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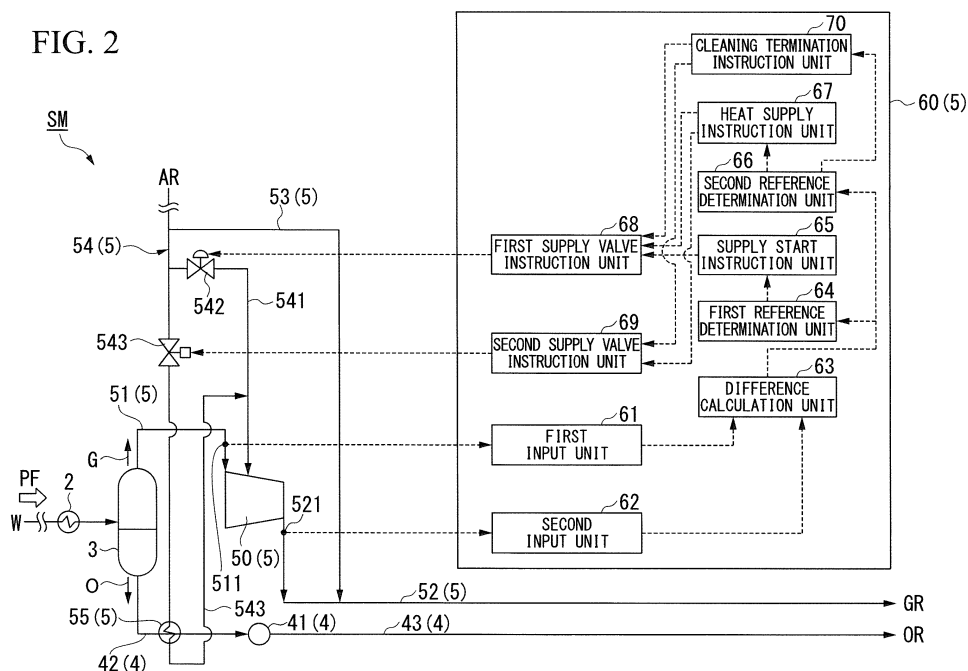
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(54) **COMPRESSOR SYSTEM, SUBSEA PRODUCTION SYSTEM PROVIDED THEREWITH, AND COMPRESSOR CLEANING METHOD**

(57) A compressor system includes a compressor (50) that includes a casing, a rotation shaft supported in the casing and an impeller that rotates together with the rotation shaft and compresses a gas. The compressor system includes a compressed gas circulation unit (52) in which the gas compressed by the compressor (50) circulates, a hydrate anti freezing agent supply unit (53)

configured to supply a hydrate anti freezing agent that prevents hydration of the gas to the compressed gas circulation unit (52), and an internal hydrate anti freezing agent supply unit (54) configured to supply part of the hydrate anti freezing agent to an internal flow path of the compressor (50).

FIG. 2



Description**[Solution to Problem]****[Technical Field]**

[0001] The present invention relates to a compressor system, a subsea production system provided therewith, and a compressor cleaning method.

[Background Art]

[0002] In subsea production systems configured to extract submarine resources, production fluids mixed with crude oils and natural gases are drawn from production wells drilled to a depth of several thousand meters in the seabed. In the subsea production systems, the drawn production fluids are separated into gases such as natural gases and liquids such as crude oils by a separator such as a scrubber and are then sent to a ship on the sea surface through flow lines that extend under the sea. In this case, in order to send gases such as natural gases to a ship on the sea surface, a compressor installed in the seabed is used.

[0003] In the compressor installed in the seabed in this manner, according to continuous operations, sediments accumulate in internal flow paths through which natural gases circulate. As a result, a flow rate of natural gases that can circulate in the internal flow paths decreases and efficiency of the compressor decreases.

[0004] For such a compressor, for example, a cleaning method in which some condensates that are hydrocarbons contained in liquids separated out in the separator are supplied to the compressor for cleaning is disclosed in Patent Literature 1. In the compressor cleaning method, the condensates decompose and remove sediments, and internal flow paths of the compressor are cleaned.

[Citation List]**[Patent Literature]**

[0005] [Patent Literature 1] PCT International Publication No. WO 2013/185801

[Summary of Invention]**[Technical Problem]**

[0006] However, in the above-described cleaning method, condensates harvested from production wells are used. Therefore, in the cleaning method, there is a risk of a necessary amount of condensates not being reliably harvested from production wells. As a result, it is difficult to reliably clean the compressor.

[0007] The present invention provides a compressor system capable of reliably cleaning a compressor, a subsea production system provided therewith, and a compressor cleaning method.

[0008] In order to address the above problems, the present invention proposes the following solutions. A compressor system according to a first aspect of the present invention includes a compressor including a casing, a rotation shaft supported in the casing, and an impeller that rotates together with the rotation shaft and compresses a gas; a compressed gas circulation unit in which the gas compressed by the compressor circulates; a hydrate anti freezing agent supply unit configured to supply a hydrate anti freezing agent that prevents hydration of the gas to the compressed gas circulation unit; and an internal hydrate anti freezing agent supply unit configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to an internal flow path formed of the impeller and the casing.

[0009] In such a configuration, part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to the compressed gas circulation unit for preventing hydration of the gas compressed by the compressor is supplied to the internal flow path. Therefore, the hydrate anti freezing agent flows in the internal flow path together with the gas, and thus sediments accumulated in the internal flow path can be removed. When the hydrate anti freezing agent is directly supplied to the internal flow path, the hydrate anti freezing agent is prevented from being diluted by the gas before reaching the internal flow path, and it is possible to clean the inside of the compressor by effectively using the hydrate anti freezing agent. When part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to the compressed gas circulation unit is used, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the internal flow path.

