric pressure of the chamber housing **310**, external air (or gas) may pass through the vacuum release valve **540** and be applied to the chamber filter **320**.

[0173] When the external air (or gas) is applied to the chamber filter **320**, the foreign substances attached to the chamber filter **320** may be separated from the chamber filter **320**. That is, when the internal atmospheric pressure of the chamber housing **310** is lower than the external atmospheric pressure of the chamber housing **310**, the vacuum release valve **540** may perform the function of the chamber blower **330**.

[0174] A plurality of chamber units **300** may be provided. For example, the powder feeding device **10** may include the plurality of chamber units **300**. The number of chamber pipes **430**, the number of coupling valves **560**, the number of chamber valves **530**, the number of vacuum release valves **540**, the number of vacuum line valves **550**, and the number of pump pipes **450** may depend on the number of chamber units **300**.

[0175] The number of chamber units **300** operating among the plurality of chamber units **300** may vary depending on the amount of powder to be transferred from the container **100**.

[0176] For example, if the amount of powder to be transferred from the container **100** is relatively large, the number of chamber units **300** operating among the plurality of chamber units **300** may relatively large.

[0177] For example, when the amount of powder to be transferred from the container **100** is relatively small, the number of chamber units **300** operating among the plurality of chamber units **300** may relatively small.

[0178] The number of chamber units **300** operating among the plurality of chamber units **300** may vary depending on an amount of powder that has been transferred among the powder to be transferred from the container **100**.

[0179] For example, the number of chamber units **300** operating among the plurality of chamber units **300** may vary over time. For example, in the powder transfer process, the number of chamber units **300** operating in the early and middle stages of the powder transfer process may be relatively large, and the number of chamber units **300** operating in the latter stage of the powder transfer process may be relatively small. As a result, the powder can be precisely measured and transferred.

[0180] The atmospheric pressure inside the chamber housing **310** of each of the plurality of chamber units **300** may be measured.

[0181] If the internal atmospheric pressure of some of the respective chamber housings **310** of the plurality of chamber units **300** is greater than or equal to the reference chamber internal pressure, the control unit **710** may spray gas (or air) into the chamber filter **320** of the chamber unit **300** forming a low internal atmospheric pressure.

[0182] If the internal atmospheric pressure of all the respective chamber housings **310** of the plurality of chamber units **300** is greater than or equal to the reference chamber internal pressure, the control unit **710** may blow the chamber filters **320** of all the plurality of chamber units **300**. In this case, the control unit **710** may operate the vacuum blower **623** to spray gas (or air) into the vacuum filter **622**.

[0183] The container pipe **410** and the container branch portion **441** may be formed integrally. For example, a "container pipe unit" may include the container pipe **410** and the container branch portion **441**.

[0184] For example, an end of the container pipe unit (**410**, **441**) may be connected to the container **100**, and another end of the container pipe unit (**410**, **441**) may be connected to the hopper branch portion **442** and the chamber branch portion **443**. The container valve **510** may be installed or coupled to the container pipe unit (**410**, **441**). The container valve **510** may open or close the container pipe unit (**410**, **441**).

[0185] The hopper pipe **420** and the hopper branch portion **442** may be formed integrally. For example, a "hopper pipe unit" may include the hopper pipe **420** and the hopper branch portion **442**.

[0186] For example, an end of the hopper pipe unit (**420**, **442**) may be connected to the hopper body **210**, and another end of the hopper pipe unit (**420**, **442**) may be connected to the container branch portion **441** and the chamber branch portion **443**. The hopper valve **520** may be installed or coupled to the hopper pipe unit (**420**, **442**). The hopper valve **520** may open or close the hopper pipe unit (**420**, **442**).

[0187] The chamber pipe **430** and the chamber branch portion **443** may be formed integrally. For example, a "chamber pipe unit" may include the chamber pipe **430** and the chamber branch portion **443**.

