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

(11) EP 4 339 464 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
20.03.2024 Bulletin 2024/12

(21) Application number: **22807744.2**

(22) Date of filing: **09.05.2022**

(51) International Patent Classification (IPC):
F04D 17/12 *(2006.01)* ***F04D 25/06*** *(2006.01)*
F04D 29/053 *(2006.01)* ***F04D 29/28*** *(2006.01)*
F04D 29/42 *(2006.01)* ***F04D 27/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
**F04D 17/12; F04D 25/06; F04D 27/02;
F04D 29/053; F04D 29/28; F04D 29/42**

(86) International application number:
PCT/KR2022/006567

(87) International publication number:
WO 2022/240096 (17.11.2022 Gazette 2022/46)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **12.05.2021 KR 20210061528**

(71) Applicant: **LG Electronics Inc.
Yeongdeungpo-gu
Seoul 07336 (KR)**

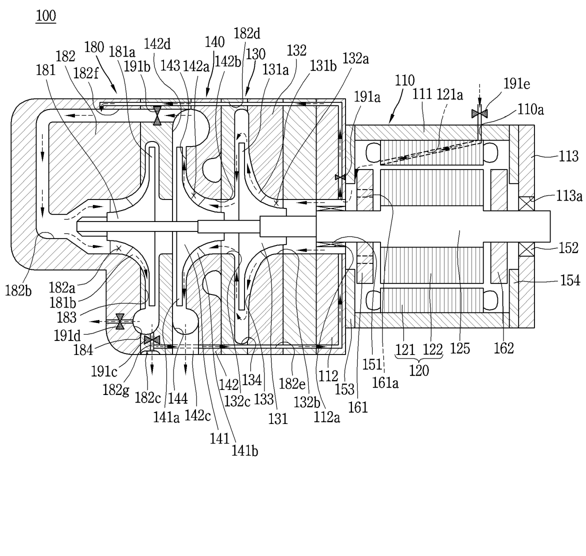
(72) Inventors:
- **OH, Junchul
Seoul 08592 (KR)**
- **BAE, Hyojo
Seoul 08592 (KR)**
- **MOON, Changgook
Seoul 08592 (KR)**
- **LEE, Byeongchul
Seoul 08592 (KR)**

(74) Representative: **Vossius & Partner
Patentanwälte Rechtsanwälte mbB
Siebertstrasse 3
81675 München (DE)**

(54) TURBOCOMPRESSOR AND METHOD FOR CONTROLLING SAME

(57) The present invention provides a turbocompressor and a method for controlling same, the turbocompressor comprising: a driving unit for enabling generation of rotational power for compressing refrigerant; a shaft extending in one direction and installed in the driving unit to be able to rotate by means of power generated by the driving unit; and first to third compression units installed on the shaft from one side of the shaft. The first compression unit comprises a first impeller rotated by power from the driving unit such that refrigerant discharged from an evaporator can be suctioned, and the suctioned refrigerant can be compressed and discharged. The second compression unit comprises a second impeller rotated by power from the driving unit such that refrigerant discharged from the first compression unit can be suctioned, and the suctioned refrigerant can be compressed and discharged. The third compression unit comprises a third impeller. The third impeller makes it possible to suction refrigerant discharged from the second compression unit, to compress the suctioned refrigerant, and to discharge same to the outside. Alternatively, the third impeller makes it possible to provide the refrigerant while bypassing the first compression unit.

FIG. 1



EP 4 339 464 A1

Description

Technical field

[0001] The present disclosure relates to a turbocompressor and a method for controlling the same, and more particularly, a turbocompressor having a structure capable of being miniaturized while achieving a high compression ratio by use of an impeller of a three-stage structure, and a method for controlling the same.

Background Art

[0002] In general, a compressor is applied to a vapor compression type refrigeration cycle (hereinafter, simply referred to as a refrigeration cycle), such as a refrigerator or an air-conditioner. Compressors may be classified into a reciprocal type, a rotary type, a scroll type, and the like according to a method of compressing refrigerant.

[0003] Among those compressors, a reciprocal compressor is a compressor in which gas is compressed by a reciprocating motion of a piston within a cylinder, and a scroll compressor is compressor in which a compression chamber is formed between a fixed wrap of a fixed scroll and an orbiting wrap of an orbiting scroll as the orbiting scroll engaged with the fixed scroll, fixed to an inner space of a hermetic case, performs an orbiting motion.

[0004] A turbocompressor (or turbo compressor) is a kind of centrifugal compressor, which executes a compression of gas by centrifugal force which is generated by rotation of wheels of backwardly-curved blades inside a casing. The turbocompressor has advantages of large capacity, low noise, low maintenance costs, and the like, as compared to a reciprocal compressor or a screw-type compressor. In addition, compression gas which is pure without containing oil can be produced.

[0005] A centrifugal turbocompressor includes an impeller and a diffuser decelerating an accelerated flow of fluid (gas, air) to switch the flow to pressure, in order to compress the gas. When a motor rotates the impeller at high speed, external gas (fluid) is suctioned in an axial direction of the impeller. The suctioned fluid is discharged in a centrifugal direction of the impeller. The fluid discharged in the centrifugal direction of the impeller is compressed while moving along a passage formed inside the turbocompressor.

[0006] An opposed type turbocompressor among two-stage turbocompressors is configured such that first-stage and second-stage impellers are disposed on both opposite sides of a motor based on the motor. This structure is mechanically stable since the impellers and journal bearings that apply a load to a shaft are disposed symmetrically to each other.

[0007] As a method for cooling the motor of the opposed type turbocompressor, cool liquid refrigerant of low temperature is injected into a motor unit. This method has an advantage of lowering temperature of the motor fast and definitely. However, refrigerant of a refrigeration cycle is partially bypassed to be used for cooling the motor, which may disadvantageously lower refrigeration performance of the refrigeration cycle to some extent.

[0008] As a method for cooling a motor while mitigating the problem, impellers are disposed on one side surface of the motor. When the impellers are disposed in such a manner, refrigerant suctioned into the impellers cools the motor while passing through the motor and then suctioned back into the impellers. Thus, since there is no need of an additional injection line, the disadvantage of the injection cooling of the opposed type is not caused. In addition, owing to the use of gaseous suction refrigerant other than cool liquid refrigerant, problems of deterioration of efficiency or reliability of an aerodynamic unit due to an introduction of the liquid refrigerant do not occur.

[0009] In a turbocompressor, an operating speed and a maximum compression ratio have a predetermined relationship. Also, there is a predetermined relationship between the operating speed and a flow rate. Due to those characteristics, upon designing the turbocompressor to have three stages or more, it is difficult to set a range of required flow rate in every compression ratio.

[0010] Especially, in order to have a flow rate range of 10% to 100% of partial load in a compression ratio of 15 or more, it is necessary to develop a technology of securing an operating range by performing compression sequentially through only two of first-stage to third-stage compression units, other than all of the three compression units, and performing suction or bypassing to a cycle through the remaining one compression unit.

[0011] Among the related art turbocompressors, Patent Document 1 (EP 2019192850 (February 26, 2020) discloses a turbocompressor having a shaft bearing cooling disposition structure.

[0012] Patent Document 1 provides, as a solution for overcoming deformation of a thrust bearing plate due to heat generation in a thrust bearing and a problem due to shaft vibration caused by the deformation, a structure in which a suction refrigerant bypass passage is formed adjacent to the thrust bearing plate to cool a thrust bearing unit, so as to suppress thermal deformation of the thrust bearing plate. Patent Document 1 also discloses, with respect to an inlet distributor having an inlet refrigerant passage, a structure in which the inlet distributor is disposed adjacent to the thrust bearing plate to cool it and has a bypass opening. Some of suction refrigerant introduced through the bypass opening cool the thrust bearing plate and rejoin the suction refrigerant.

[0013] In Patent Document 1, however, a guide which distributes suction refrigerant into a first-stage compression unit is difficult to be manufactured and assembled, and efficiency of the compressor is lowered due to flow resistance. Also, depending on operating conditions of the compressor, upon an introduction of refrigerant of high density, if the refrigerant is distributed for the purpose of cooling a bearing, heat generation is caused instead.

[0014] In Patent Document 1, refrigerant in a liquid state is injected and stirred well to cool a motor and a bearing unit. However, the liquid refrigerant of high density is expanded by one-time stirring in terms of characteristics of a horizontal type compressor and then introduced into a suction unit.

[0015] On the other hand, Patent Document 2 (US 7293954 (November 13, 2007)) discloses a control system for predicting and suppressing a surge in a turbocompressor. As a method for controlling a surge, hot-gas bypass is used. A bypass tube connects a discharge unit and a suction unit, and a bypass valve is applied to open and close the bypass tube. Paten Document 2 discloses the characteristics that, when a surge occurrence is determined in the control system for suppressing the surge, a hot-gas bypass valve is open and closed by a predetermined value through a control device.

[0016] In Patent Document 2, when the hot-gas bypass is applied, discharge gas of high temperature and high pressure in the discharge unit is mixed with suction gas, which raises suction pressure so as to allow surge avoidance.

[0017] In this way, when the hot-gas bypass is applied, it raises temperature of suction refrigerant. This may deteriorate efficiency of the compressor, and have a negative impact on reliability of a mechanism part. Especially, when performing three-stage compression, pressure and temperature of discharge gas that is discharged to a third-stage compression unit are extremely higher than those of a first-stage or second-stage compression unit. If the related art hot-gas bypass is used for surge avoidance in the three-stage turbocompressor, temperature of suction refrigerant is excessively increased.

Disclosure of Invention

Technical Problem

[0018] The present disclosure has been invented to solve those problems. One aspect of the present disclosure is to provide a turbocompressor having a structure that can be compact in size while achieving a high compression ratio by virtue of an impeller with a three-stage structure, and a method for controlling the same.

[0019] Another aspect of the present disclosure is to provide a turbocompressor that employs impellers of a three-stage structure, by which a flow rate range is not reduced while securing a compression ratio, and a method for controlling the same.

[0020] Another aspect of the present disclosure is to provide a turbocompressor having a structure in which only first-stage and second-stage compression units are used for discharge and a third-stage compression unit bypasses refrigerant or guides the refrigerant to flow to a suction part of the first-stage compression unit, so as to reduce an operating speed and minimize a loss, and a method for controlling the same.

[0021] Another aspect of the present disclosure is to provide a turbocompressor having a structure capable of securing a required flow rate range in every compression ratio upon being designed to three stages or more, and a method for controlling the same.

Solution to Problem

[0022] To achieve these and other advantages and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, there is provided a turbocompressor that includes a driving unit that is configured to generate rotational power for compressing refrigerant; a shaft that extends in one direction and is disposed in the driving unit to be rotatable by the power generated in the driving unit; and first to third compression units that are disposed on the shaft at one side of the shaft. The first compression unit includes a first impeller that is rotated by the power from the driving unit to suction refrigerant exhausted from an evaporator, compress the suctioned refrigerant, and discharge the compressed refrigerant. The second compression unit includes a second impeller that is rotated by the power from the driving unit to suction the refrigerant discharged from the first compression unit, compress the suctioned refrigerant, and discharge the compressed refrigerant. The third compression unit includes a third impeller that suctions the refrigerant discharged from the second compression unit, compresses the suctioned refrigerant, and discharges the compressed refrigerant to outside or bypasses the refrigerant to the first compression unit.

[0023] According to one example related to the present disclosure, the first compression unit may include a first inlet through which the refrigerant exhausted from the evaporator is suctioned. The first inlet may be connected to a first bypass passage that communicates with the third impeller to supply refrigerant, and the first bypass passage may have a first valve therein that allows or blocks a flow of the refrigerant from the first inlet to the third impeller.

[0024] The first compression unit may include a first impeller housing in which the first impeller is accommodated, and the first inlet may be formed in one side of the fist impeller housing in a direction parallel to the shaft.

[0025] The second compression unit may include a second outlet through which refrigerant discharged from the second impeller is supplied to the third impeller. The third compression unit may include an inflow passage that communicates with the second outlet and through which the refrigerant discharged from the second impeller flows into the third impeller. A second valve may be disposed in the second outlet or the inflow passage, and allow or block the flow of the refrigerant discharged from the second impeller to the third impeller.

[0026] The second compression unit may include a second impeller housing in which the second impeller is accommodated, and the second outlet may be disposed in the second impeller housing.

[0027] According to another example related to the present disclosure, the third compression unit may include a third volute disposed on a side portion of the third impeller to accumulate and exhaust refrigerant discharged from the third impeller, and a second bypass passage may be defined between the first inlet and the third volute.

[0028] A third valve may be disposed in the second bypass passage, and allow the refrigerant discharged from the third impeller to flow from the third volute to the first inlet or block the flow of the refrigerant.