[0010] The compressor system may include a control unit configured to perform supply control such that, when predetermined conditions are satisfied, the internal hydrate anti freezing agent supply unit starts supply of the hydrate anti freezing agent to the internal flow path.

[0011] In such a configuration, when supply control of the hydrate anti freezing agent is performed by the control unit, it is possible to limit supply of the hydrate anti freezing agent to the compressor that is in a state in which cleaning is necessary. Therefore, the hydrate anti freezing agent supplied from the internal hydrate anti freezing agent supply unit can be efficiently used for cleaning the compressor and it is possible to minimize a supply amount of the hydrate anti freezing agent.

[0012] In the compressor system, the control unit may include a first reference determination unit configured to determine whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference and a supply start instruction unit configured to send an instruction to the internal hydrate anti freezing agent supply unit to start supply of the hy-

drate anti freezing agent to the internal flow path when the first reference determination unit determines that the first reference is satisfied.

[0013] In such a configuration, when a difference between characteristic values of the gas on the inlet side and the outlet side of the compressor is calculated, the calculated difference is compared with a predetermined first reference and determination is performed in the first reference determination unit, it is possible to easily determine whether the internal flow path is in a state in which cleaning is necessary. When the supply start instruction unit starts supply of the hydrate anti freezing agent to the internal flow path based on the determination result, it is possible to perform cleaning of the internal flow path. Therefore, it is possible to determine whether the compressor is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the internal flow path for which cleaning is necessary, the hydrate anti freezing agent supplied from the internal hydrate anti freezing agent supply unit can be used for cleaning the compressor more efficiently and a supply amount of the hydrate anti freezing agent can be further minimized.

[0014] The compressor system may include a heating unit configured to heat the hydrate anti freezing agent, and the internal hydrate anti freezing agent supply unit may supply the hydrate anti freezing agent heated by the heating unit to the internal flow path.

[0015] In such a configuration, when the heating unit is provided, a high temperature hydrate anti freezing agent can be supplied to the internal flow path. It is thus possible to improve solubility of sediments due to the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to increase a dissolution rate of sediments accumulated in the internal flow path and effectively clean the internal flow path.

[0016] The compressor system may include a heating unit configured to heat the hydrate anti freezing agent, and the control unit may include a second reference determination unit configured to determine whether a difference between characteristic values of the gas on the inlet side of the compressor and the outlet side of the compressor satisfies a predetermined second reference after supply of the hydrate anti freezing agent to the internal flow path starts; and a heat supply instruction unit configured to send an instruction to the internal hydrate anti freezing agent supply unit to supply the hydrate anti freezing agent heated by the heating unit to the internal flow path when the second reference determination unit determines that the second reference is satisfied.

[0017] In such a configuration, when a difference between characteristic values of the gas on the inlet side and the outlet side of the compressor is calculated, the calculated difference is compared with a second reference and determination is performed in the second reference determination unit, it is possible to easily determine again whether the internal flow path is in a state in

which cleaning is necessary. Therefore, for example, it is possible to easily determine a state of the internal flow path that is different from the state determined using the first reference. Based on the determination result, when the heat supply instruction unit sends an instruction to supply the hydrate anti freezing agent heated by the heating unit to the internal flow path, it is possible to perform cleaning of the internal flow path more effectively using the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to perform greater cleaning on the compressor as necessary. Therefore, when the internal flow path is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor more efficiently.

[0018] According to a second aspect of the present invention, there is provided a subsea production system that includes the compressor system and a separator configured to separate a production fluid drawn from a production well into a gas and a liquid and supply the result to the compressor.

[0019] In such a configuration, it is also possible to reliably and efficiently clean the compressor that is installed at a position at which maintenance is difficult, for example, in the seabed. Therefore, it is possible to prevent clogging due to sediments and it is possible to reliably send the gas through the compressor.

[0020] According to a third aspect according to the present invention, there is provided a compressor cleaning method in which a compressor including a casing, a rotation shaft supported in the casing and an impeller that rotates together with the rotation shaft and compresses a gas is cleaned, the method including: a first reference determining process of determining whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference; and a supply start process in which, when it is determined that the first reference is satisfied in the first reference determining process, supply of a hydrate anti freezing agent that prevents hydration of the gas compressed by the compressor to an internal flow path formed of the impeller and the casing starts.

[0021] In such a configuration, when a difference between characteristic values of the gas on the inlet side and the outlet side of the compressor is calculated, the calculated difference is compared with a first reference and determination is performed in the first reference determining process, it is possible to easily determine whether the internal flow path is in a state in which cleaning is necessary. When supply of the hydrate anti freezing agent to the internal flow path starts in the supply start process based on the determination result, it is possible to perform cleaning of the internal flow path. Therefore, it is possible to determine whether the compressor is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the internal flow path for

which cleaning is necessary, the hydrate anti freezing agent supplied from the internal hydrate anti freezing agent supply unit can be used for cleaning the compressor more efficiently and a supply amount of the hydrate anti freezing agent can be further minimized.

[0022] The compressor cleaning method may include a second reference determining process in which, after supply of the hydrate anti freezing agent to the internal flow path starts, it is determined whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined second reference; and a heat supply process in which, when it is determined that the second reference is satisfied in the second reference determining process, the heated hydrate anti freezing agent is supplied to the internal flow path.

[0023] In such a configuration, when a difference between characteristic values of the gas on the inlet side and the outlet side of the compressor is calculated, the calculated difference is compared with the second reference and determination is performed in the second reference determining process, it is possible to easily determine again whether the internal flow path is in a state in which cleaning is necessary. For example, it is possible to easily determine whether the internal flow path is in a state different from the state determined using the first reference (for example, whether greater cleaning is necessary for the internal flow path). Based on the determination result temperature, in the heat supply process, when the hydrate anti freezing agent heated to a high temperature is supplied from a hydrate anti freezing agent spraying unit to the internal flow path, it is possible to perform cleaning of the internal flow path more effectively. Therefore, it is possible to perform greater cleaning on the compressor as necessary. Therefore, when the internal flow path is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor more efficiently.