[0188] For example, an end of the chamber pipe unit (**430**, **443**) may be connected to the chamber housing **310**, and another end of the chamber pipe unit (**430**, **443**) may be connected to the container branch portion **441** and the

hopper branch portion **442**. The chamber valve **530** may be installed or coupled to the chamber pipe unit (**430**, **443**). The chamber valve **530** may open or close the chamber pipe unit (**430**, **443**).

[0189] The container pipe unit (**410**, **441**) may be branched from the other end of the container pipe unit (**410**, **441**) and may lead to the hopper pipe unit (**420**, **442**) and the chamber pipe unit (**430**, **443**).

[0190] For example, the powder contained in the container **100** may pass through the container pipe unit (**410**, **441**) and flow into the hopper pipe unit (**420**, **442**) or/and the chamber pipe unit (**430**, **443**).

[0191] For example, in a state in which the container valve **510** and the hopper valve **520** are opened and the chamber valve **530** is closed, the powder contained in the container **100** may pass through the container pipe unit (**410**, **441**) and flow into the hopper pipe unit (**420**, **442**).

[0192] For example, in a state in which the container valve **510** and the chamber valve **530** are opened and the hopper valve **520** is closed, the powder accommodated in the container **100** may pass through the container pipe unit (**410**, **441**) and flow into the chamber pipe unit (**430**, **443**).

[0193] The filter (**320**, **622**) may include or indicate at least one of the chamber filter **320** and the vacuum filter **622**. The blower (**330**, **623**) may include or indicate at least one of the chamber blower **330** and the vacuum blower **623**.

[0194] FIG. **4** is a flow chart illustrating a powder transfer method according to an embodiment of the disclosure.

[0195] Referring to FIGS. **1** to **4**, a powder transfer method S**10** may include a step S**100** of measuring an internal pressure. The internal pressure may include or indicate at least one of an internal pressure of the chamber housing **310** and a pressure difference of the vacuum filter housing **621**.

[0196] In the step S**100**, the pressure sensor **731** may measure the internal pressure of the chamber housing **310**. In the step S**100**, the sensor unit **730** may generate the second signal S**2** including information on the internal pressure of the chamber housing **310** and transmit the second signal S**2** to the control unit **710**.

[0197] In the step S**100**, the pressure sensor **731** may measure the pressure difference of the vacuum filter housing **621**. In the step S**100**, the sensor unit **730** may generate the second signal S**2** including information on the pressure difference of the vacuum filter housing **621** and transmit the second signal S**2** to the control unit **710**.

[0198] In the step S**100**, the sensor unit **730** may transmit the second signal S**2** including at least one of the information on the internal pressure of the chamber housing **310** and the information on the pressure difference of the vacuum filter housing **621** to the control unit **710**.

[0199] The powder transfer method S**10** may include a step S**200** of determining whether filter blowing is necessary. In the step S**200**, the control unit **710** may determine whether gas (or air) needs to be sprayed into the filters **320** and **622**.

[0200] For example, in the step S**200**, the control unit **710** may compare a chamber internal pressure with a reference chamber internal pressure. The chamber internal pressure may refer to an internal pressure of the chamber housing **310**.

[0201] In the step S**200**, the control unit **710** may determine whether the chamber internal pressure extracted from the second signal S**2** is greater than or equal to the reference chamber internal pressure. If the chamber internal pressure is greater than or equal to the reference chamber internal pressure, the control unit **710** may determine that gas needs to be sprayed into the chamber filter **320**.

[0202] For example, in the step S**200**, the control unit **710** may compare the pressure difference of the vacuum filter housing **621** with a reference pressure difference.

[0203] For example, in the step S**200**, the control unit **710** may determine that the vacuum filter **622** needs to be replaced if the pressure difference extracted from the second signal S**2** is greater than or equal to the reference pressure difference.

[0204] For example, if the pressure difference extracted from the second signal S**2** is greater than or equal to the reference pressure difference, the control unit **710** may transmit the seventh signal S**7** to the alarm unit **750**. The alarm unit **750** may generate an alarm about an abnormality of the vacuum filter **622** in response to the seventh signal S**7**. An operator or the like may recognize a state of the vacuum filter **622** through the alarm generated by the alarm unit **750**. The operator may replace the vacuum filter **622**.