[0029] A third outlet communicating with an external cycle may be formed in the third volute, and a fourth valve may be disposed in the third outlet. The fourth valve may allow or block a flow of the refrigerant discharged from the third impeller to the external cycle.

[0030] The driving unit may have therein a refrigerant inflow passage communicating with the first inlet, and a fifth valve for allowing or blocking an introduction of refrigerant exhausted from the evaporator may be connected to the refrigerant inflow passage.

[0031] To achieve these and other advantages and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, there is provided a turbocompressor according to another embodiment that includes a driving unit that is configured to generate rotational power for compressing refrigerant; a shaft that extends in one direction and is disposed in the driving unit to be rotatable by the power generated in the driving unit; first to third compression units that are disposed on the shaft at one side of the shaft; and a control unit that is electrically connected to the driving unit to control operations of the first to third compression units. The first compression unit includes a first impeller that is rotated by the power from the driving unit to suction refrigerant exhausted from an evaporator, compress the suctioned refrigerant, and discharge the compressed refrigerant. The second compression unit includes a second impeller that is rotated by the power from the driving unit to suction the refrigerant discharged from the first compression unit, compress the suctioned refrigerant, and discharge the compressed refrigerant. The third compression unit includes a third impeller that suctions the refrigerant discharged from the second compression unit, compresses the suctioned refrigerant, and discharges the compressed refrigerant to outside or bypasses the refrigerant to the first compression unit.

[0032] The first compression unit may include a first inlet through which the refrigerant exhausted from the evaporator is suctioned. The first inlet may be connected to a first bypass passage that communicates with the third impeller to supply refrigerant, and the first bypass passage may have a first valve therein that allows or blocks a flow of the refrigerant from the first inlet to the third impeller.

[0033] The second compression unit may include a second outlet through which refrigerant discharged from the second impeller is supplied to the third compression unit. The third compression unit may include an inflow passage that communicates with the second outlet and through which the refrigerant discharged from the second impeller flows into the third impeller. A second valve may be disposed in the second outlet or the inflow passage and allow or block the flow of the refrigerant discharged from the second impeller to the third impeller.

[0034] According to one example related to the present disclosure, the third compression unit may include a third volute disposed on a side portion of the third impeller to accumulate and exhaust refrigerant discharged from the third impeller, and a second bypass passage may be defined between the first inlet and the third volute.

[0035] The control unit may be electrically connected to the fourth valve, and control the fourth valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted.

[0036] The control unit may be electrically connected to the second valve, and control the second valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted.

[0037] According to another example related to the present disclosure, a third valve may be disposed in the second bypass passage, and allow the refrigerant discharged from the third impeller to flow from the third volute to the first inlet or block the flow of the refrigerant.

[0038] The control unit may be electrically connected to the third valve, and control the third valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted, and controls the third valve to be turned on when the target pressure ratio is higher than the available pressure ratio or when the surge occurrence is predicted.

[0039] A third outlet communicating with an external cycle may be formed in the third volute, and a fourth valve may be disposed in the third outlet. The fourth valve may allow or block a flow of the refrigerant discharged from the third impeller to the external cycle.

[0040] The control unit may be electrically connected to the fourth valve, and control the fourth valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted.

[0041] The driving unit may have therein a refrigerant inflow passage communicating with the first inlet, and a fifth valve for allowing or blocking an introduction of the refrigerant exhausted from the evaporator may be disposed in the refrigerant inflow passage.

[0042] The control unit may be electrically connected to the fifth valve, and control the fifth valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted, perform heating when a target flow rate is not higher than an available flow rate, and control the fifth valve to be turned on when it is possible to respond to an injection load.

[0043] To achieve these and other advantages and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, there is provided a method for controlling a turbocompressor that includes determining whether or not a target flow rate is higher than an available flow rate; determining whether or not a target pressure ratio is higher than an available pressure ratio; determining whether or not a surge occurrence is predicted; and determining whether to perform cooling or heating.

[0044] When it is determined to perform cooling, an operation of the compressor is controlled to be stopped.

[0045] The third compression unit may operate when the target pressure ratio is lower than the available pressure ratio, and the first to fifth valves may be turned off when the third compression unit operates, so as to perform an operation responsive to a load such that refrigerant is discharged.

[0046] The second compression unit may operate when the surge occurrence is not predicted, and the second and third valves may be turned off when the second compression unit operates, so as to perform an operation responsive to a load such that refrigerant is discharged.

Advantageous Effects of Invention

[0047] According to the present disclosure, only first-stage and second-stage compression units can be allowed for discharging refrigerant while a third-stage compression unit can bypass the refrigerant or allow refrigerant to flow to a suction part of the first-stage compression unit. This can decrease an operating speed and thus minimize a loss.

[0048] In the present disclosure, in order to secure a flow rate range of 10 % to 100 % of partial load at a pressure ratio of 15 or more, all the first-stage to third-stage compression units may not sequentially perform compression, but only the first-stage and second-stage compression units can sequentially perform compression and the third-stage compression unit can suction refrigerant or bypass the refrigerant to a cycle, thereby securing an operating range.

[0049] Also, in the present disclosure, a surge margin valve can be applied in such a manner. The surge margin valve may operate to avoid an operating speed upon an occurrence of an insecure operation at a surge point in the turbocompressor according to the present disclosure, or serve as a safety valve only for the turbocompressor as well as a bypass of the cycle, so as to operate appropriately in real time.

[0050] According to the present disclosure, without refrigerant distributors disclosed in the related art, operation characteristics of several valves can be controlled to minimize a problem that a large amount of refrigerant used for cooling at high speed flows into a first-stage inlet and a liquid compression is caused. This can improve reliability.

[0051] Also, in the present disclosure, although one more valve is additionally needed for direct bypass from a third-stage compression unit to a first-stage compression unit, a flow rate of the turbocompressor can increase to secure a larger operating range than a choking region. Therefore, a rated capacity can be expanded without increasing an operating speed, such that the turbocompressor can be applied to various products.

[0052] According to the present disclosure, a method of exhausting refrigerant by bypassing the refrigerant from the third-stage compression unit to an external cycle can simplify passages (e.g., pipes), thereby securing an operating range.

Brief Description of Drawings

[0053]

FIG. 1 is a sectional view of a turbocompressor according to the present disclosure.

FIG. 2 is a conceptual diagram illustrating flow, suction, and discharge of refrigerant in a turbocompressor according to the present disclosure.

FIG. 3 is a conceptual view illustrating first to third compression units in a turbocompressor according to the present disclosure.

FIG. 4 is a block diagram illustrating an electrical connection relationship of a control unit with a driving unit, first to third compression units, and first to fifth valves.

FIG. 5 is a flowchart illustrating an operation for the purpose of an operation of low-flow rate and high-pressure ratio in a turbocompressor according to the present disclosure.

FIG. 6 is a flowchart illustrating an operation for the purpose of an operation of low-flow rate and mid-pressure ratio in a turbocompressor according to the present disclosure.

FIG. 7 is a flowchart illustrating an operation for the purpose of an operation of high-flow rate and low-pressure ratio in a turbocompressor according to the present disclosure.

FIG. 8 is a graph showing flow rate, compression ratio, and surge line by comparing a three-stage turbocompressor according to the present disclosure with the related art two-stage turbocompressor.

Mode for the Invention

[0054] For the sake of brief description with reference to the drawings, the same or equivalent components may be provided with the same or similar reference numbers, and description thereof will not be repeated.

[0055] In addition, a structure that is applied to one embodiment will be equally applied to another embodiment as long as there is no structural and functional contradiction in the different embodiments.

[0056] A singular representation may include a plural representation unless it represents a definitely different meaning from the context.

[0057] In describing the present disclosure, if a detailed explanation for a related known function or construction is considered to unnecessarily divert the gist of the present disclosure, such explanation has been omitted but would be understood by those skilled in the art.

[0058] The accompanying drawings are used to help easily understand the technical idea of the present disclosure and it should be understood that the idea of the present disclosure is not limited by the accompanying drawings. The idea of the present disclosure should be construed to extend to any alterations, equivalents and substitutes besides the accompanying drawings.

[0059] A description will now be given in detail of a turbocompressor 100 according to the present disclosure, with reference to the accompanying drawings.

[0060] FIG. 1 is a sectional view illustrating a turbocompressor 100 according to the present disclosure. Referring to FIG. 1, a turbocompressor 100 according to the present disclosure includes a driving unit 120, a shaft 125, and first to third compression units 130, 140, and 180.

[0061] The driving unit 120 allows a generation of rotational driving force (or rotational power) for compressing refrigerant. The driving unit 120 includes a stator 120 and a rotor 122, and a detailed description thereof will be described later.

[0062] The shaft 125 extends in one direction, and is rotated by the driving force generated in the driving unit 120.

[0063] The first to third compression units 130, 140, and 180 are installed on the shaft 125 at one side of the shaft 125. The first to third compression units 130, 140, and 180 include first to third impellers 131, 141, and 181, respectively, for compressing refrigerant.

[0064] The first compression unit 130 includes a first impeller 131 that is rotated by the driving force applied from the driving unit 120 to suction refrigerant flowed out of an evaporator, compress the suctioned refrigerant, and discharge the compressed refrigerant.

[0065] The second compression unit 140 includes a second impeller 141 that is rotated by the driving force applied from the driving unit 120 to suction the refrigerant discharged from the first compression unit 130, compress the suctioned refrigerant, and discharge the compressed refrigerant.

[0066] The third compression unit 180 includes a third impeller 181 that suctions the refrigerant discharged from the second compression unit 140, compress the suctioned refrigerant, and discharge the compressed refrigerant to outside or bypass the refrigerant to the first compression unit.

[0067] By the refrigerant compression of the first and second compression units 130 and 140, the third compression unit 180 can receive suction refrigerant and bypass the received refrigerant to a housing or cycle, thereby minimizing a loss and securing a wide operating range.

[0068] The third compression unit 180 is configured to compress refrigerant of high density after the compressions in the first and second compression units 130 and 140. Therefore, the first compression unit 130 does not have to compress a relatively large flow rate of refrigerant upon the compression of the refrigerant, and the refrigerant compressed in the third compression unit 180 can be re-supplied to a rear end of an evaporator that is an inlet of the housing, thereby minimizing the loss.

[0069] Also, since a flow rate and a compression ratio are increased at a target speed for a target compression ratio, the compressor can be driven by reducing the operating speed through the first to third compression units 130, 140, and 180, which may result in securing efficiency improvement.

[0070] Also, this method can minimize an operation at a surge point and securing an operating region although the flow rate and the compression ratio are reduced at the same operating speed, compared to the three-stage compression through the first to third compression units 130, 140, and 180.

[0071] In the related art two-stage turbocompressor 100, the hot-gas bypass is configured to suction two-stage compressed discharge refrigerant back into the first-stage compression unit. This causes a relatively drastic increase in temperature and pressure, which limits a flow rate of the bypass. On the other hand, in the turbocompressor 100 according to the present disclosure, the refrigerant compressed through the third compression unit 180 is re-supplied to the first and second compression units 130 and 140. Therefore, the relative increase in temperature and pressure can be minimized and design margin for surge characteristics that the turbocompressor 100 typically has can be obtained.

[0072] Also, in the present disclosure, a surge margin valve can be applied in such a manner. The surge margin valve may operate to avoid an operating speed upon an occurrence of an insecure operation at the surge point in the turbocompressor 100 according to the present disclosure, or serve as a safety valve only for the turbocompressor 100, in addition to a bypass of a cycle, so as to operate appropriately in real time.

[0073] Detailed structures of the first to third compression units 130, 140, and 180 and the first to third impellers 131, 141, and 181 thereof will be described later.

[0074] The turbocompressor 100 according to the present disclosure may further include a casing 110. A driving unit 120 is disposed in an inner space of the casing 110. The first compression unit 130 and the second compression unit 140 are installed outside the casing 110, and a shaft 125 is connected between the driving unit 120 and the compression units 130 and 140.

[0075] The embodiment of the present disclosure illustrates an example of the turbocompressor 100 in which the driving unit 120 is disposed in the inner space of the casing 110, the first compression unit 130 and the second compression unit 140 are installed outside the casing 110, and the shaft 125 is connected between the driving unit 120 and the compression units 130 and 140.

[0076] The casing 110 may include a shell 111 having both ends open and formed in a cylindrical shape, and a front frame 112 and a rear frame 113 covering both the open ends of the shell 111.

[0077] A stator 121 of the driving unit 120 to be explained later is fixedly coupled to an inner circumferential surface of the shell 111. Shaft holes 112a and 113a through which the shaft 125 to be explained later is inserted are formed through central portions of the front frame 112 and the rear frame 113. Radial bearings 151 and 152 that support the shaft 125 in a radial direction may be disposed in the shaft hole 112a of the front frame 112 and the shaft hole 113a of the rear frame 113, respectively.