[Advantageous Effects of Invention]

[0024] According to the present invention, it is possible to efficiently clean the compressor by supplying the hydrate anti freezing agent to the internal flow path.

[Brief Description of Drawings]

[0025]

Fig. 1 is a diagram schematically showing a subsea production system in an embodiment of the present invention.

Fig. 2 is a systematic diagram showing a subsea module in an embodiment of the present invention.

Fig. 3 is a cross-sectional view of a main part showing an internal flow path of a compressor in an embodiment of the present invention.

Fig. 4 is a flowchart describing a compressor cleaning method in an embodiment of the present invention.

5 [Description of Embodiments]

[0026] Hereinafter, embodiments according to the present invention will be described with reference to Fig. 1 to Fig. 4. A subsea production system 1 according to an embodiment of the present invention is a subsea production system that is one for ocean oil and gas field development methods. As shown in Fig. 1, the subsea production system 1 includes a production well W for harvesting a production fluid PF mixed with crude oil O, natural gas G and the like extracted from an oil gas field F that is located several hundreds to thousands of meters from the seabed, a manifold M for collecting and distributing the production fluid PF harvested in the production well W, a flow line FL that is a pipe through which the production fluid PF distribute by the manifold M is conveyed, and a subsea module SM configured to separate the production fluid PF conveyed through the flow line FL into a liquid and a gas and send them to the sea surface. The subsea production system 1 includes a riser R that is a pipe through which the crude oil O and the natural gas G are conveyed to the sea surface from the subsea module SM, an umbilical line AL that is a cable through which power is supplied to the subsea module SM and the like, and a ship S to which the riser R and the umbilical line AL moored in the sea are connected and in which the crude oil O and the natural gas G are stored.

[0027] The manifold M is installed in the vicinity of the production well W of the oil gas field F in the seabed. The manifold M is a device configured to collect and distribute the extracted production fluid PF and convey it through a plurality of flow lines FL.

[0028] The flow line FL is a pipeline through which the production fluid PF is pressure-fed from the manifold M to the subsea module SM according to pressure energy of the oil gas field F.

[0029] The riser R extends from the subsea module SM of the seabed to the ship S on the sea surface. In the riser R of this embodiment, an oil pipeline OR through which the crude oil O sent from the subsea module SM is conveyed to a storage tank (not shown) disposed in the ship S on the sea surface and a gas pipeline GR through which the natural gas G sent from the subsea module SM is conveyed to the storage tank are separately provided. The riser R includes the gas pipeline GR through which the natural gas G is supplied such that the natural gas G is prevented from freezing due to hydration in the seabed and a pipeline for a hydrate anti freezing agent AR through which a hydrate anti freezing agent is supplied from the ship S.

[0030] The umbilical line AL is a composite cable including a power cable, a hydraulic cable and a signal cable for controlling the subsea module SM. The umbilical line AL sends power and signals from a generator

(not shown) in the ship S to the subsea module SM and the manifold M.

[0031] The subsea module SM separates the production fluid PF supplied through the flow line FL into a gas and a liquid and pressure-feeds the gas and the liquid to the sea surface. As shown in Fig. 2, the subsea module SM of this embodiment includes a main heat exchanger 2 configured to cool the production fluid PF drawn from the production well W, a separator 3 configured to separate the production fluid PF cooled in the main heat exchanger 2 into a gas and a liquid, a pump system 4 configured to send the liquid separated out in the separator 3 to the riser R, and a compressor system 5 configured to send the gas separated out by the separator 3 to the riser R.

[0032] The main heat exchanger 2 cools the production fluid PF having a high temperature that is drawn from the production well W and sent to the flow line FL to a temperature at which the production fluid PF can be used in the separator 3. The main heat exchanger 2 of this embodiment cools the production fluid PF according to heat exchange with low temperature seawater of the seabed.

[0033] The separator 3 separates the production fluid PF into the natural gas G that is a gas and the crude oil O that is a liquid. The separator 3 of this embodiment is a scrubber. The separator 3 separates the natural gas G and the crude oil O containing condensates from the production fluid PF. The separator 3 sends the separated crude oil O to the pump system 4. The separator 3 sends the separated natural gas G to the compressor system 5.

[0034] The pump system 4 compresses the crude oil O sent from the separator 3 and sends it to the oil pipeline OR. As shown in Fig. 2, the pump system 4 includes a pump 41 configured to compress the crude oil O, a liquid circulation unit 42 configured to send the crude oil O from the separator 3 to the pump 41, and a compressed liquid circulation unit 43 in which the crude oil O compressed by the pump 41 circulates.

[0035] The pump 41 compresses and sends out the received crude oil O. The liquid circulation unit 42 supplies the crude oil O from the separator 3 to the pump 41. Specifically, the liquid circulation unit 42 of this embodiment is a pipe that is connected from the separator 3 to the pump 41. The crude oil O circulates inside the liquid circulation unit 42. The compressed liquid circulation unit 43 sends the crude oil O compressed by the pump 41 to the oil pipeline OR. Specifically, the compressed liquid circulation unit 43 of this embodiment is a pipe that is connected from the pump 41 to the oil pipeline OR. The compressed crude oil O circulates inside the compressed liquid circulation unit 43.