[0205] For another example, in the step S**200**, if the pressure difference extracted from the second signal S**2** is greater than or equal to the reference pressure difference, the control unit **710** may determine that gas needs to be sprayed into the vacuum filter **622**.

[0206] The powder transfer method S**10** may include a filter blowing step S**300**. If the chamber internal pressure is determined to be greater than or equal to the reference chamber internal pressure or the pressure difference is determined to be greater than or equal to the reference pressure difference, the control unit **710** may perform the step S**300**.

[0207] In the step S**300**, the control unit **710** may operate the chamber blower **330**. For example, if the chamber internal pressure is determined to be greater than or equal to the reference chamber internal pressure, the chamber blower **330** may operate in response to the fourth signal S**4**.

[0208] In the step S**300**, the control unit **710** may operate the vacuum blower **623**. For example, if the pressure difference is determined to be greater than or equal to the reference pressure difference, the vacuum blower **623** may operate in response to the fifth signal S**5**.

[0209] For example, if the internal pressure of all the respective chamber housings **310** of the plurality of chamber units **300** is greater than or equal to the reference chamber internal pressure, the control unit **710** may operate the vacuum blower **623**.

[0210] In the step S**300**, an operation time and an operation output of at least one of the chamber blower **330** and the vacuum blower **623** may be preset. For another example, in the step S**300**, the operation time and the operation output of at least one of the chamber blower **330** and the vacuum blower **623** may vary depending on the chamber internal pressure. For example, in the step S**300**, the operation time and the operation output of the vacuum blower **623** may vary depending on the pressure difference.

[0211] For example, the operation time and the operation output of at least one of the chamber blower **330** and the vacuum blower **623** may have a positive correlation with a value by subtracting the reference chamber internal pressure from the chamber internal pressure.

[0212] For example, the operation time and the operation output of the vacuum blower **623** may have a positive

correlation with a value by subtracting the reference pressure difference from the pressure difference.

[0213] The powder transfer method **S10** may include a powder transfer step **S400**. If it is determined that there is no need to spray gas (or air) into the filters **320** and **622**, the control unit **710** may perform the step **S400**.

[0214] In the step **S400**, the control unit **710** may operate the valve assembly **500** and the vacuum pump **740**. In the step **S400**, at least a portion of the powder stored in the container **100** may be transferred to at least one of the hopper body **210** and the chamber housing **310**.

[0215] The powder transfer method **S10** may include a step **S500** of determining whether a termination reason has occurred. For example, if an amount of the transferred powder is greater than or equal to the second reference powder amount, it may be determined that the termination reason has occurred.

[0216] The powder transfer step **S400** may be performed in parallel with the internal pressure measurement step **S100**. For example, if it is determined that gas (or air) needs to be sprayed into the filters **320** and **622** while the powder transfer step **S400** is being performed, the powder transfer step **S400** may be stopped and the filter blowing step **S300** may be performed.

[0217] FIG. **5** is a flowchart illustrating a filter blowing step.

[0218] Referring to FIGS. **1** to **5**, the filter blowing step **S300** may include a step **S310** of determining a transfer mode. In the step **S310**, the control unit **710** may determine whether the transfer mode is the first transfer mode. For example, the control unit **710** may determine the amount of powder transferred to the hopper body **210** and the chamber housing **310** based on the second signal **S2**.

[0219] For example, if the amount of powder transferred to the hopper body **210** and the chamber housing **310** is less than the first reference powder amount, the control unit **710** may determine that the transfer mode is the first transfer mode.

[0220] For example, if the amount of powder transferred to the hopper body **210** and the chamber housing **310** is greater than or equal to the first reference powder amount and less than the second reference powder amount, the control unit **710** may determine that the transfer mode is the second transfer mode.