[0078] A first thrust bearing 153 may be coupled to an inner surface of the front frame 112, and a second thrust bearing 154 may be coupled to an inner surface of the rear frame 113. A first axial support plate (thrust runner) 161 and a second axial support plate (thrust runner) 162 may be fixed to the shaft 125 to be explained later to face the first thrust bearing 153 and the second thrust bearing 154, respectively. That is, the first thrust bearing 153 configures a first direction thrust limiting part together with the first axial support plate 161, and the second thrust bearing 154 configures a second direction thrust limiting part together with the second axial support plate 162. Accordingly, the first direction thrust limiting part and the second direction thrust limiting part form thrust bearings in opposite directions, so as to cancel thrusts with respect to rotational elements including the shaft 125.

[0079] Meanwhile, the driving unit 120 is configured to generate a rotational driving force (or rotational power) for compressing refrigerant. The driving unit 120 includes a stator 121 and a rotor 122. The shaft 125 for transferring rotational force of the rotor 122 to the first impeller 131 and the second impeller 141 to be explained later is coupled to a center of the rotor 122.

[0080] The stator 121 may be fixed to an inner circumferential surface of the casing 110 in a press-fitting manner or may be fixed to the casing 110 in a welding manner. For example, an outer circumferential surface of the stator 121 may be cut into a D-like shape, to define a passage with the inner circumferential surface of the casing 110 such that a fluid can move.

[0081] The rotor 121 is located inside the stator 121, and spaced apart from the stator 121. Balance weights for offsetting an eccentric load, which is generated due to the first impeller 131 and the second impeller 141 to be explained later, may be coupled to both axial ends of the rotor 122. However, the balance weights may alternatively be coupled to the shaft 125, without being installed on the rotor 122.

[0082] A refrigerant inflow passage 182f through which refrigerant discharged from an evaporator can be introduced may be defined in the driving unit 120. The structure thereof will be described later.

[0083] When the balance weights are coupled to the shaft 125, the first axial support plate 161 and the second axial support plate (thrust runner) 162 may be used as the balance weights.

[0084] The shaft 125 is press-fitted through the center of the rotor 122. Therefore, the shaft 125 rotates together with the rotor 122 by receiving rotational force, which is generated by interaction between the stator 121 and the rotor 122. The rotational force is transferred to the first impeller 131 and the second impeller 141 to suction, compress, and discharge refrigerant.

[0085] The first axial support plate 161 and the second axial support plate (thrust runner) 162 that are supported in the axial direction by the first and second thrust bearings 153 and 154 disposed on the casing 110 are fixed to both sides of the shaft 125, namely, both sides of the rotor 122. Accordingly, as aforementioned, the first axial support plate 161 and the second axial support plate 162 disposed on the shaft 125 can be supported in the opposite directions by the first thrust bearing 153 and the second thrust bearing 154 disposed on the casing 110, thereby effectively canceling the thrusts generated by the first compression unit 130 and the second compression unit 140.

[0086] The first axial support plate 161 and the second axial support plate 162 may be integrally disposed on both ends of the rotor 122. However, in this case, frictional heat, which is generated in the process that the first axial support plate 161 and the second axial support plate 162 support the shaft 125 in the axial direction, may be transmitted to the rotor 122. If the support plates 161 and 162 are deformed by receiving a load in the axial direction, the rotor 122 may be deformed. Therefore, the first axial support plate 161 and the second axial support plate 162 may preferably be spaced apart from the both ends of the rotor 122.

[0087] Also, when the first axial support plate 161 and the second axial support plate 162 are fixed to the shaft 125 to be explained later, as aforementioned, the first axial support plate 161 and the second axial support plate 162 may be adjusted in terms of weight or fixed position, so as to be used as the balance weights. In this instance, separate weight balances are not needed on the rotor 122. Thus, the weight of the rotational elements can be reduced and an axial length of the turbocompressor 100 can be shortened. This can reduce the size of the turbocompressor 100.

[0088] Here, the first thrust bearing 153 and the second thrust bearing 154 may not be disposed on the front frame 112 and the rear frame 113, but may be alternatively disposed on opposite sides, namely, the first axial support plate 161 and the second axial support plate 162.

[0089] Also, a front fixed plate (not illustrated) and a rear fixed plate (not illustrated) fixed to the casing 110 may further be disposed separately inside the casing 110, namely, between the front frame 112 and the rotor 122 or between the rear frame 113 and the rotor 122, and the first thrust bearing 153 and the second thrust bearing 154 may be disposed on the front fixed plate and the rear fixed plate. In this case, the axial length of the turbocompressor 100 may be elongated and the number of assembly processes may increase, but reliability can be enhanced as compared to installation of the thrust bearings directly on the casing 110.

[0090] Here, although not illustrated, both the first thrust bearing 153 and the second thrust bearing 154 may be disposed on one side of the driving unit 120, namely, on one of a front side or a rear side based on the stator 121.

[0091] On the other hand, the compression unit 130, 140, 180 may be configured as a single compression unit to proceed a single compression, but as illustrated in the embodiment of the present disclosure, may be configured as a plurality of compression units to proceed multi-stage compression. For the multi-stage compression, it may be preferable in terms of reliability that the plurality of compression units 130, 140, and 180 are disposed on both sides of the casing 110 based on the driving unit 120, considering the characteristics of the turbocompressor 100 having a great load in the axial direction.

[0092] However, when the plurality of compression nits are disposed on both sides to face each other, the length of the compressor may be increased and compression efficiency may be lowered. Therefore, the plurality of compression units 130, 140, and 180 may preferably be disposed at one side with respect to the driving unit 120, in terms of high efficiency and size reduction. Hereinafter, when the plurality of compression units are disposed to compress refrigerant through multiple stages, the plurality of compression units will be described by referring to as first to third compression units 130, 140, and 180 according to the order of compressing the refrigerant.

[0093] The first compression unit 130 and the second compression unit 140 are consecutively disposed at one side of the casing 110 along the axial direction.

[0094] The first compression unit 130 and the second compression unit 140 include first and second impellers 131 and 141, respectively, disposed to face the same direction such that refrigerant is introduced from the right side.

[0095] The first compression unit 130 includes a first inlet 132b through which refrigerant exhausted from the evaporator can be suctioned. The first compression unit 130 may include a first impeller housing 132 for accommodating the first impeller 131, and the first inlet 132b may be formed at one side of the first impeller housing 132. FIG. 1 illustrates an example in which the first inlet 132b is formed in parallel to the shaft at the first impeller housing 132 in the vicinity of the center of the turbocompressor 100.

[0096] A first bypass passage 182d is connected to communicate with the first inlet 132b to supply refrigerant to a third impeller 181. A first valve 191a may be disposed in the first bypass passage 182d to allow or block the flow of refrigerant from the first inlet 132b to the third impeller 181.

[0097] The first inlet 132b may be formed at one side of the first impeller housing 132 to be in parallel to the shaft.

[0098] The first valve 191a may be understood as a first bypass valve.

[0099] FIG. 1 illustrates an example, on an upper side, in which the first bypass passage 182d is formed in a shape like "¬" in the first impeller housing 132, a second impeller housing 142, and a third impeller housing 182, but the present disclosure may not be limited thereto. The first bypass passage 182d may alternatively be formed in any structure as long as it allows the first inlet 132b to communicate with an inflow passage 182f of the third compression unit 180.

[0100] The impellers 131, 141, and 181 of the first compression unit 130, the second compression unit 140, and the third compression unit 180 may be coupled by being accommodated in the impeller housings 132, 142, and 182, respectively. That is, the first impeller 131 of the first compression unit 130 may be accommodated in the first impeller housing 132 and coupled to the shaft 125, the second impeller 141 of the second compression unit 140 may be accommodated in the second impeller housing 142 and coupled to the shaft 125, and the third impeller 181 of the third compression unit 180 may be accommodated in the third impeller housing 182 and coupled to the shaft 125. However, in some cases, the first impeller 131, the second impeller 141, and the third impeller 181 may be coupled to the shaft 1215 in a manner of being consecutively disposed in one impeller housing. However, if a plurality of impellers are disposed in one impeller housing, the shape of the impeller housing may considerably be complicated.

[0101] Here, the embodiment of the present disclosure illustrates the example of the multi-stage turbocompressor 100 in which the plurality of impellers are consecutively disposed at one side of the driving unit 120 (or casing 110) in the axial direction.

[0102] A first impeller accommodation space 132a in which the first impeller 131 is accommodated is defined in the first impeller housing 132. The first inlet 132b, which is connected to a suction pipe 115 such that refrigerant is suctioned therethrough from an evaporator of a refrigeration cycle, is formed in one end of the first impeller housing 132. A first outlet 132c through which first-stage compressed refrigerant is guided to the second impeller housing 142 to be explained later is formed in another end of the first impeller housing 132.

[0103] The first impeller accommodation space 132a may be formed in a hermetic shape except for the first inlet 132b and the first outlet 132c to fully accommodate the first impeller 131, but may alternatively be formed in a semi-hermetic shape in which a rear surface side of the first impeller 131 is open and the open surface is closed by a front surface of the second impeller housing 142 to be explained later.

[0104] A first diffuser 133 is disposed between the first inlet 132b and the first outlet 132c to be spaced apart a predetermined distance from an outer circumferential surface of a blade portion 131b of the first impeller 131, and a first volute 134 is disposed at a downstream side of the first diffuser 133. The first inlet 132b is formed in a center of one axial end of the first diffuser 133, and the first outlet 132c is formed in a downstream side of the first volute 134.

[0105] The first impeller 131 includes a first circular plate portion 131a coupled to the shaft 125, and a plurality of first blade portions 131b formed on a front surface of the first circular plate portion 131a. The plurality of first blade portions 131b may be formed in a conical shape on the front surface of the first circular plate portion 131a but the rear surface of the first circulate plate portion 131a may be formed in a flat plate shape to receive back pressure.

[0106] Here, a back pressure plate (not illustrated) coupled to the shaft 125 may be disposed with being spaced apart a predetermined distance from the rear of the first circular plate portion 131a, and a first sealing member (not illustrated) formed in an annular shape may be disposed on the first back pressure plate. Accordingly, a first back pressure space (not illustrated) in which a predetermined amount of refrigerant is filled may be defined between a front surface of the second impeller housing 142 to be explained later and the first back pressure plate at the rear of the first circular plate portion. However, since pressure of refrigerant suctioned through the first inlet 132b is not so high and thus thrust applied to the shaft 125 is not great, the first back pressure space may be excluded.

[0107] The second compression unit 140 may include a second outlet 142d through which refrigerant discharged from the second impeller 141 can be applied to the third impeller 181. As an example, as will be described later, the second outlet 1423 may be disposed in the second impeller housing 142. Also, the third compression unit 180 may include an inflow passage 182f. The inflow passage 182f may communicate with the second outlet 142d, such that the refrigerant discharged from the second impeller 141 can flow into the third impeller 181.

[0108] A second valve 191b for allowing or blocking the flow of the refrigerant discharged from the second impeller 141 to the third impeller 181 may be disposed in the second outlet 142d or the inflow passage 182f.

[0109] The second valve 191b may be understood as an inflow valve for allowing or blocking the flow of the refrigerant discharged from the second impeller 141 to the third impeller 181.

[0110] FIG. 1 illustrates an example in which the second outlet 142d is disposed in a second volute and the second valve 191b is disposed in the inflow passage 182f. However, the present disclosure may not be limited to this structure, but the second valve 191b may alternatively be disposed at the side of the second outlet 142d.

[0111] Meanwhile, a second impeller accommodation space 142a in which the second impeller 141 is accommodated is defined in the second impeller housing 142. A second inlet 142b, which is connected to the first outlet 132c such that first-stage compressed refrigerant is suctioned therethrough is formed in one end of the second impeller housing 142. A second discharge port 142c which is connected to a discharge pipe 116 such that second-stage compressed refrigerant is guided to a condenser of the refrigeration cycle is formed in another end of the second impeller housing 142.

[0112] A second diffuser 143 is disposed between the second inlet 142b and the second discharge port 142c to be spaced apart a predetermined distance from an outer circumferential surface of a blade portion 141b of the second impeller 141, and a second volute 144 is disposed at a downstream side of the second diffuser 143. The second inlet 142b is formed in a center of one axial end of the second diffuser 143, and the second discharge port 142c is formed in a downstream side of the second volute 144.

[0113] The second impeller 141 includes a second circular plate portion 141a coupled to the shaft 125, and a plurality of second blade portions 141b formed on a front surface of the second circular plate portion 141a. The plurality of second blade portions 141b may be formed in a conical shape on the front surface of the second circular plate portion 141a but the rear surface of the second circulate plate portion 131a may be formed in a flat plate shape to receive back pressure.