[0036] The compressor system 5 compresses the natural gas G sent from the separator 3 and sends it to the gas pipeline GR. As shown in Fig. 2, the compressor system 5 includes a compressor 50 configured to compress the natural gas G, a gas circulation unit 51 configured to send the natural gas G from the separator 3 to the compressor 50, a compressed gas circulation unit 52

in which the natural gas G that is compressed by the compressor 50 circulates, a hydrate anti freezing agent supply unit 53 configured to supply a hydrate anti freezing agent for preventing hydration of the natural gas G to the compressed gas circulation unit 52, an internal hydrate anti freezing agent supply unit 54 configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressor 50, a heating unit 55 configured to heat the hydrate anti freezing agent, and a control unit 60 configured to perform supply control such that the internal hydrate anti freezing agent supply unit 54 starts supply of the hydrate anti freezing agent.

[0037] The compressor 50 is a multistage centrifugal compressor including a plurality of impellers 503. As shown in Fig. 3, the compressor 50 of this embodiment includes a casing 501 on which an internal flow path FC through which a gas flows from an upstream side to a downstream side is formed, a rotation shaft 502 that is supported in the casing 501 and rotates around an axis SL, and the impellers 503 that rotate together with the rotation shaft 502 and compress a gas.

[0038] The casing 501 is a stationary body and has a tubular shape. In the casing 501, the rotation shaft 502 is disposed to penetrate the center. A bearing device (not shown) is provided in the casing 501. The bearing device rotatably supports the rotation shaft 502.

[0039] The rotation shaft 502 is a rotating body, has a columnar shape and extends in an axis SL direction in which the shaft line SL extends. The impeller 503 is a rotating body. The plurality of impellers 503 are provided at intervals in the shaft line SL direction of the rotation shaft 502. The impellers 503 compress the natural gas G (gas) using a centrifugal force according to rotation. The impeller 503 includes a disk 503a, a blade 503b, and a cover 503c. The impeller 503 is a so-called closed type impeller 503.

[0040] The disk 503a is formed in a disk shape whose diameter gradually increases outward in a radial direction of the rotation shaft 502 toward a downstream side that is one side in the shaft line SL direction in the rotation shaft 502. The blade 503b is formed to protrude toward an upstream side in the shaft line SL direction which is a side opposite to a downstream side in the shaft line SL direction from the disk 503a. The plurality of blades 503b are formed in the disk 503a at predetermined intervals in a circumferential direction of the shaft line SL. The cover 503c covers the plurality of blades 503b from an upstream side in the shaft line SL direction. The cover 503c is formed in a disk shape that faces the disk 503a.

[0041] The internal flow path FC is formed by the impeller 503 and the casing 501 so as to connect the impellers 503 so that the natural gas G is gradually compressed. The internal flow path FC includes a compression flow path FC1 defined by the impeller 503 and a casing flow path FC2 that is formed inside the casing 501 and in which a flow of the natural gas G is adjusted.

[0042] The compression flow path FC1 is defined by a

surface that faces an upstream side in the shaft line SL direction of the disk 503a, a surface that faces a downstream side in the shaft line SL direction of the cover 503c, and a surface that faces in a circumferential direction of the blade 503b. The casing flow path FC2 adjusts a flow of the natural gas G to flow the natural gas G through the compression flow path FC1 defined by the impeller 503.

[0043] The gas circulation unit 51 supplies the natural gas G from the separator 3 to the compressor 50. Specifically, the gas circulation unit 51 of this embodiment is a pipe that is connected from the separator 3 to the compressor 50 as shown in Fig. 2. The natural gas G circulates inside the gas circulation unit 51. The gas circulation unit 51 of this embodiment includes an inlet side characteristic value measuring unit 511 configured to measure a characteristic value of the natural gas G on an inlet side of the compressor 50.

[0044] The inlet side characteristic value measuring unit 511 measures a characteristic value of the natural gas G that flows into the compressor 50. The inlet side characteristic value measuring unit 511 is provided in the vicinity of an inlet port of the compressor 50 of the gas circulation unit 51. The inlet side characteristic value measuring unit 511 of this embodiment is a pressure sensor that measures a pressure value as a characteristic value. The inlet side characteristic value measuring unit 511 transmits the measured pressure value of the natural gas G to the control unit 60.

[0045] The compressed gas circulation unit 52 sends the natural gas G compressed by the compressor 50 to the riser R. Specifically, the compressed gas circulation unit 52 of this embodiment is a pipe that is connected from the compressor 50 to the gas pipeline GR. The compressed natural gas G circulates inside the compressed gas circulation unit 52. The compressed gas circulation unit 52 of this embodiment includes an outlet side characteristic value measuring unit 521 configured to measure a characteristic value of the natural gas G (gas) on an outlet side of the compressor 50.

[0046] The outlet side characteristic value measuring unit 521 measures a characteristic value of the natural gas G discharged from the compressor 50. The outlet side characteristic value measuring unit 521 is provided in the vicinity of an outlet port of the compressor 50 of the compressed gas circulation unit 52. Similarly to the inlet side characteristic value measuring unit 511, the outlet side characteristic value measuring unit 521 of this embodiment is a pressure sensor that measures a pressure value as a characteristic value. The outlet side characteristic value measuring unit 521 transmits the measured pressure value of the natural gas G to the control unit 60.

[0047] The hydrate anti freezing agent supply unit 53 circulates the hydrate anti freezing agent supplied from the ship S on the sea surface through the pipeline for a hydrate anti freezing agent AR to the compressed gas circulation unit 52. The hydrate anti freezing agent supply

unit 53 of this embodiment is a pipe that is connected from the pipeline for a hydrate anti freezing agent AR to the compressed gas circulation unit 52. The hydrate anti freezing agent circulates inside the hydrate anti freezing agent supply unit 53. The hydrate anti freezing agent supply unit 53 is connected downstream from a position at which the outlet side characteristic value measuring unit 521 of the compressed gas circulation unit 52 is provided. Also, as the hydrate anti freezing agent of this embodiment, a fluid having lipophilicity and hydrophilicity is preferably used. As the hydrate anti freezing agent, for example, monoethylene glycol used for preventing hydration by preventing hydration of the natural gas G is particularly preferably used.