[0221] For example, the transfer mode may be included in the first signal **S1**. In this case, regardless of the second signal **S2**, the transfer mode may be determined based on the first signal **S1**.

[0222] The filter blowing step **S300** may include a step **S320** of performing a first blowing mode. If the transfer mode is determined to be the first transfer mode, the control unit **710** may perform the step **S320**.

[0223] The filter blowing step **S300** may include a step **S330** of performing a second blowing mode. If it is determined that the transfer mode is not the first transfer mode, the control unit **710** may perform the step **S330**. That is, if it is determined that the transfer mode is the second transfer mode, the control unit **710** may perform the step **S330**.

[0224] FIG. **6** is a flowchart illustrating a step of performing a first blowing mode.

[0225] Referring to FIGS. **1** to **6**, the first blowing mode performing step **S320** may include a step **S321** of performing a first pre-blowing process. For example, if the chamber internal pressure is greater than or equal to the reference chamber internal pressure, the step **S321** may be performed. In the step **S321**, the chamber unit **300** may communicate with the outside through the vacuum release valve **540**.

[0226] For example, in the step **S321**, the control unit **710** may control the vacuum line valve **550**, the coupling valve **560**, and the vacuum release valve **540**. In the step **S321**, the vacuum line valve **550** and the coupling valve **560** may be closed, and the vacuum release valve **540** may be opened.

[0227] The first blowing mode performing step **S320** may include a blower operation step **S322**. In the step **S322**, the blowers **330** and **623** may spray gas (or air) into the filters **320** and **622**.

[0228] For example, in the step **S322**, gas (or air) may be sprayed into the chamber filter **320**. For example, in the step **S322**, the chamber blower **330** may spray gas (or air) into the chamber filter **320**.

[0229] For example, in the step **S322**, gas (or air) may be sprayed into the vacuum filter **622**. For example, in the step **S322**, the vacuum blower **623** may spray gas (or air) into the vacuum filter **622**.

[0230] For another example, in the step **S322**, the vacuum filter **622** may be replaced with a new vacuum filter **622**. The replacement of the vacuum filter **622** may be performed manually or automatically.

[0231] The first blowing mode performing step **S320** may include a step **S323** of performing a first post-blowing process. In the step **S323**, the control unit **710** may control the vacuum line valve **550**, the coupling valve **560**, and the vacuum release valve **540**. In the step **S323**, the vacuum line valve **550** and the coupling valve **560** may be opened, and the vacuum release valve **540** may be closed.

[0232] FIG. **7** is a flowchart illustrating a step of performing a second blowing mode.

[0233] Referring to FIGS. **1** to **7**, the second blowing mode performing step **S330** may include step **S331** of performing a second pre-blowing process. For example, if the chamber internal pressure is greater than or equal to the reference chamber internal pressure, the step **S331** may be performed.

[0234] In the step **S331**, the control unit **710** may control the vacuum line valve **550**, the chamber valve **530**, and the vacuum release valve **540**. In the step **S331**, the vacuum line valve **550** and the chamber valve **530** may be closed, and the vacuum release valve **540** may be opened.

[0235] The second blowing mode performing step **S330** may include a blower operation step **S332**. In the step **S332**, the blowers **330** and **623** may spray gas (or air) into the filters **320** and **622**.

[0236] For example, in the step **S332**, air (or gas) may be sprayed into the chamber filter **320**. For example, in the step **S332**, the chamber blower **330** may spray gas (or air) into the chamber filter **320**.

[0237] For example, in the step **S332**, gas (or air) may be sprayed into the vacuum filter **622**. For example, in the step **S332**, the vacuum blower **623** may spray gas (or air) into the vacuum filter **622**.

[0238] For another example, in the step **S332**, the vacuum filter **622** may be replaced with a new vacuum filter **622**. The replacement of the vacuum filter **622** may be performed manually or automatically.

[0239] The second blowing mode performing step **S330** may include a step **S333** of performing a second post-blowing process. In the step **S333**, the control unit **710** may control the vacuum line valve **550**, the chamber valve **530**,

and the vacuum release valve **540**. In the step S**333**, the vacuum line valve **550** and the chamber valve **530** may be opened, and the vacuum release valve **540** may be closed.