[0114] Here, a second back pressure plate 145 coupled to the shaft 125 may be disposed with being spaced apart a predetermined distance from the rear of the second circular plate portion 141a. A second sealing groove 145a formed in an annular shape may be formed in the second back pressure plate 145 such that a second sealing member 146 can be inserted therein. Accordingly, a second back pressure space (not illustrated) in which a predetermined amount of refrigerant is filled is defined between the second back pressure plate (not illustrated) and the front surface of the casing 110 at the rear of the second circular plate portion 141a. Refrigerant introduced into the second back pressure space partially flows into the second sealing groove (not illustrated) to push the second sealing member (not illustrated) upward, thereby sealing the back pressure space.

[0115] The second back pressure space may be connected to a back pressure passage to be explained later. A back pressure adjustment valve for selectively opening and closing the back pressure passage to vary pressure of the second back pressure space depending on an operating speed (i.e., compression ratio) of the compressor may be disposed in the back pressure passage.

[0116] For example, the back pressure passage may be defined through the second impeller housing 142 and the casing 110. That is, a first back pressure passage may be defined in a housing that constitutes a wall body of the second impeller housing 142, and a second back pressure passage communicating with the first back pressure passage may be defined in the front frame 112 of the casing 110. Of course, the back pressure passage may alternatively be formed in a pipe shape branched from the middle of the discharge pipe, but it may be preferable in view of reduction of the number of components and manufacturing costs that the back pressure passage is defined inside the impeller housing and the front frame.

[0117] However, in some cases, the back pressure passage may alternatively be defined by assembling a separate valve frame, in which the back pressure passage is formed, to the front surface of the casing 110.

[0118] The third compression unit 180 is disposed adjacent to the second compression unit 140.

[0119] The third compression unit 180 is installed at one side of an opposite side to a position where the driving unit 120 of the casing 110 is disposed.

[0120] That is, the third impeller 181 of the third compression unit 180 is accommodated in the third impeller housing 182 and coupled to the shaft 125.

[0121] The third impeller 181, as illustrated in FIG. 1, is disposed to face an opposite direction to the first and second impellers 131 and 141.

[0122] Meanwhile, a third impeller accommodation space 182a in which the third impeller 181 is accommodated is defined in the third impeller housing 182. A third inlet 182b into which the refrigerant discharged from the second compression unit 140 flows, is formed in one end of the third impeller housing 182. A third discharge port 182c through which third-stage compressed refrigerant is discharged is formed in a lower side of the third impeller housing 182.

[0123] The third impeller accommodation space 182a may be formed in a hermetic shape except for the third inlet 182b and the third discharge port 182c to fully accommodate the third impeller 181, but may alternatively be formed in a semi-hermetic shape in which a rear surface side of the third impeller 181 is open and the open surface is closed by a rear surface of the second impeller housing 142 to be explained later.

[0124] A third diffuser 183 is disposed between the third inlet 182b and the third discharge port 182c to be spaced apart a predetermined distance from an outer circumferential surface of a blade portion 181b of the third impeller 181, and a third volute 184 is disposed at a downstream side of the third diffuser 183. The third inlet 182b is formed in a center of one axial end of the third diffuser 183, and the third discharge port 182c is formed in a downstream side of the third volute 184.

[0125] The third impeller 181 includes a third circular plate portion 181a coupled to the shaft 125, and a plurality of third blade portions 181b formed on a front surface of the third circular plate portion 181a. The plurality of third blade portions 181b may be formed in a conical shape on the front surface of the third circular plate portion 181a but the rear surface of the third circulate plate portion 131a may be formed in a flat plate shape to receive back pressure.

[0126] Here, a back pressure plate (not illustrated) coupled to the shaft 125 may be disposed with being spaced apart a predetermined distance from the rear of the third circular plate portion 181a, and a sealing member (not illustrated) formed in an annular shape may be disposed on the back pressure plate. Accordingly, a back pressure space (not illustrated) in which a predetermined amount of refrigerant is filled may be defined between a rear surface of the second impeller housing 142 to be explained later and the back pressure plate at the rear of the third circular plate portion.

[0127] The third compression unit 180 may include a third volute 184 through which refrigerant discharged from the third impeller 181 can be exhausted. A second bypass passage 182e may be defined between the first inlet 132b and the third volute 184.

[0128] A third valve 191c may be disposed in the second bypass passage 182e. The third valve 191c may allow refrigerant discharged from the third impeller 181 to flow from the third volute 132b to the first inlet 132b or block the flow of the refrigerant.

[0129] The third valve 191c may be understood as a second bypass valve installed in the second bypass passage 182e.

[0130] A third outlet 182g communicating with an external cycle may be formed in the third volute 184. A fourth valve 191d may be installed in the third outlet 182g. The fourth valve 191d may allow the refrigerant discharged from the third impeller 181 to flow to the external cycle or block the flow of the refrigerant.

[0131] The fourth valve 191d may be understood as a third bypass valve installed in the third bypass passage 182e.

[0132] FIG. 1 illustrates an example in which the third outlet 182g is formed in a left direction in the third impeller housing 182, the third outlet 182g communicates with the external cycle, and the fourth valve 191d is installed in the third outlet 182g.

[0133] As such, according to the present disclosure, the third outlet 182g communicating with the external cycle may be formed in the third volute 184, and the fourth valve 191d may be installed in the third outlet 182g. The third outlet 182g may communicate with the external cycle. With the configuration in which the fourth valve 191d is installed in the third outlet 182g, in order to secure a flow rate range of 10 % to 100% of partial load at a pressure ratio of 15 or more, all the first-stage to third-stage compression units may not sequentially perform compression, but only the first-stage and second-stage compression units may sequentially perform compression while only the third-stage compression unit performs suction or bypassing to the cycle, thereby securing an operating range.

[0134] Hereinafter, a description will be given of the aforementioned turbocompressor 100 having the multi-stage structure in which the plurality of impellers 131, 141, and 181 are consecutively disposed at one axial side with respect to the driving unit 120 (or casing 110) according to the present disclosure.

[0135] As illustrated in FIG. 1, the third impeller accommodation space 182a in which the third impeller 181 is accommodated is defined in the third impeller housing

182. An inflow passage 182f is defined in one end of the third impeller housing 182 to receive refrigerant discharged from the second compression unit 140. The third outlet 182g and the third discharge port 182c through which refrigerant compressed by the third impeller 181 is exhausted are formed in another end of the third impeller housing 182.

[0136] On the other hand, the driving unit 120 may include a refrigerant inflow passage 182f that can communicate with the first inlet 132b, and a fifth valve 191e may be connected to the refrigerant inflow passage 182f. The refrigerant inflow passage 182f may thusly be formed in at least one direction, for example.

[0137] The fifth valve 191e may be understood as an injection valve through which refrigerant supplies from the evaporator into the turbocompressor 100.

[0138] Referring to FIG. 1, an example in which the refrigerant inflow passage 182f is defined in the stator 121 of the driving unit 120 is illustrated. For example, the refrigerant inflow passage 182f is formed in a diagonal direction of the stator 121, but is not limited to this.

[0139] Also, FIG. 1 illustrates the example in which an inlet port communicating with the refrigerant inflow passage 182f is formed in the casing 110 and the fifth valve 191e is installed in the inlet port.

[0140] The fifth valve 191e may allow or block the flow of the refrigerant discharged from the evaporator into the turbocompressor 100.

[0141] A valve space (not illustrated) having a predetermined depth in a radial direction may be defined in the front frame 112 of the casing 110, and a back pressure valve (not illustrated) may be inserted into the valve space. A valve spring (not illustrated) for elastically supporting the back pressure valve may be disposed between the valve space and the back pressure valve.

[0142] Also, a second back pressure hole (not illustrated) through which the valve space communicates with the inner space of the casing 110 may be formed at one side of a first back pressure hole (not illustrated). The second back pressure hole is formed more inward than the first back pressure hole, namely, closer to a center side than the first back pressure hole, so as to be open when receiving higher pressure than pressure applied to the first back pressure hole, in case where the back pressure valve is open by pressure. However, in some cases, the second back pressure hole may be formed at the same position as the first back pressure hole, namely, a position where the first back pressure hole and the second back pressure hole are open and closed at the same time, or may be formed more outward than the first back pressure hole.

[0143] The back pressure valve may be configured as a ball valve or a piston valve. The back pressure valve may have three positions depending on a difference between force by pressure of refrigerant introduced through the back pressure passage and force by elastic force of an elastic member. That is, the back pressure valve may have a first position at which both the first back pressure hole and the second back pressure hole are closed, a second position where the first back pressure hole is open and the second back pressure hole is closed, and a third position where both the first back pressure hole and the second back pressure hole are open.

[0144] To this end, a valve spring may be configured as a compression coil spring and disposed between an inner surface of the back pressure valve and the valve space. In some cases, the valve spring may be configured as a tension coil spring and disposed between an outer side of the back pressure valve and the valve space.

[0145] Meanwhile, the aforementioned embodiment illustrates that the first back pressure passage is connected to a discharge side, namely, the second discharge port of the second compression unit 140, but in some cases, may alternatively be connected to a discharge side of the first compression unit. Even in this case, the basic configurations of the valve space and the back pressure valve may be equal to those of the previous embodiment.

[0146] The scroll compressor 100 according to the embodiment may operate as follows.

[0147] That is, when power is applied to the driving unit 120, rotational force is generated by induction current between the stator 121 and the rotor 122. The shaft 125 rotates together with the rotor 122 by the rotational force. The rotational force of the driving unit 120 is transferred to the first impeller 131, the second impeller 141, and the third impeller 181 by the shaft 125. The first impeller 131, the second impeller 141, and the third impeller 181 simultaneously rotate in the impeller accommodation spaces 132a, 142a, and 182a, respectively.

[0148] Refrigerant that has passed through the evaporator of the refrigeration cycle is introduced into the first impeller accommodation space 132a through the suction pipe and the first inlet 132b. The refrigerant increases in static pressure and simultaneously obtains centrifugal force while moving along the blade portions 131b of the first impeller 131. The refrigerant then passes through the first diffuser 133.

[0149] After the refrigerant passes through the first diffuser 133, kinetic energy leads to an increase in pressure head by the centrifugal force in the first diffuser 133. The centrifugally-compressed high temperature and high pressure refrigerant is accumulated in the first volute 134 and discharged through the first outlet 132c.

[0150] The refrigerant discharged from the first outlet 132c is transferred to the second impeller 141 through the second inlet 142b. During this, the refrigerant increases in static pressure again and simultaneously obtains the centrifugal force in the second impeller 141. The refrigerant then passes through the second diffuser 143.

[0151] The refrigerant passing through the second diffuser 143 is compressed up to desired pressure by the centrifugal force. The second-stage compressed high temperature and high pressure refrigerant is accumulated in the second volute 144 and discharged to the condenser through the second discharge port 142c and a discharge pipe (not illustrated). This series of processes are repeatedly performed.

[0152] Meanwhile, the refrigerant that has passed through the second diffuser 143 and accumulated in the second volute 144 is partially supplied to the third compression unit 180. The refrigerant supplied to the third compression unit 180 flows along the inflow passage 182f of the third compression unit 180, and flows into the third impeller accommodation space 182a through the third inlet 182b.

[0153] Afterwards, the refrigerant is transferred to the third impeller 181. The refrigerant increases in static pressure again and simultaneously obtains centrifugal force in the third impeller 181, and then passes through the second diffuser 183.

[0154] The refrigerant passing through the third diffuser 183 is compressed up to desired pressure by the centrifugal force. The third-stage compressed high temperature and high pressure refrigerant is accumulated in the third volute 184 and partially discharged to the condenser through the third discharge port 182c and the discharge pipe (not illustrated). This series of processes are repeatedly performed.

[0155] Another part of the refrigerant accumulated in the third volute 184 may be supplied to the external cycle through the third outlet 182g.

[0156] Also, still another part of the refrigerant accumulated in the third volute 184 may flow along the second bypass passage 182e under the control of the control unit 170 to be explained later so as to be supplied to the first compression unit 130 again.

[0157] At this time, the first impeller 131 and the second impeller 141 receive a thrust pushed rearward by the refrigerant suctioned through the first inlet 132b and the second inlet 142b of the impeller housings 132 and 142. Especially, the second impeller 141 receives a considerably great rearward thrust as the refrigerant, first-stage compressed by the first impeller 131, is introduced through the second inlet 142b. The rearward thrust is prevented by a first thrust bearing 153 and a second thrust bearing 154 disposed inside the casing 110, such that the first impeller 131 and the second impeller 141 are suppressed from being pushed rearward together with the shaft 125.

[0158] As aforementioned, when the first impeller 131 and the second impeller 141 are installed at one side based on the driving unit 120, a considerably great thrust is applied toward the axially rear side. Therefore, a cross-sectional area of the thrust bearing should be widely secured to maintain reliability of the compressor. However, this may increase frictional loss on the thrust bearing as well as the size of the turbocompressor 100, thereby causing a reduction of efficiency of the compressor. Also, during a high-speed operation, the load of the driving unit 120 may increase and heat may be generated more. However, the heat may not be effectively cooled or a separate cooling device is required. This may cause an increase in an overall manufacturing cost.