[0048] The internal hydrate anti freezing agent supply unit 54 supplies part of the hydrate anti freezing agent that flows in the hydrate anti freezing agent supply unit 53 to the internal flow path FC of the compressor 50. Specifically, the internal hydrate anti freezing agent supply unit 54 of this embodiment includes a first supply pipe 541, a first supply valve 542 configured to adjust a flow of a hydrate anti freezing agent that flows in the first supply pipe 541, a second supply pipe 543 that branches from the first supply pipe 541, and a second supply valve 544 configured to adjust a flow of a hydrate anti freezing agent that flows in the second supply pipe 543.

[0049] The first supply pipe 541 branches from the hydrate anti freezing agent supply unit 53 and is connected to the casing 501 of the compressor 50. Specifically, the first supply pipe 541 of this embodiment is connected to pass through the inside of the casing 501 of the compressor 50. The first supply pipe 541 branches at the inside of the casing 501. At a distal portion of the first supply pipe 541, a hydrate anti freezing agent spraying unit 541a configured to spray a hydrate anti freezing agent toward the casing flow path FC2 is provided.

[0050] The first supply valve 542 adjusts supply of a hydrate anti freezing agent into the first supply pipe 541. Specifically, when the first supply valve 542 of this embodiment is closed, supply of a hydrate anti freezing agent into the first supply pipe 541 stops and when the first supply valve 542 of this embodiment is opened, supply of a hydrate anti freezing agent into the first supply pipe 541 starts. The first supply valve 542 is a solenoid valve in which opening and closing operations are controlled by the control unit 60.

[0051] The second supply pipe 543 branches from the first supply pipe 541 and supplies a hydrate anti freezing agent to the compressor 50. The second supply pipe 543 of this embodiment branches from the first supply pipe 541 on an upstream side relative to a position at which the first supply valve 542 is provided and is connected to the first supply pipe 541 again at a downstream side relative to a position at which the first supply valve 542 is provided.

[0052] The second supply valve 544 adjusts supply of a hydrate anti freezing agent into the second supply pipe 543. Specifically, when the second supply valve 544 of

this embodiment is closed, supply of a hydrate anti freezing agent into the second supply pipe 543 stops and when the second supply valve 544 of this embodiment is opened, supply of a hydrate anti freezing agent into the second supply pipe 543 starts. The second supply valve 544 is a solenoid valve whose opening and closing operations are controlled by the control unit 60.

[0053] The heating unit 55 is provided in the internal hydrate anti freezing agent supply unit 54 and heats a hydrate anti freezing agent. The heating unit 55 of this embodiment is provided at a position that is on a downstream side relative to the second supply valve 544 of the second supply pipe 543 and at which the second supply pipe 543 and the liquid circulation unit 42 cross. The heating unit 55 heats a hydrate anti freezing agent by using heat of the crude oil O that flows in the pump system 4. Specifically, the heating unit 55 heats monoethylene glycol which is a hydrate anti freezing agent that flows in the second supply pipe 543 at an ambient temperature of, for example, about 20 °C to 50 °C, to a high temperature of 110 °C or more.

[0054] When predetermined conditions are satisfied, the control unit 60 performs supply control such that the internal hydrate anti freezing agent supply unit 54 starts supply of a hydrate anti freezing agent into the internal flow path FC of the compressor 50. When predetermined conditions are satisfied, the control unit 60 of this embodiment controls opening and closing operations of the first supply valve 542 and the second supply valve 544, and thus supply of a hydrate anti freezing agent into the internal flow path FC is controlled.

[0055] Specifically, the control unit 60 of this embodiment includes a first input unit 61 configured to receive a characteristic value measured by the inlet side characteristic value measuring unit 511, a second input unit 62 configured to receive a characteristic value measured by the outlet side characteristic value measuring unit 521, and a difference calculation unit 63 configured to calculate a difference between the characteristic value received by the first input unit 61 and the characteristic value received by the second input unit 62. The control unit 60 of this embodiment includes a first reference determination unit 64 configured to determine whether the difference calculated by the difference calculation unit 63 satisfies a predetermined first reference and a supply start instruction unit 65 configured to send an instruction to start supply of a hydrate anti freezing agent to the internal flow path FC based on the determination result of the first reference determination unit 64. The control unit 60 of this embodiment includes a second reference determination unit 66 configured to determine whether the difference calculated by the difference calculation unit 63 satisfies a predetermined second reference, a heat supply instruction unit 67 configured to send an instruction to supply the hydrate anti freezing agent heated by the heating unit 55 to the internal flow path FC based on the determination result of the second reference determination unit 66, and a cleaning termination instruction

unit 70 configured to send an instruction to terminate supply of the hydrate anti freezing agent to the internal flow path FC based on the determination result of the second reference determination unit 66. The control unit 60 of this embodiment includes a first supply valve instruction unit 68 configured to open or close the first supply valve 542 based on an input signal and a second supply valve instruction unit 69 configured to open or close the second supply valve 544 based on an input signal.

[0056] The first input unit 61 receives a pressure value of the natural gas G measured by the inlet side characteristic value measuring unit 511. The first input unit 61 outputs information about the input pressure value to the difference calculation unit 63. The second input unit 62 receives a pressure value of the natural gas G measured by the outlet side characteristic value measuring unit 521. The second input unit 62 outputs information about the input pressure value to the difference calculation unit 63.