[0240] FIG. **8** is a flowchart illustrating the powder transfer step S**400**.

[0241] Referring to FIGS. **1** to **8**, the powder transfer step S**400** may include a step S**410** of measuring a powder amount. In the step S**410**, the sensor unit **730** may measure an amount of powder located in the hopper body **210** and the chamber unit **300**. The second signal S**2** may include information on the amount of powder located in the hopper body **210** and the chamber unit **300**.

[0242] The powder transfer step S**400** may include a step S**420** of comparing an amount of the transferred powder with the first reference powder amount. In the step S**420**, the control unit **710** may determine whether the amount of powder located in the hopper body **210** and the chamber unit **300** is less than the first reference powder amount.

[0243] The powder transfer step S**400** may include a step S**430** of performing a first transfer mode. If the amount of powder located in the hopper body **210** and the chamber unit **300** is determined to be less than the first reference powder amount, the step S**430** may be performed. The step S**430** and the powder amount measurement step S**410** may be performed in parallel.

[0244] In the step S**430**, the container valve **510**, the hopper valve **520**, the coupling valve **560**, and the vacuum line valve **550** may maintain an open state. In the step S**430**, the chamber valve **530** and the vacuum release valve **540** may maintain a closed state. In the step S**430**, the vacuum pump **740** may operate, and the internal atmospheric pressure of the hopper body **210** may be lower than the internal atmospheric pressure of the container body **110**.

[0245] In the step S**430**, at least a portion of the powder accommodated in the container **100** may sequentially pass through the container pipe **410** and the hopper pipe **420** and be transferred to the inside of the hopper body **210**.

[0246] The powder transfer step S**400** may include a step S**440** of comparing an amount of the transferred powder with the second reference powder amount. If it is determined that the amount of the powder located in the hopper body **210** and the chamber unit **300** is not less than the first reference powder amount, the step S**440** may be performed.

[0247] For example, if it is determined that the amount of the powder located in the hopper body **210** and the chamber unit **300** is greater than or equal to the first reference powder amount, the step S**440** may be performed.

[0248] In the step S**440**, the control unit **710** may determine whether the amount of the powder located in the hopper body **210** and the chamber unit **300** is less than the second reference powder amount.

[0249] The powder transfer step S**400** may include a step S**450** of performing a second transfer mode. If it is determined that the amount of the powder located in the hopper body **210** and the chamber unit **300** is less than the second reference powder amount, the step S**450** may be performed. The step S**450** and the powder amount measurement step S**410** may be performed in parallel.

[0250] In the step S**450**, the container valve **510**, the chamber valve **530**, and the vacuum line valve **550** may maintain an open state. In the step S**450**, the hopper valve **520**, the coupling valve **560**, and the vacuum release valve **540** may maintain a closed state. In the step S**450**, the vacuum pump **740** may operate, and the internal atmospheric pressure of the chamber housing **310** may be lower than the internal atmospheric pressure of the container body **110**.

[0251] For another example, in the step S**450**, at least one of the container valve **510** and the chamber valve **530** may be opened or closed one or more times.

[0252] For example, at least one of the container valve **510** and the chamber valve **530** may be kept open during an "opening period" and then closed. The shorter the opening period, the more precisely the amount of powder to be transferred may be controlled.

[0253] For example, if the container valve **510** is kept open during the opening period and then closed, an amount of powder to be transferred and added to the chamber housing **310** may be less than or equal to an amount of powder accommodated in the chamber pipe **430**. As a result, the amount of powder transferred to the chamber housing **310** can be controlled.

[0254] If the amount of powder transferred to the chamber unit **300** and the hopper body **210** is less than the second reference powder amount, the process in which the container valve **510** is kept open during the opening period and then closed may be repeated.