[0159] Considering this, the impeller 131 and the second impeller 141 can receive thrust rearward, and also the third impeller 181 can receive the thrust rearwards. Therefore, the thrust of the first and second impellers 131 and 141 and the thrust of the third impeller 181 can be offset to each other, thereby reducing a load applied to the thrust bearing. This can reduce the size of the thrust bearing and decrease the frictional loss due to the thrust bearing, thereby enhancing the efficiency of the compressor.

[0160] Also, during the high-speed operation, an amount of heat generated from the driving unit 120 may increase, but bypassed refrigerant can partially be induced into the inner space of the casing 110 to cool the driving unit 120. This can improve performance of the driving unit 120 and enhance the efficiency of the compressor.

[0161] FIG. 4 is a block diagram illustrating electrical connection relationship of the control unit 170 with the driving unit 120, the first to third compression units 130, 140, and 180 and the first to fifth valves 191a, 191b, 191c, 191d, and 191e.

[0162] As illustrated in FIG. 4, the turbocompressor 100 according to the present disclosure may further include the control unit 170.

[0163] The control unit 170 may operate or stop (turn on or off) the turbocompressor 100 based on a target flow rate, an available flow rate, a target pressure ratio, and an available pressure ratio of the turbocompressor 100.

[0164] For example, the control unit 170 may be configured to include a controller or substrate on which a CPU and the like are mounted, but may not be limited thereto. The control unit 170 may also be understood as a configuration in which various logics or programs associated with a control method to be explained later can be stored and utilized.

[0165] The control unit 170 is electrically connected to each of the driving unit 120, the first to third compression units 130, 140, and 180, and the first to fifth valves 191a, 191b, 191c, 191d, and 191e, and this example is illustrated in FIG. 4.

[0166] Upon each of an operation at a low flow rate and high pressure ratio, an operation at a low flow rate and mid-pressure ratio, or an operation at a high flow rate and low pressure ratio, the control unit 170 may turn on or off the first to fifth valves 191a, 191b, 191c, 191d, and 191e or control the second or third compression unit 140 or 180 to compress refrigerant, so as to respond to a load.

[0167] Meanwhile, a method for controlling the turbocompressor (S100, S200, and S300) according to the present disclosure is configured such that the control unit 170 controls the turbocompressor 100 to be driven or stopped (turned on or off) based on a target flow rate, an available flow rate, a target pressure ratio, and an available pressure ratio of the turbocompressor 100.

[0168] The turbocompressor control method (S100, S200, and S300) according to the present disclosure includes determining whether or not a target flow rate is higher than an available flow rate (S10, S210, S310), determining whether or not a target pressure ratio is higher than an available pressure ratio (S20, S220, S320), determining whether or not a surge occurrence is predicted (S50, S250, S350), and determining whether to perform cooling or heating (S30, S230, S330).

[0169] In the turbocompressor control method (S100, S200, and S300) according to the present disclosure, upon each of an operation at a low flow rate and high pressure ratio, an operation at a low flow rate and mid-pressure ratio, or an operation at a high flow rate and low pressure ratio, the first to fifth valves 191a, 191b, 191c, 191d, and 191e may be turned on or off or the second or third compression unit 140 or 180 may perform compression of refrigerant, to deal with the load.

[0170] Hereinafter, an example in which the turbocompressor control method (S100, S200, and S300) according to the present disclosure is performed by the control unit 170 will be described with reference to the flowchart of FIGS. 5 to7.

[0171] FIG. 5 is a flowchart illustrating a step (S100) of performing an operation at a low flow rate and high pressure ratio in the turbocompressor 100 according to the present disclosure.

[0172] The control unit 170 determines whether or not a target flow rate is higher than an available flow rate (S10). When the target flow rate is higher than the available flow rate (YES), the control unit 170 determines whether or not a target pressure ratio is higher than an available pressure ratio (S20). When the target flow rate is lower than the available flow rate (No), the control unit 170 determines whether to perform cooling or heating (S30).

[0173] When it is determined to perform cooling, the operation of the turbocompressor 100 is stopped (S35).

[0174] On the other hand, when it is determined to perform heating, the control unit 170 determines whether or not it is possible to respond to an injection load (S40). When it is possible to respond to the injection load (Yes), the control unit 170 turns the fifth valve 191e on (S43) to perform an operation in response to the load (S70).

[0175] The control unit 170 determines whether or not the target pressure ratio is higher than the available pressure ratio (S20). When the target pressure ratio is higher than the available pressure ratio (YES), the control unit 170 predicts whether or not a surge occurs (S50).

[0176] On the other hand, when the target pressure ratio is lower than the available pressure ratio (NO), the third compression unit 180 operates (S55). When the third compression unit 180 operates, the control unit 170 turns off the first to fifth valves 191a, 191b, 191c, 191d, and 191e (S57). In this case, Discharge 2 in FIG. 2 is performed and also an operation responsive to the load is performed (S70).

[0177] When it is predicted that the surge will occur (YES), the third valve 191c is turned on (S60), to perform the operation responsive to the load (S70).

[0178] On the other hand, when it is predicted that the surge will not (NO), the third compression unit 180 operates (S55). When the third compression unit 180 operates, the control unit 170 turns off the first to fifth valves 191a, 191b, 191c, 191d, and 191e (S57). In this case, Discharge 2 in FIG. 2 is performed and also the operation responsive to the load is performed (S70).

[0179] FIG. 6 is a flowchart illustrating a step (S200) of performing an operation at a low flow rate and mid-pressure ratio in the turbocompressor 100 according to the present disclosure.

[0180] The control unit 170 determines whether or not a target flow rate is higher than the available flow rate (S210). When the target flow rate is higher than the available flow rate (YES), the control unit 170 determines whether or not a target pressure ratio is higher than an available pressure ratio (S220). When the target flow rate is lower than the available flow rate (NO), the control unit 170 determines whether to perform cooling or heating (S230).

[0181] When it is determined to perform cooling, the operation of the turbocompressor 100 is stopped (S235).

[0182] On the other hand, when it is determined to perform heating, the control unit 170 determines whether or not it is possible to respond to an injection load (S240). When it is possible to respond to the injection load (YES), the control unit 170 turns the fifth valve 191e on (S243) to perform an operation in response to the load (S270).

[0183] The control unit 170 determines whether or not the target pressure ratio is higher than the available pressure ratio (S220). When the target pressure ratio is higher than the available pressure ratio (Yes), the control unit 170 predicts whether or not a surge will occur (S250).

[0184] On the other hand, the control unit 170 determines whether or not the target pressure ratio is higher than the available pressure ratio (S220). When the target pressure ratio is lower than the available pressure ratio (NO), the second compression unit 140 operates (S255). When the second compression unit 140 operates, the third valve 191c is turned off (S257). In this case, Discharge 1 in FIG. 2 is performed and also the operation responsive to the load is performed (S270).

[0185] Also, when it is predicted that the surge will occur (YES), the third valve 191c is turned on (S260), to perform the operation responsive to the load (S270).

[0186] On the other hand, when it is predicted that the surge will not occur (No), the second compression unit 140 operates (S255). When the second compression unit 140 operates, the third valve 191c is turned off (S257). In this case, Discharge 1 in FIG. 2 is performed and also the operation responsive to the load is performed (S270).

[0187] When the second compression unit 140 operates (S255), the second valve 191b is turned off and the first valve 191a is turned on in the third compression unit 180. Also, Discharge 2 in FIG. 2 may be performed or the fourth valve 191d may be turned on to perform the operation responsive to the load (S256).

[0188] Accordingly, a discharge backflow in a whole system can be suppressed by a pressure difference between Discharge 1 and Discharge 2 in FIG. 2, an operation response to a system load can be performed, and an occurrence of a surge in a refrigerant passage can be avoided. To this end, a backflow preventing valve (for example, a check valve) and a differential pressure valve may be disposed.

[0189] FIG. 7 is a flowchart illustrating a step (S300) of performing an operation at a high flow rate and low pressure ratio in the turbocompressor 100 according to the present disclosure.

[0190] The control unit 170 determines whether or not a target flow rate is higher than an available flow rate (S310). When the target flow rate is higher than the available flow rate (YES), the control unit 170 determines whether or not a target pressure ratio is higher than an available pressure ratio (S320). When the target flow rate is lower than the available flow rate (NO), the control unit 170 determines whether to perform cooling or heating (S330).

[0191] When it is determined to perform cooling, it is determined whether or not the third compression unit 180 is able to respond to the flow rate (S333). When the response is unable (NO), the operation of the turbocompressor 100 is stopped (S335). On the other hand, when the third compression unit 180 is able to respond to the flow rate (YES), the second valve 191b is turned off and the first valve 191a is turned on in the third compression unit 180. Also, Discharge 2 in FIG. 2 may be performed or the fourth valve 191d may be turned on to perform the operation responsive to the load (S356).

[0192] On the other hand, when it is determined to perform heating, the control unit 170 determines whether or not it is possible to respond to an injection load (S340). When it is possible to respond to the injection load (YES), the control unit 170 turns the fifth valve 191e on (S343) to perform an operation in response to the load (S370). When it is impossible to respond to the injection load (NO), the operation is stopped (S335).

[0193] Meanwhile, the control unit 170 determines whether or not the target pressure ratio is higher than the available pressure ratio (S320). When the target pressure ratio is higher than the available pressure ratio (YES), the control unit 170 predicts whether or not a surge will occur (S350).

[0194] When it is predicted that the surge will occur (YES), the third valve 191c is turned on (S360), to perform the operation responsive to the load (S370).

[0195] On the other hand, when it is predicted that the surge will not occur (NO), the second compression unit 140 operates (S355). When the second compression unit 140 operates, the second and third valves 191b and 191c are turned off. In this case, Discharge 1 in FIG. 2 is performed (S357) and also the operation responsive to the load is performed (S370).

[0196] When the second compression unit 140 operates (S355), the second valve 191b is turned off and the first valve 191a is turned on in the third compression unit 180. Also, Discharge 2 in FIG. 2 may be performed or the fourth valve 191d may be turned on to perform the operation responsive to the load (S356).

[0197] Accordingly, a discharge backflow in a whole system can be suppressed by a pressure difference between Discharge 1 and Discharge 2 in FIG. 2, an operation response to a system load can be performed, and an occurrence of a surge in a refrigerant passage can be avoided. To this end, a backflow preventing valve (for example, a check valve) and a differential pressure valve may be disposed.

[0198] The scroll compressor 100 and the method for controlling the same (S100, S200, S300) are not limited to the configuration and the method of the embodiments described above, but the embodiments may be configured such that all or some of the embodiments are selectively combined so that various modifications can be made.

[0199] It will be apparent to those skilled in the art that the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The above detailed description should not be limitedly construed in all aspects and should be considered as illustrative. Therefore, all changes and modifications that fall within the metes and bounds of the claims, or equivalents of such metes and bounds are therefore intended to be embraced by the appended claims.

Industrial applicability

[0200] The present disclosure can be applied to a turbocompressor and a method for controlling the same.

Claims

1. A turbocompressor comprising:

a driving unit that is configured to generate rotational power for compressing refrigerant;
a shaft that extends in one direction and is disposed in the driving unit to be rotatable by the power generated in the driving unit; and
first to third compression units that are disposed on the shaft at one side of the shaft,
wherein the first compression unit comprises a first impeller that is rotated by the power from the driving unit to suction refrigerant exhausted from an evaporator, compress the suctioned refrigerant, and discharge the compressed refrigerant,
the second compression unit comprises a second impeller that is rotated by the power from the driving unit to suction the refrigerant discharged from the first compression unit, compress the suctioned refrigerant, and discharge

the compressed refrigerant, and
the third compression unit comprises a third impeller that suctions the refrigerant discharged from the second compression unit, compresses the suctioned refrigerant, and discharges the compressed refrigerant to outside or bypasses the refrigerant to the first compression unit.

2. The turbocompressor of claim 1, wherein the first compression unit comprises a first inlet through which the refrigerant exhausted from the evaporator is suctioned,

the first inlet is connected to a first bypass passage that communicates with the third impeller to supply refrigerant, and
the first bypass passage has a first valve therein that allows or blocks a flow of the refrigerant from the first inlet to the third impeller.

3. The turbocompressor of claim 2, wherein the first compression unit comprises a first impeller housing in which the first impeller is accommodated, and the first inlet is formed in one side of the fist impeller housing in a direction parallel to the shaft.