[0057] The difference calculation unit 63 calculates a difference by subtracting a pressure value on an inlet side of a compressor input by the first input unit 61 from a pressure value on an outlet side of a compressor input by the second input unit 62. The difference calculation unit 63 outputs the calculated difference to the first reference determination unit 64. After the calculated difference is output to the first reference determination unit 64, when information is input again from the first input unit 61 and the second input unit 62, the difference calculation unit 63 outputs the calculated difference to the second reference determination unit 66.

[0058] The first reference determination unit 64 compares information about the difference input from the difference calculation unit 63 with a first reference. Here, the first reference is a value indicating a state in which cleaning is necessary since sediments have precipitated and the internal flow path FC of the compressor 50 is narrowed. The first reference of this embodiment is set to a value smaller than a value of a rise a pressure of the natural gas G that is compressed while circulating in the compression flow path FC1 in a normal state in which cleaning is not necessary. That is, the first reference of this embodiment is a value of a difference between pressures on an inlet side and an outlet side of the compressor 50 while the internal flow path FC is narrowed due to sediments and the natural gas G is hardly compressed.

[0059] The first reference determination unit 64 of this embodiment determines whether the input difference value is less than the first reference. When it is determined that the calculated difference is less than the first reference and satisfies the first reference, the first reference determination unit 64 sends a signal to the supply start instruction unit 65.

[0060] When the first reference determination unit 64 determines that the first reference is satisfied, the supply start instruction unit 65 sends an instruction to the internal hydrate anti freezing agent supply unit 54 to start supply of a hydrate anti freezing agent to the internal flow path FC. When the signal is input from the first reference de-

termination unit 64, the supply start instruction unit 65 of this embodiment sends a signal to the first supply valve instruction unit 68 and sends an instruction to the first supply valve 542.

[0061] The second reference determination unit 66 compares information about the difference input from the difference calculation unit 63 with the second reference. Here, the second reference is a value indicating a state in which sediments of the internal flow path FC of the compressor 50 are not sufficiently removed and greater cleaning is necessary. The second reference of this embodiment is set to a value smaller than a value of a rise of a pressure of the natural gas G that is compressed while circulating in the compression flow path FC1 in a normal state and is greater than the first reference. That is, the second reference of this embodiment is a value of a difference between pressures on the inlet side and the outlet side of the compressor 50 in a state in which cleaning has been performed once, but the result is that this is not enough to satisfy the first reference, sediments remain in the internal flow path FC, and the natural gas G is not sufficiently compressed.

[0062] The second reference determination unit 66 of this embodiment determines whether the input difference value is less than the second reference. When it is determined that the calculated difference is less than the second reference and satisfies the second reference, the second reference determination unit 66 sends a signal to the heat supply instruction unit 67. When it is determined that the calculated difference is greater than the second reference and does not satisfy the second reference, the second reference determination unit 66 sends a signal to the cleaning termination instruction unit 70.

[0063] When the second reference determination unit 66 determines that the second reference is satisfied, the heat supply instruction unit 67 sends an instruction to the internal hydrate anti freezing agent supply unit 54 to supply the hydrate anti freezing agent heated by the heating unit 55 to the internal flow path FC. The heat supply instruction unit 67 of this embodiment receives the signal from the second reference determination unit 66. As a result, the heat supply instruction unit 67 sends a signal to the first supply valve instruction unit 68 and the second supply valve instruction unit 69 after the signal is sent from the supply start instruction unit 65, and sends an instruction to the first supply valve 542 and the second supply valve 544.

[0064] When the second reference determination unit 66 determines that the second reference is not satisfied, the cleaning termination instruction unit 70 sends an instruction to the internal hydrate anti freezing agent supply unit 54 to terminate supply of a hydrate anti freezing agent to the internal flow path FC. The cleaning termination instruction unit 70 of this embodiment receives a signal from the second reference determination unit 66. As a result, the cleaning termination instruction unit 70 sends a signal to the first supply valve instruction unit 68 and the second supply valve instruction unit 69 and sends an

instruction to the first supply valve 542 and the second supply valve 544.

[0065] When the signal is input from the supply start instruction unit 65, the first supply valve instruction unit 68 sends an instruction to open the first supply valve 542. When a signal is input from the heat supply instruction unit 67, the first supply valve instruction unit 68 sends an instruction to close the first supply valve 542. When a signal is input from the cleaning termination instruction unit 70, the first supply valve instruction unit 68 sends an instruction to close the first supply valve 542.

[0066] When a signal is input from the heat supply instruction unit 67, the second supply valve instruction unit 69 sends an instruction to open the second supply valve 544. When a signal is input from the cleaning termination instruction unit 70, the second supply valve instruction unit 69 sends an instruction to close the second supply valve 544.

[0067] Next, operations of the subsea production system 1 of the above-described embodiment will be described. The subsea production system 1 of this embodiment collects the production fluid PF that is harvested from the oil gas field F through the production well W in the manifold M, conveys the collected production fluid PF into the flow line FL according to pressure energy generated when the production fluid PF is extracted from the oil gas field F, and supplies the production fluid PF to the subsea module SM.

[0068] In the subsea module SM, power is supplied to devices from a generator (not shown) in the ship S by the umbilical line AL. The production fluid PF supplied to the subsea module SM is cooled by the main heat exchanger 2 and flows into the separator 3. The production fluid PF flowed into the separator 3 is separated into the crude oil O that is a liquid and the natural gas G that is a gas. Note that the crude oil O separated out in the separator 3 includes condensates and the like.

[0069] The crude oil O separated out in the separator 3 circulates inside the liquid circulation unit 42 and is sent to the pump 41. The pump 41 compresses the crude oil O, sends it to the oil pipeline OR through the compressed liquid circulation unit 43 and supplies it to a crude oil O storage tank (not shown) in the ship S.