[0255] In the step S**450**, the internal atmospheric pressure of the chamber housing **310** may be higher than the internal atmospheric pressure of the chamber housing **310** in the first transfer mode performing step S**430**. For example, an output of the vacuum pump **740** in the second transfer mode performing step S**450** may be lower than an output of the vacuum pump **740** in the first transfer mode performing step S**430**.

[0256] As a difference between the internal atmospheric pressure of the chamber housing **310** and the external atmospheric pressure decreases, the amount of powder flowing into the chamber housing **310** per hour may decrease. As a result, the amount of powder flowing into the chamber housing **310** can be more precisely controlled.

[0257] In the step S**450**, at least a portion of the powder accommodated in the container **100** may sequentially pass through the container pipe **410** and the chamber pipe **430** and be transferred to the inside of the chamber housing **310**. When the second transfer mode performing step S**450** is completed, the coupling valve **560** may be opened. When the coupling valve **560** is opened, the powder accommodated in the chamber housing **310** may be transferred to the inside of the hopper body **210**.

[0258] The first reference powder amount and the second reference powder amount may be positive real numbers. The second reference powder amount may be greater than the first reference powder amount. The second reference powder amount may indicate an amount or powder to be transferred to the inside of the hopper body **210** among the powder stored in the container **100**.

[0259] For another example, in the process of transferring the powder stored in the container **100** to the inside of the hopper body **210**, it may be necessary to omit the first transfer mode and transfer the powder in the second transfer mode. In this case, the first reference powder amount may be set to a real number less than or equal to zero.

[0260] Only specific examples of implementations of certain embodiments are described. Variations, improvements and enhancements of the disclosed embodiments and other embodiments may be made based on the disclosure of this patent document.

What is claimed is:

1. A powder feeding device comprising:
a container including a container body forming a storage space inside the container body;
a hopper including a hopper body forming an accommodation space inside the hopper body;
a chamber unit including a chamber housing, the chamber housing forming a hollow portion and coupled to the hopper body;
a pipe assembly including:
a container pipe unit which extends from the container and is opened or closed;
a hopper pipe unit which is branched from the container pipe unit, is connected to the hopper body, and is opened or closed; and
a chamber pipe unit which is branched from the container pipe unit, is connected to the chamber housing, and is opened or closed; and
a valve assembly including a coupling valve which is coupled to at least one of the chamber housing and the hopper body and connects or disconnects the storage space with the hollow portion.

2. The powder feeding device of claim 1, wherein the valve assembly further includes:
a container valve coupled to the container pipe unit, the container valve opening or closing the container pipe unit;
a hopper valve coupled to the hopper pipe unit, the hopper valve opening or closing the hopper pipe unit; and
a chamber valve coupled to the chamber pipe unit, the chamber valve opening or closing the chamber pipe unit.

3. The powder feeding device of claim 1, wherein the chamber unit further includes a chamber port extending from the chamber housing, and
wherein the pipe assembly further includes a pump pipe, and an end of the pump pipe extends from the chamber port and another end of the pump pipe leads to a vacuum pump.

4. The powder feeding device of claim 3, wherein the valve assembly further includes a vacuum line valve coupled to the pump pipe, the vacuum line valve opening or closing the pump pipe.

5. The powder feeding device of claim 4, wherein the valve assembly further includes a vacuum release valve coupled to the chamber port, the vacuum release valve opening or closing the chamber port.

6. The powder feeding device of claim 5, wherein the end of the pump pipe is located between the vacuum release valve and the chamber housing.

7. The powder feeding device of claim 5, wherein the chamber unit further includes a chamber filter which is located in the hollow portion of the chamber housing and performs a filter function.

8. The powder feeding device of claim 7, wherein the chamber unit further includes a chamber blower spraying a gas into the chamber filter.

9. The powder feeding device of claim 8, further comprising:
a pressure sensor measuring an internal atmospheric pressure of the chamber housing; and
a control unit connected to the pressure sensor and receiving a second signal from the pressure sensor,
wherein the control unit operates the chamber blower when the internal atmospheric pressure of the chamber housing from the second signal is greater than or equal to a reference chamber internal pressure.