4. The turbocompressor of claim 1 or 2, wherein the second compression unit comprises a second outlet through which refrigerant discharged from the second impeller is supplied to the third impeller,

the third compression unit comprises an inflow passage that communicates with the second outlet and through which the refrigerant discharged from the second impeller flows into the third impeller,
a second valve is disposed in the second outlet or the inflow passage, and
the second valve allows or blocks the flow of the refrigerant discharged from the second impeller to the third impeller.

5. The turbocompressor of claim 4, wherein the third compression unit comprises a third volute disposed on a side portion of the third impeller to accumulate and exhaust refrigerant discharged from the third impeller, and
a second bypass passage is defined between the first inlet and the third volute.

6. The turbocompressor of claim 5, wherein a third valve is disposed in the second bypass passage, and the third valve allows the refrigerant discharged from the third impeller to flow from the third volute to the first inlet or block the flow of the refrigerant.

7. The turbocompressor of claim 5, wherein a third outlet communicating with an external cycle is formed in the third volute, and a fourth valve is disposed in the third outlet, and
the fourth valve allows or blocks a flow of the refrigerant discharged from the third impeller to the external cycle.

8. The turbocompressor of claim 2, wherein the driving unit has therein a refrigerant inflow passage communicating with the first inlet, and
a fifth valve for allowing or blocking an introduction of refrigerant exhausted from the evaporator is connected to the refrigerant inflow passage.

9. A turbocompressor comprising:

a driving unit that is configured to generate rotational power for compressing refrigerant;
a shaft that extends in one direction and is disposed in the driving unit to be rotatable by the power generated in the driving unit;
first to third compression units that are disposed on the shaft at one side of the shaft; and
a control unit that is electrically connected to the driving unit to control operations of the first to third compression units,
wherein the first compression unit comprises a first impeller that is rotated by the power from the driving unit to suction refrigerant exhausted from an evaporator, compress the suctioned refrigerant, and discharge the compressed refrigerant,
the second compression unit comprises a second impeller that is rotated by the power from the driving unit to suction the refrigerant discharged from the first compression unit, compress the suctioned refrigerant, and discharge the compressed refrigerant, and
the third compression unit comprises a third impeller that suctions the refrigerant discharged from the second compression unit, compresses the suctioned refrigerant, and discharges the compressed refrigerant to outside or bypasses the refrigerant to the first compression unit.

10. The turbocompressor of claim 9, wherein the first compression unit comprises a first inlet through which the refrigerant exhausted from the evaporator is suctioned,

the first inlet is connected to a first bypass passage that communicates with the third impeller to supply refrigerant, and
the first bypass passage has a first valve therein that allows or blocks a flow of the refrigerant from the first inlet to the third impeller.

11. The turbocompressor of claim 9 or 10, wherein the second compression unit comprises a second outlet

through which refrigerant discharged from the second impeller is supplied to the third compression unit,

the third compression unit comprises an inflow passage that communicates with the second outlet and through which the refrigerant discharged from the second impeller flows into the third impeller,
a second valve is disposed in the second outlet or the inflow passage, and
the second valve allows or blocks the flow of the refrigerant discharged from the second impeller to the third impeller.

12. The turbocompressor of claim 10, wherein the third compression unit comprises a third volute disposed on a side portion of the third impeller to accumulate and exhaust refrigerant discharged from the third impeller, and
a second bypass passage is defined between the first inlet and the third volute.

13. The turbocompressor of claim 11, wherein the control unit is electrically connected to the second valve, and controls the second valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted.

14. The turbocompressor of claim 12, wherein a third valve is disposed in the second bypass passage, and the third valve allows the refrigerant discharged from the third impeller to flow from the third volute to the first inlet or blocks the flow of the refrigerant.

15. The turbocompressor of claim 14, wherein the control unit is electrically connected to the third valve, and controls the third valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted, and controls the third valve to be turned on when the target pressure ratio is higher than the available pressure ratio or when the surge occurrence is predicted.

16. The turbocompressor of claim 12, wherein a third outlet communicating with an external cycle is formed in the third volute, and a fourth valve is disposed in the third outlet,

the fourth valve allows or blocks a flow of refrigerant discharged from the third impeller to the external cycle, and
the control unit is electrically connected to the fourth valve, and controls the fourth valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted.

17. The turbocompressor of claim 12, wherein the driving unit has therein a refrigerant inflow passage communicating with the first inlet, and

a fifth valve for allowing or blocking an introduction of the refrigerant exhausted from the evaporator is connected to the refrigerant inflow passage, and
the control unit is electrically connected to the fifth valve, and controls the fifth valve to be turned off when a target pressure ratio is not higher than an available pressure ratio or when a surge occurrence is not predicted, performs heating when a target flow rate is not higher than an available flow rate, and controls the fifth valve to be turned on when it is possible to respond to an injection load.

18. A method for controlling a turbocompressor, the method comprising:

determining whether or not a target flow rate is higher than an available flow rate;
determining whether or not a target pressure ratio is higher than an available pressure ratio;
determining whether or not a surge occurrence is predicted; and
determining whether to perform cooling or heating.

19. The method of claim 18, wherein the third compression unit operates when the target pressure ratio is lower than the available pressure ratio, and the first to fifth valves are turned off when the third compression unit operates, so as to perform an operation responsive to a load such that refrigerant is discharged.

20. The method of claim 18, wherein the second compression unit operates when the surge occurrence is not predicted, and the second and third valves are turned off when the second compression unit operates, so as to perform an operation responsive to a load such that refrigerant is discharged.

FIG. 1

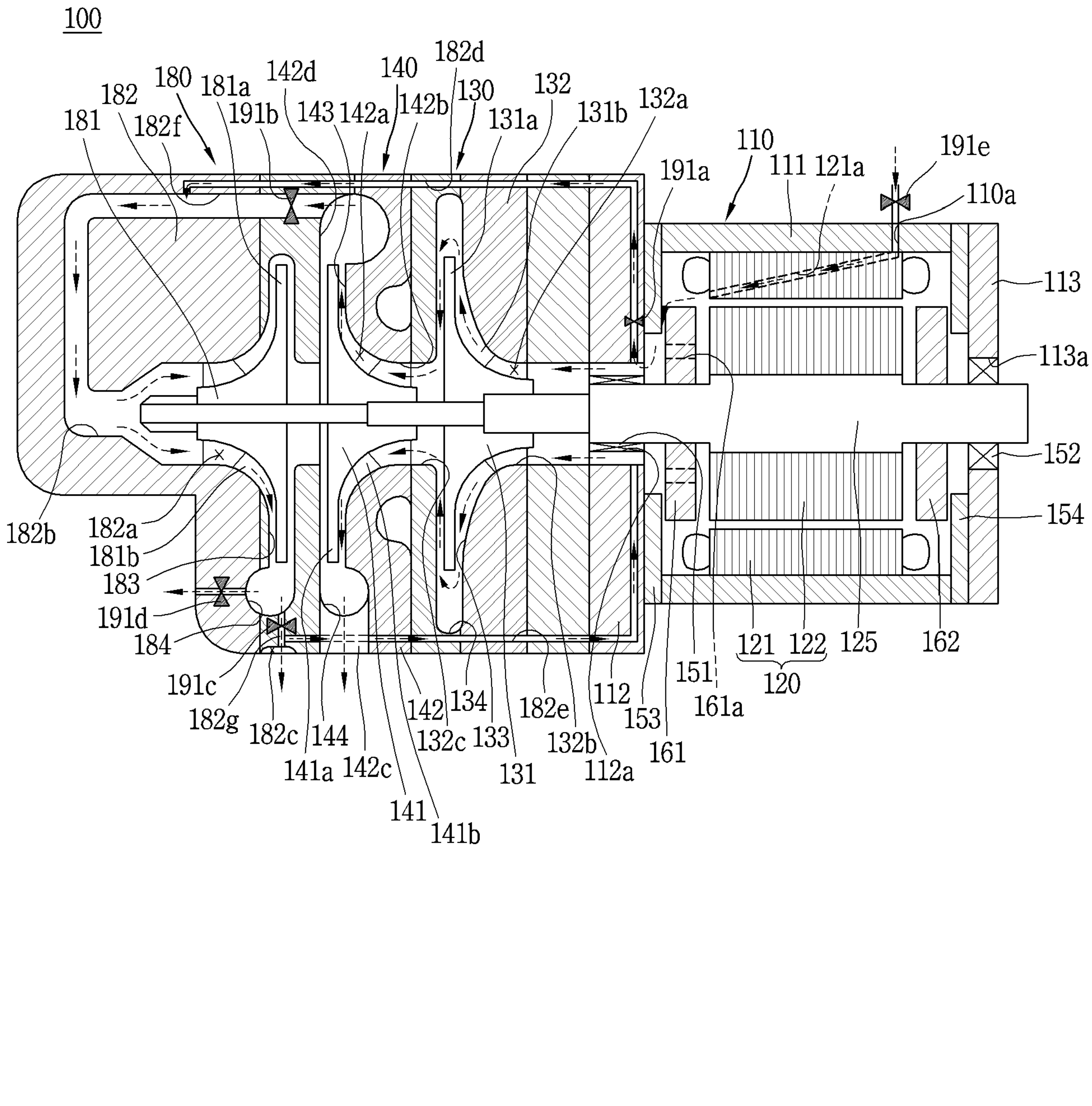

100
180
181
182
182f
181a
191b
142d
143
142a
140
142b
182d
130
131a
132
131b
132a
110
111
121a
191e
191a
110a
113
113a
152
154
182b
182a
181b
183
191d
184
191c
182g
182c
144
141a
142c
141
141b
142
132c
133
134
131
182e
132b
112
112a
153
161
151
161a
121
122
120
125
162