[0070] The natural gas G separated out by the separator 3 circulates inside the liquid circulation unit 42 and is sent to the compressor 50. In the compressor 50, when the natural gas G circulates in the internal flow path FC, the impeller 503 rotates together with the rotation shaft 502 so that the natural gas G is compressed in the compression flow path FC1 and sent to the compressed gas circulation unit 52. A hydrate anti freezing agent is supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52. The hydrate anti freezing agent is sent to the gas pipeline GR together with the compressed natural gas G. In the compressed gas circulation unit 52, while preventing hydration using the supplied the hydrate anti freezing agent, the natural gas G is supplied to a natural gas G storage tank (not

shown) in the ship S.

[0071] Next, a cleaning method of the compressor 50 of the above-described embodiment will be described. In the compressor 50 configured to compress the natural gas G and supply it to the ship S as described above, when an operation continues, sediments are precipitated and accumulate in the internal flow path FC in which the natural gas G circulates. By the cleaning method of the compressor 50, cleaning is performed on the compressor 50 in which such sediments accumulate. The cleaning method of the compressor 50 of this embodiment will be described with reference to Fig. 2 to Fig. 4.

[0072] In the cleaning method of the compressor 50 of this embodiment, as shown in Fig. 4, for a characteristic value of the natural gas G which is a gas separated out by the separator 3 on the inlet side and the outlet side of the compressor 50, a pressure value is measured and acquired, and a state of the compressor 50 is measured (a characteristic value acquiring process S100). Specifically, in the characteristic value acquiring process S100, the inlet side characteristic value measuring unit 511 measures a pressure value of the natural gas G that circulates in the gas circulation unit 51 and acquires a pressure value of the natural gas G on the inlet side of the compressor 50. The outlet side characteristic value measuring unit 521 measures a pressure value of the natural gas G that circulates in the compressed gas circulation unit 52 and acquires a pressure value of the natural gas G on the outlet side of the compressor 50.

[0073] Next, in the cleaning method of the compressor 50 of this embodiment, a difference between the acquired pressure value on the inlet side of the compressor 50 and the acquired pressure value on the outlet side thereof is calculated (a difference calculating process S200). Specifically, in the difference calculating process S200, information about the pressure value measured by the inlet side characteristic value measuring unit 511 is input to the first input unit 61 of the control unit 60. In the difference calculating process S200, information about the pressure value measured by the outlet side characteristic value measuring unit 521 is input to the second input unit 62 of the control unit 60. In the control unit 60, information input to the first input unit 61 and the second input unit 62 is input to the difference calculation unit 63. In the difference calculation unit 63, a difference between the pressure value on the outlet side of the compressor 50 and the pressure value on the inlet side thereof is calculated by subtracting information input from the first input unit 61 from information input from the second input unit 62.

[0074] Next, in the cleaning method of the compressor 50 of this embodiment, it is determined whether a hydrate anti freezing agent has been supplied to the internal flow path FC of the compressor 50 (a hydrate anti freezing agent supply determining process S300). Specifically, in the hydrate anti freezing agent supply determining process S300, the difference calculation unit 63 determines whether a hydrate anti freezing agent has already been

supplied to the internal flow path FC. In the difference calculation unit 63, when it is determined that information has been input once from the first input unit 61 and the second input unit 62, it is determined that a hydrate anti freezing agent has already been supplied to the internal flow path FC and information about the difference is output to the second reference determination unit 66. On the other hand, in the difference calculation unit 63, when it is determined that information has not been input from the first input unit 61 and the second input unit 62, it is determined that a hydrate anti freezing agent has not been supplied to the internal flow path FC, and information about the difference is output to the first reference determination unit 64.

[0075] When it is determined that a hydrate anti freezing agent has not been supplied to the internal flow path FC, it is determined whether the calculated difference satisfies a predetermined first reference (a first reference determining process S400). Specifically, in the first reference determining process S400, in the control unit 60, the calculated difference is input from the difference calculation unit 63 to the first reference determination unit 64. The first reference determination unit 64 determines whether the input difference value is less than the first reference. When it is determined that the calculated difference is less than the first reference, the first reference determination unit 64 sends a signal to the supply start instruction unit 65. On the other hand, when it is determined that the calculated difference is greater than the first reference, the first reference determination unit 64 terminates cleaning of the compressor 50 without sending a signal.

[0076] When the first reference determination unit 64 determines that the difference is less than the first reference and satisfies the first reference, supply of a hydrate anti freezing agent to be supplied to a gas compressed by the compressor 50 to the internal flow path FC starts (a supply start process S500). Specifically, in the supply start process S500, in the control unit 60, a signal is sent from the first reference determination unit 64 to the supply start instruction unit 65, and a signal is sent from the supply start instruction unit 65 to the first supply valve instruction unit 68. When a signal is sent from the supply start instruction unit 65, the first supply valve instruction unit 68 sends an instruction to open to the first supply valve 542. When the first supply valve 542 that has received the instruction is opened, part of the hydrate anti freezing agent that circulates in the hydrate anti freezing agent supply unit 53 flows into the first supply pipe 541. The hydrate anti freezing agent flowed into the first supply pipe 541 is sprayed from the hydrate anti freezing agent spraying unit 541a provided inside the casing 501 toward the casing flow path FC2 and is supplied to the internal flow path FC. The hydrate anti freezing agent supplied into the internal flow path FC circulates in the internal flow path FC together with the natural gas G, flows into the compressed gas circulation unit 52, and is discharged from the inside of the internal flow path FC.