10. The powder feeding device of claim 1, further comprising a vacuum pump and a vacuum filter unit,
wherein the pipe assembly further includes a pump pipe, and an end of the pump pipe extends from the chamber unit and another end of the pump pipe leads to the vacuum pump, and
wherein the vacuum filter unit includes:
a vacuum filter housing coupled to the pump pipe; and
a vacuum filter located in the vacuum filter housing.

11. The powder feeding device of claim 1, further comprising:
a weight sensor connected to the hopper body and measuring a weight applied to the weight sensor; and
a control unit connected to the weight sensor and receiving a second signal from the weight sensor,
wherein the control unit opens the container pipe unit and the hopper pipe unit and closes the chamber pipe unit when an increase amount of a weight measured by the weight sensor from the second signal is less than or equal to a first reference powder amount.

12. The powder feeding device of claim 11, wherein the control unit opens the container pipe unit and the chamber pipe unit and closes the hopper pipe unit when the increase amount of the weight from the second signal is greater than or equal to the first reference powder amount and is less than a second reference powder amount.

13. A powder transfer method of transferring a powder stored in a container to one of a hopper and a chamber unit, the powder transfer method comprising:
measuring an internal pressure of a chamber housing included in the chamber unit;
comparing the measured internal pressure with a reference chamber internal pressure; and
spraying a gas into a chamber filter included in the chamber housing when the measured internal pressure is greater than or equal to the reference chamber internal pressure, or transferring the powder stored in the container to one of the hopper and the chamber unit when the measured internal pressure is less than the reference chamber internal pressure,
wherein transferring the powder is performed in parallel with measuring the internal pressure.

14. The powder transfer method of claim 13, wherein spraying the gas into the chamber filter comprises:
determining whether a transfer mode is a first transfer mode;
performing a first blowing mode when the transfer mode is the first transfer mode; and
performing a second blowing mode when the transfer mode is not the first transfer mode.

15. The powder transfer method of claim 14, wherein when an amount of the powder introduced into the hopper and the chamber unit is less than a first reference powder amount, the transfer mode is the first transfer mode, and
wherein when the amount of the powder introduced into the hopper and the chamber unit is greater than or equal to the first reference powder amount and is less than a second reference powder amount, the transfer mode is a second transfer mode.

16. The powder transfer method of claim **14**, wherein performing the first blowing mode comprises:

performing a first pre-blowing process of blocking the hopper and the container from communicating with the chamber housing and exposing the chamber housing to an outside air;

spraying the gas into the chamber filter; and

performing a first post-blowing process of blocking the chamber housing from the outside air and communicating the chamber housing with the hopper and the container.

17. The powder transfer method of claim **14**, wherein performing the second blowing mode comprises:

performing a second pre-blowing process of blocking the hopper and the container from communicating with the chamber housing and exposing the chamber housing to an outside air;

spraying the gas into the chamber filter; and

performing a second post-blowing process of blocking the chamber housing from the outside air and communicating the chamber housing with the container.

18. The powder transfer method of claim **13**, wherein transferring the powder comprises:

measuring an amount of the powder introduced into the hopper and the chamber unit;

comparing the measured amount of the powder with a first reference powder amount; and

performing a first transfer mode when the measured amount of the powder is less than the first reference powder amount.

19. The powder transfer method of claim **18**, wherein transferring the powder comprises:

comparing the measured amount of the powder with a second reference powder amount when the measured amount of the powder is greater than or equal to the first reference powder amount; and

performing a second transfer mode when the measured amount of the powder is less than the second reference powder amount,

wherein in performing the first transfer mode, the powder stored in the container is transferred to the hopper, and

wherein in performing the second transfer mode, the powder stored in the container is transferred to the chamber housing,

20. The powder transfer method of claim **19**, wherein performing the first transfer mode is performed in parallel with measuring the amount of the powder, and

wherein performing the second transfer mode is performed in parallel with measuring the amount of the powder.

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