FIG. 2

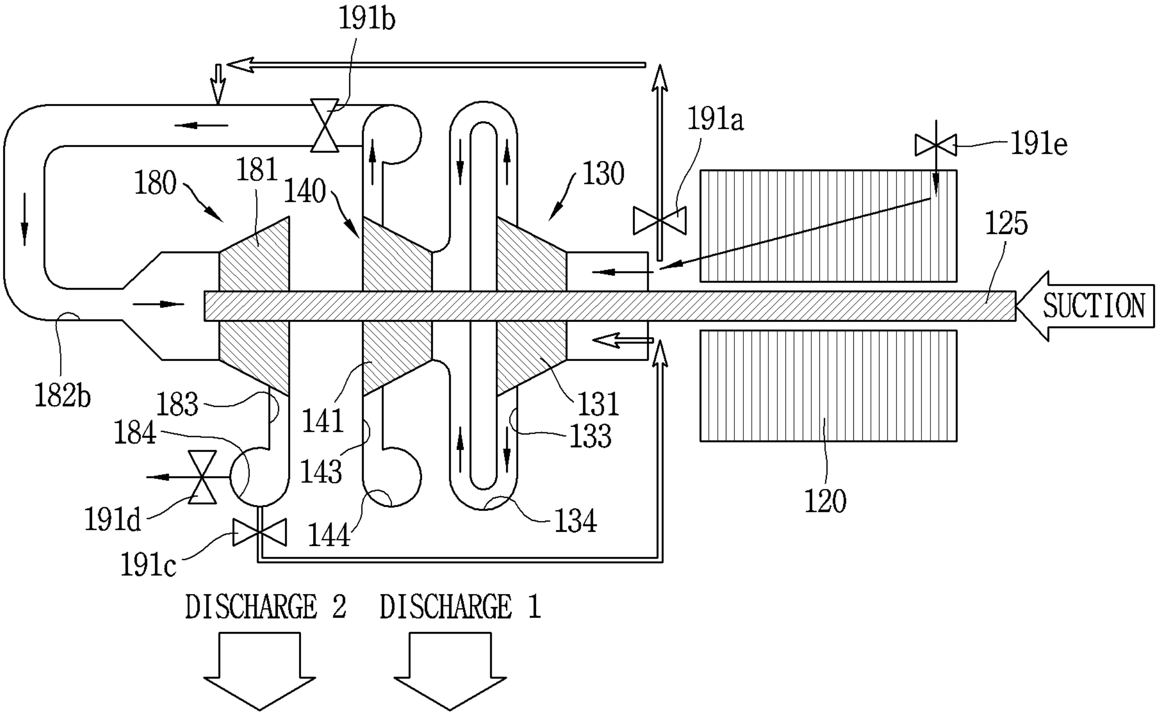

191b
191a
191e
180
181
140
130
125
SUCTION
182b
183
184
141
131
133
143
134
144
120
191d
191c
DISCHARGE 2
DISCHARGE 1

FIG. 3

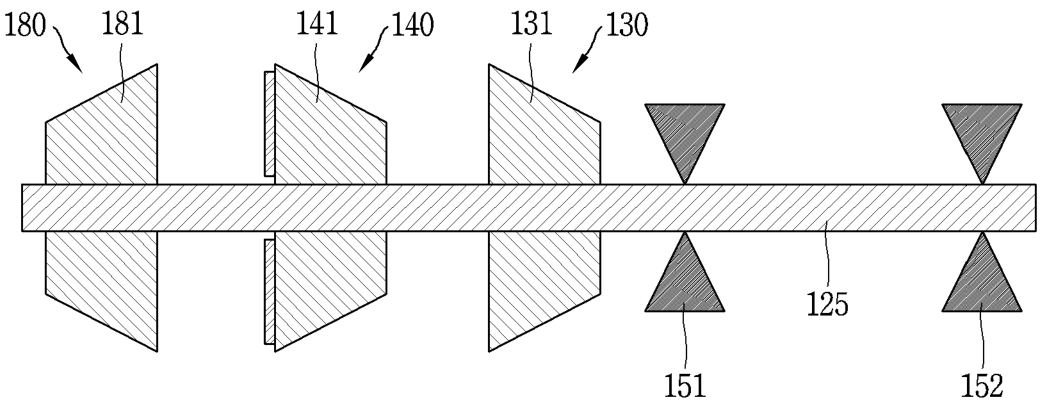

180
181
141
140
131
130
125
151
152

FIG. 4

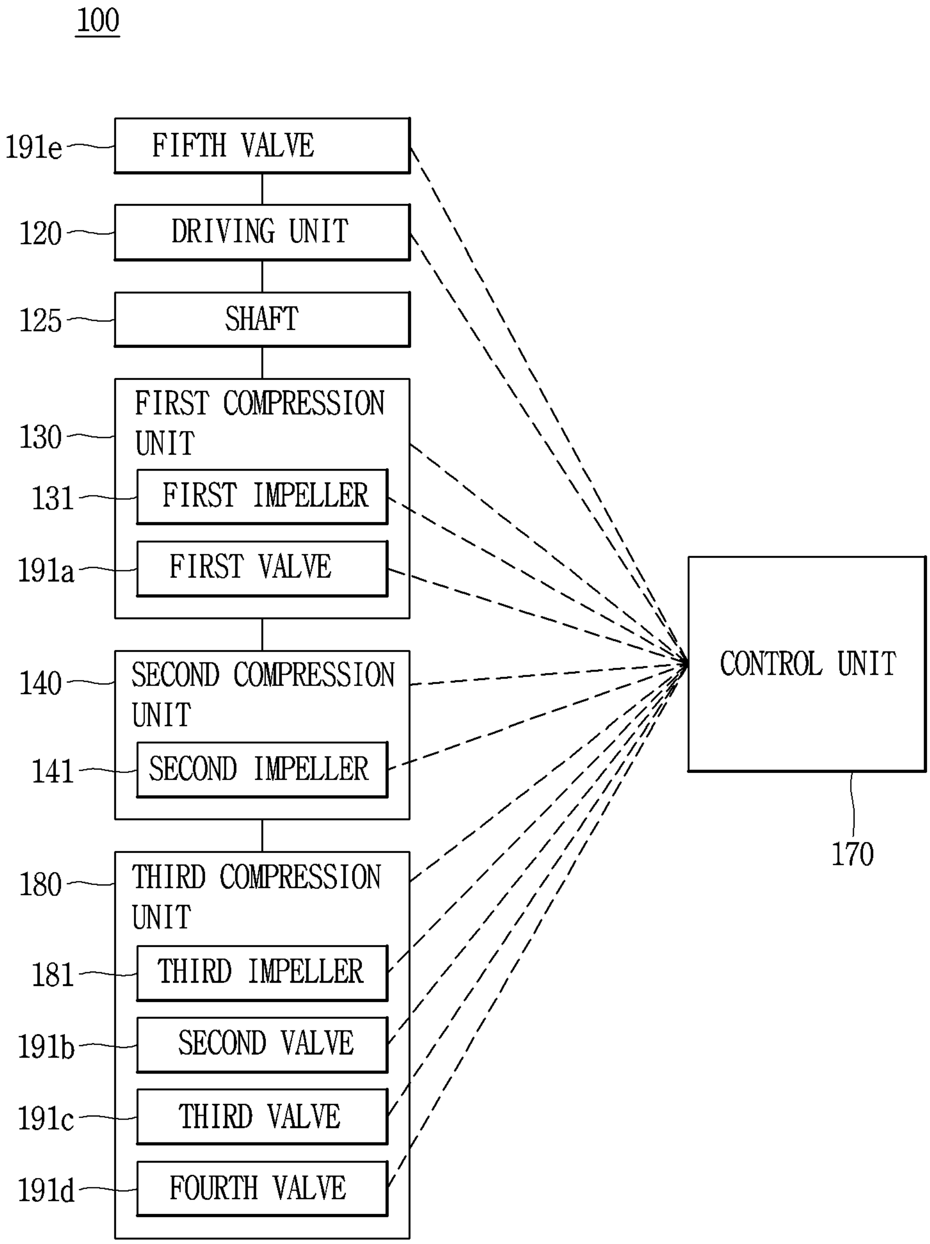

100
191e
FIFTH VALVE
120
DRIVING UNIT
125
SHAFT
130
FIRST COMPRESSION UNIT
131
FIRST IMPELLER
191a
FIRST VALVE
140
SECOND COMPRESSION UNIT
141
SECOND IMPELLER
180
THIRD COMPRESSION UNIT
181
THIRD IMPELLER
191b
SECOND VALVE
191c
THIRD VALVE
191d
FOURTH VALVE
CONTROL UNIT
170

FIG. 5

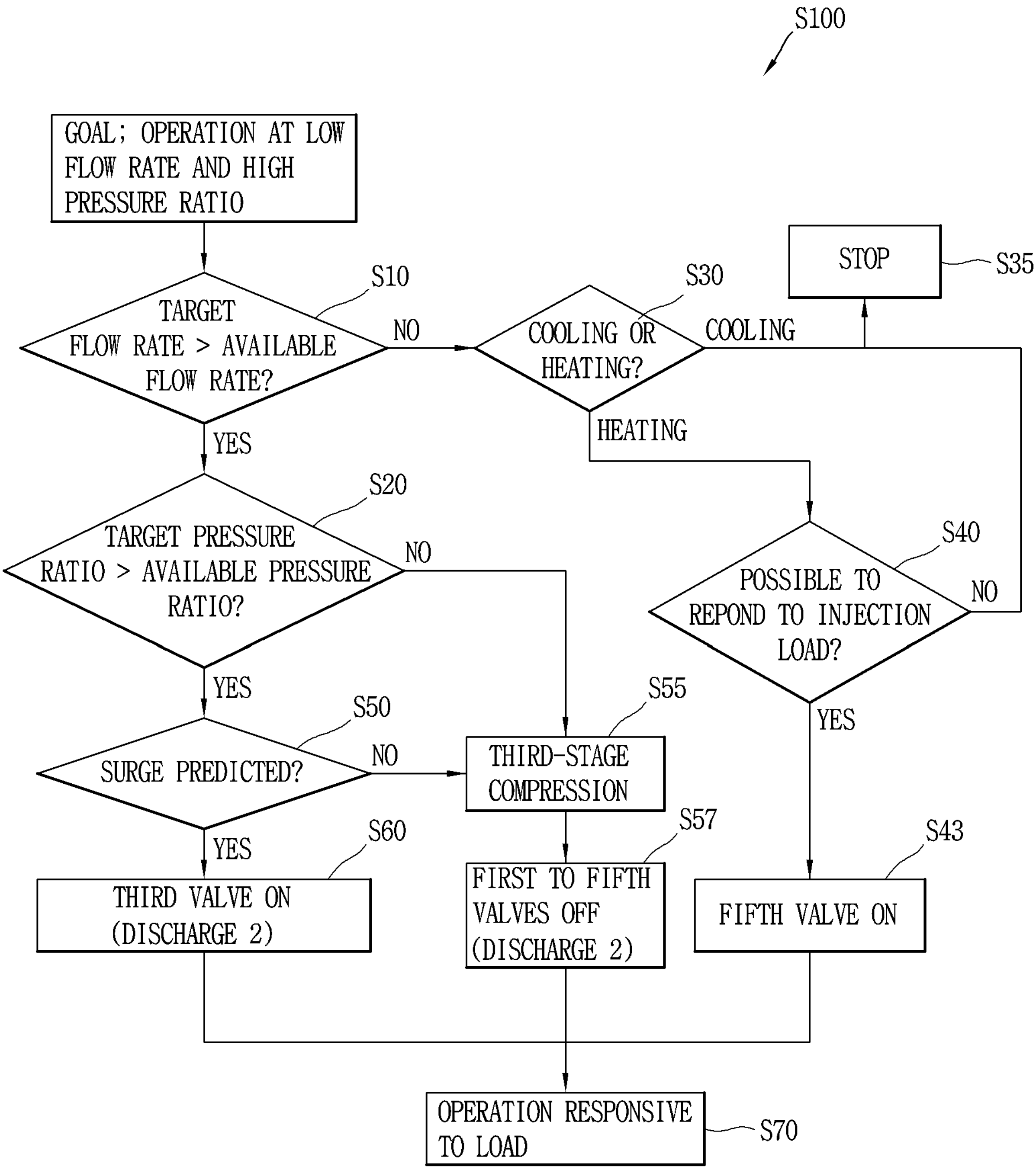

S100
GOAL; OPERATION AT LOW FLOW RATE AND HIGH PRESSURE RATIO
S10
TARGET FLOW RATE > AVAILABLE FLOW RATE?
NO
YES
S30
COOLING OR HEATING?
COOLING
HEATING
STOP
S35
S20
TARGET PRESSURE RATIO > AVAILABLE PRESSURE RATIO?
NO
YES
S40
POSSIBLE TO REPOND TO INJECTION LOAD?
NO
YES
S50
SURGE PREDICTED?
NO
YES
S55
THIRD-STAGE COMPRESSION
S60
THIRD VALVE ON (DISCHARGE 2)
S57
FIRST TO FIFTH VALVES OFF (DISCHARGE 2)
S43
FIFTH VALVE ON
OPERATION RESPONSIVE TO LOAD
S70

FIG. 6

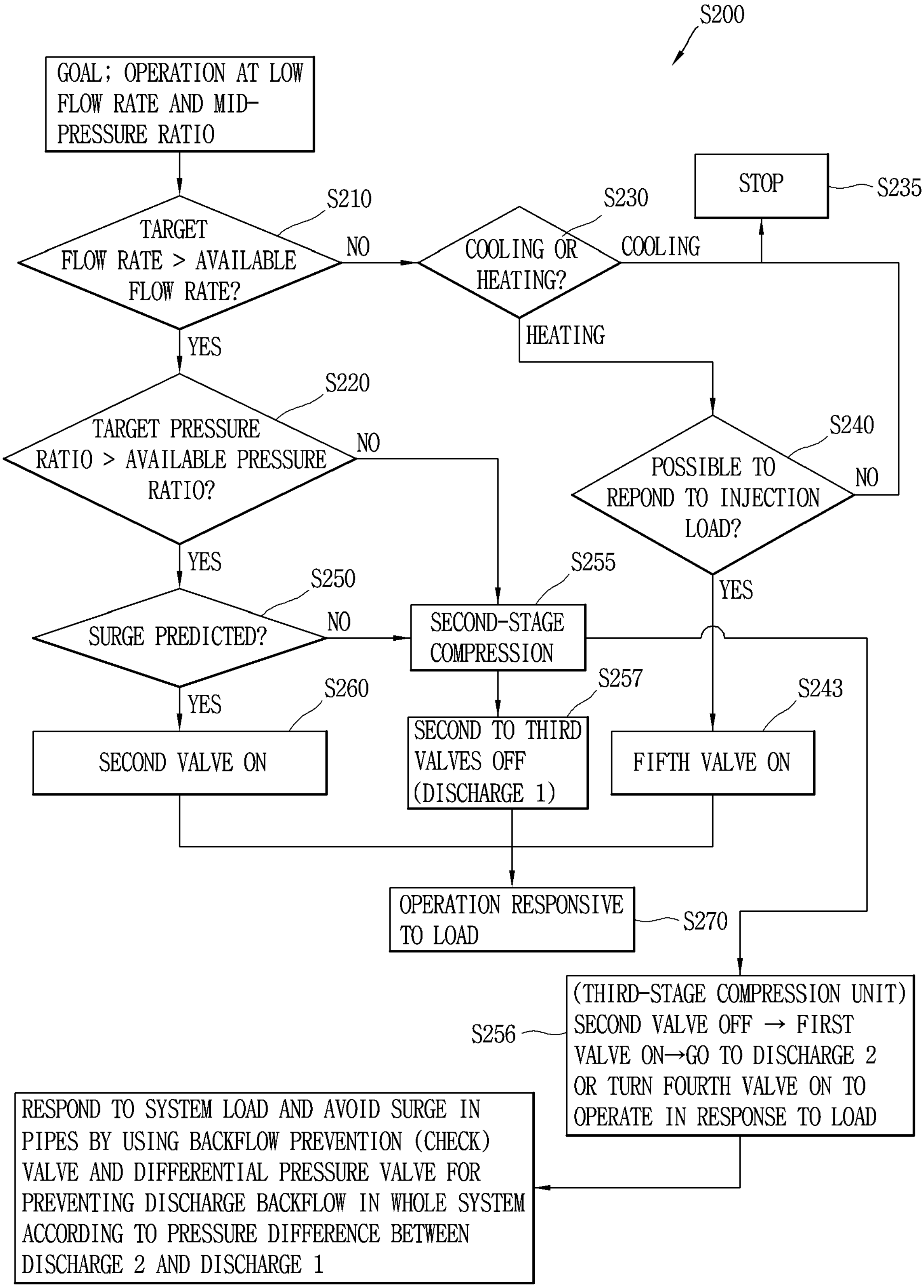

S200
GOAL; OPERATION AT LOW FLOW RATE AND MID-PRESSURE RATIO
S210
TARGET FLOW RATE > AVAILABLE FLOW RATE?
NO
S230
COOLING OR HEATING?
COOLING
STOP
S235
HEATING
YES
S220
TARGET PRESSURE RATIO > AVAILABLE PRESSURE RATIO?
NO
S240
POSSIBLE TO REPOND TO INJECTION LOAD?
NO
YES
S255
S250
SURGE PREDICTED?
NO
SECOND-STAGE COMPRESSION
YES
YES
S260
S257
S243
SECOND VALVE ON
SECOND TO THIRD VALVES OFF (DISCHARGE 1)
FIFTH VALVE ON
OPERATION RESPONSIVE TO LOAD
S270
S256
(THIRD-STAGE COMPRESSION UNIT) SECOND VALVE OFF → FIRST VALVE ON→GO TO DISCHARGE 2 OR TURN FOURTH VALVE ON TO OPERATE IN RESPONSE TO LOAD
RESPOND TO SYSTEM LOAD AND AVOID SURGE IN PIPES BY USING BACKFLOW PREVENTION (CHECK) VALVE AND DIFFERENTIAL PRESSURE VALVE FOR PREVENTING DISCHARGE BACKFLOW IN WHOLE SYSTEM ACCORDING TO PRESSURE DIFFERENCE BETWEEN DISCHARGE 2 AND DISCHARGE 1

FIG. 7

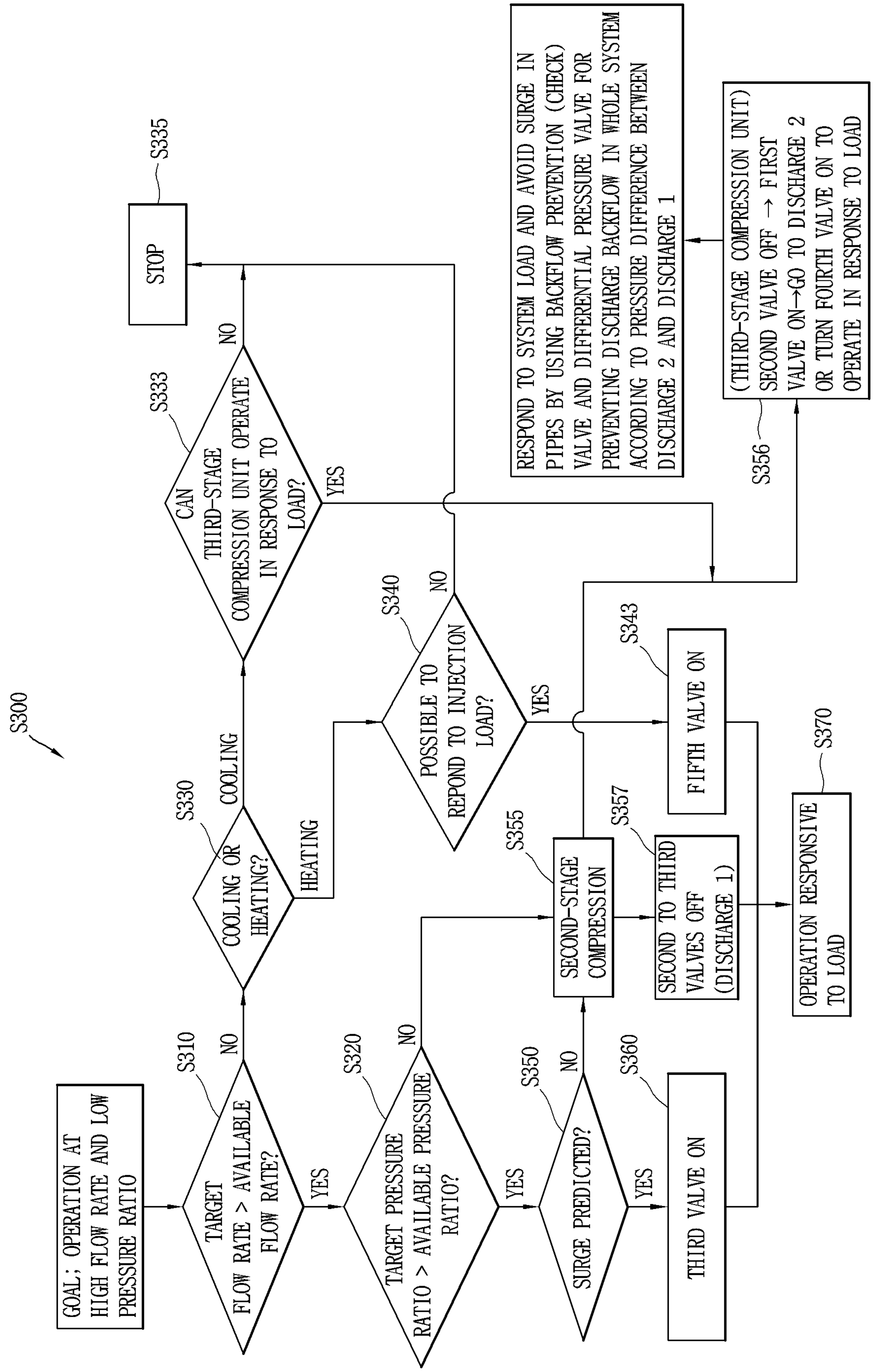
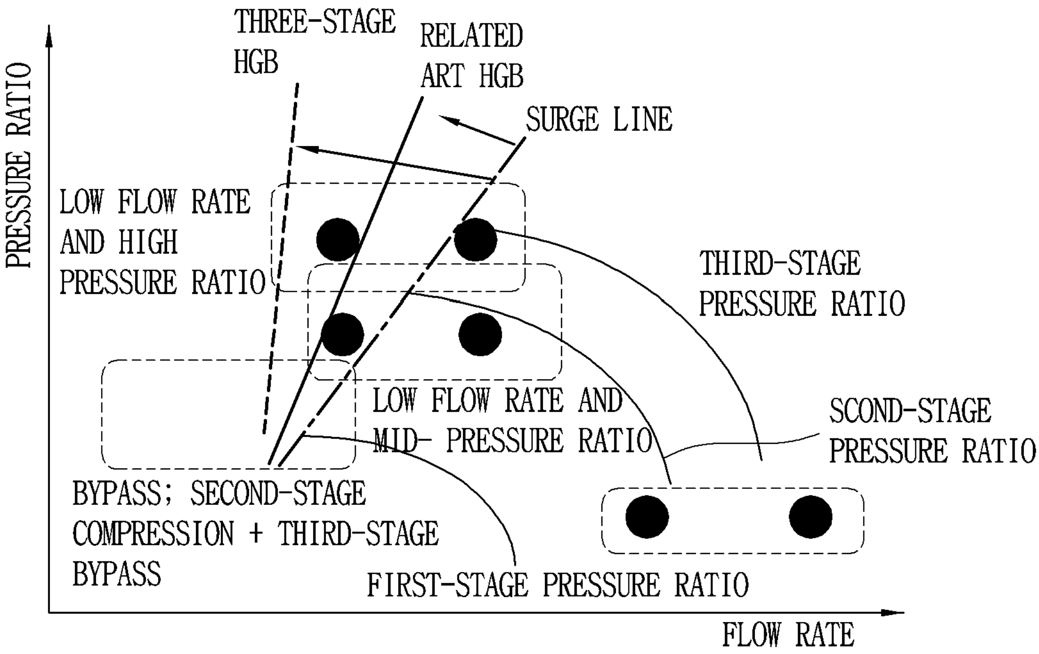

S300
GOAL; OPERATION AT HIGH FLOW RATE AND LOW PRESSURE RATIO
S310
TARGET FLOW RATE > AVAILABLE FLOW RATE?
YES
NO
S320
TARGET PRESSURE RATIO > AVAILABLE PRESSURE RATIO?
YES
NO
S350
SURGE PREDICTED?
YES
NO
S360
THIRD VALVE ON
S330
COOLING OR HEATING?
COOLING
HEATING
S333
CAN THIRD-STAGE COMPRESSION UNIT OPERATE IN RESPONSE TO LOAD?
YES
NO
S335
STOP
S340
POSSIBLE TO REPOND TO INJECTION LOAD?
YES
NO
S343
FIFTH VALVE ON
S355
SECOND-STAGE COMPRESSION
S357
SECOND TO THIRD VALVES OFF (DISCHARGE 1)
S370
OPERATION RESPONSIVE TO LOAD
S356
(THIRD-STAGE COMPRESSION UNIT) SECOND VALVE OFF → FIRST VALVE ON→GO TO DISCHARGE 2 OR TURN FOURTH VALVE ON TO OPERATE IN RESPONSE TO LOAD
RESPOND TO SYSTEM LOAD AND AVOID SURGE IN PIPES BY USING BACKFLOW PREVENTION (CHECK) VALVE AND DIFFERENTIAL PRESSURE VALVE FOR PREVENTING DISCHARGE BACKFLOW IN WHOLE SYSTEM ACCORDING TO PRESSURE DIFFERENCE BETWEEN DISCHARGE 2 AND DISCHARGE 1

FIG. 8


PRESSURE RATIO
THREE-STAGE HGB
RELATED ART HGB
SURGE LINE
LOW FLOW RATE AND HIGH PRESSURE RATIO
THIRD-STAGE PRESSURE RATIO
LOW FLOW RATE AND MID- PRESSURE RATIO
SCOND-STAGE PRESSURE RATIO
BYPASS; SECOND-STAGE COMPRESSION + THIRD-STAGE BYPASS
FIRST-STAGE PRESSURE RATIO
FLOW RATE

INTERNATIONAL SEARCH REPORT

International application No. **PCT/KR2022/006567**

A. CLASSIFICATION OF SUBJECT MATTER

F04D 17/12(2006.01)i; **F04D 25/06**(2006.01)i; **F04D 29/053**(2006.01)i; **F04D 29/28**(2006.01)i; **F04D 29/42**(2006.01)i; **F04D 27/02**(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D 17/12(2006.01); F04D 25/16(2006.01); F04D 27/00(2006.01); F04D 27/02(2006.01); F04D 29/28(2006.01); F04D 29/46(2006.01); H02P 7/00(2006.01)

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

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 터보 압축기(turbo compressor), 임펠러(impeller), 바이패스 유로(bypass conduit), 밸브(valve), 볼류트(volute), 서지(surge)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-291597 A (EBARA CORP.) 17 October 2000 (2000-10-17) See figure 1.	1,9
A		2-8,10-20
Y	KR 10-2019-0105792 A (HANWHA POWER SYSTEMS CO., LTD.) 18 September 2019 (2019-09-18) See paragraphs [0027]-[0029] and figure 2.	1,9
Y	JP 10-089287 A (HITACHI LTD.) 07 April 1998 (1998-04-07) See figure 1.	9
A	KR 10-2010-0037122 A (IHI CORPORATION) 08 April 2010 (2010-04-08) See figure 1.	1-20
A	KR 10-2018-0115575 A (LG ELECTRONICS INC.) 23 October 2018 (2018-10-23) See figure 1.	1-20

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" 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

Date of the actual completion of the international search	Date of mailing of the international search report
16 August 2022	**16 August 2022**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208**	
Facsimile No. **+82-42-481-8578**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2019)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2022/006567

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2000-291597 A	17 October 2000	None	
KR 10-2019-0105792 A	18 September 2019	None	
JP 10-089287 A	07 April 1998	None	
KR 10-2010-0037122 A	08 April 2010	CN 101755127 A	23 June 2010
		EP 2180192 A1	28 April 2010
		JP 2009-024582 A	05 February 2009
		WO 2009-011241 A1	22 January 2009
KR 10-2018-0115575 A	23 October 2018	None	

Form PCT/ISA/210 (patent family annex) (July 2019)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2019192850 A **[0011]**
- US 7293954 B **[0015]**