[0077] Then, pressure values of the natural gas G are measured and acquired again on the inlet side and the outlet side of the compressor 50, and a state of the compressor 50 is measured (the characteristic value acquiring process S100). Then, a difference between the acquired pressure value on the inlet side of the compressor 50 and the acquired pressure value on the outlet side thereof is calculated (the difference calculating process S200). Next, it is determined whether a hydrate anti freezing agent has been supplied to the internal flow path FC of the compressor 50 (the hydrate anti freezing agent supply determining process S300). In this case, information has been already input once from the first input unit 61 and the second input unit 62. Therefore, in the hydrate anti freezing agent supply determining process S300, the difference calculation unit 63 determines that a hydrate anti freezing agent is supplied to the internal flow path FC and outputs information about the difference to the second reference determination unit 66.

[0078] When it is determined that a hydrate anti freezing agent is supplied to the internal flow path FC, it is determined that the calculated difference satisfies a predetermined second reference (a second reference determining process S600). Specifically, in the second reference determining process S600, in the control unit 60, the calculated difference is input from the difference calculation unit 63 to the second reference determination unit 66. The second reference determination unit 66 determines whether the input difference value is less than the second reference. When it is determined that the calculated difference is less than the second reference, the second reference determination unit 66 sends a signal to the heat supply instruction unit 67. On the other hand, when it is determined that the calculated difference is greater than the second reference, the second reference determination unit 66 sends a signal to the cleaning termination instruction unit 70, closes the first supply valve 542 and the second supply valve 544 and terminates cleaning of the compressor 50.

[0079] When the second reference determination unit 66 determines that the difference is less than the second reference and satisfies the second reference, the heated hydrate anti freezing agent is supplied to the internal flow path FC (a heat supply process S700). Specifically, in the heat supply process S700, in the control unit 60, a signal is sent from the second reference determination unit 66 to the heat supply instruction unit 67 and a signal is sent from the heat supply instruction unit 67 to the first supply valve instruction unit 68 and the second supply valve instruction unit 69. When the signal is sent from the heat supply instruction unit 67, the first supply valve instruction unit 68 sends an instruction to close to the first supply valve 542. When the signal is sent from the heat supply instruction unit 67, the second supply valve instruction unit 69 sends an instruction to open to the second supply valve 544. When the first supply valve 542 that has received the instruction is closed, the hydrate anti freezing agent flowing into the first supply pipe 541

is stopped. When the second supply valve 544 that has received the instruction is opened, flowing of the hydrate anti freezing agent into the second supply pipe 543 starts. The hydrate anti freezing agent flowed into the second supply pipe 543 passes through the heating unit 55 and is thus heated through heat exchange with the crude oil O that flows in the liquid circulation unit 42. The hydrate anti freezing agent heated to a high temperature flows into the first supply pipe 541 from a downstream side relative to the first supply valve 542. The high temperature hydrate anti freezing agent flowed into the first supply pipe 541 is sprayed from the hydrate anti freezing agent spraying unit 541a inside the casing 501 toward the casing flow path FC2 and is supplied to the internal flow path FC. The high temperature hydrate anti freezing agent supplied into the internal flow path FC circulates in the internal flow path FC together with the natural gas G, flows into the compressed gas circulation unit 52, and is discharged from the inside of the internal flow path FC.

[0080] According to the compressor system 5 described above, part of the hydrate anti freezing agent that is supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 for preventing hydration of the natural gas G compressed by the compressor 50 is sprayed to the casing flow path FC2 through the first supply pipe 541 when the first supply valve 542 is opened. The hydrate anti freezing agent not only prevents freezing of the natural gas G and prevents hydration but also has lipophilicity and hydrophilicity. Therefore, it is possible to remove oil contamination and aqueous contamination by the hydrate anti freezing agent. Therefore, when the hydrate anti freezing agent sprayed to the casing flow path FC2 flows in the internal flow path FC together with the natural gas G, it is possible to effectively remove sediments that are precipitated on a wall surface of the internal flow path FC. When the hydrate anti freezing agent is directly supplied to the casing flow path FC2, the hydrate anti freezing agent is prevented from being diluted by the natural gas G before reaching the internal flow path FC, and it is possible to clean the inside of the compressor 50 by effectively using the hydrate anti freezing agent. When part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 is used, it is possible to reliably supply a necessary amount of the hydrate anti freezing agent to the internal flow path FC. Accordingly, the compressor 50 can be reliably and effectively cleaned.

[0081] When the control unit 60 satisfies predetermined conditions as in the first reference determination unit 64 and the second reference determination unit 66, the hydrate anti freezing agent flows into the first supply pipe 541 and the second supply pipe 543 from the hydrate anti freezing agent supply unit 53. As a result, the hydrate anti freezing agent is ejected into the casing flow path FC2 by the hydrate anti freezing agent spraying unit 541 a. That is, when supply of the hydrate anti freezing agent to the internal flow path FC is controlled by the first ref-

erence determination unit 64 and the second reference determination unit 66, the hydrate anti freezing agent can be limit supply to the compressor 50 that is in a state in which cleaning is necessary. Therefore, it is possible to efficiently use the hydrate anti freezing agent supplied from the first supply pipe 541 and the second supply pipe 543 for cleaning the compressor 50 and minimize a supply amount of the hydrate anti freezing agent.

[0082] In the control unit 60, a pressure value of the natural gas G on the inlet side of the compressor 50 measured by the inlet side characteristic value measuring unit 511 of the gas circulation unit 51 is input to the first input unit 61. In addition, in the control unit 60, a pressure value of the natural gas G on the outlet side of the compressor 50 measured by the outlet side characteristic value measuring unit 521 of the compressed gas circulation unit 52 is input to the second input unit 62. Accordingly, it is possible to acquire pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50. When the difference calculation unit 63 calculates a difference between the acquired pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 and the first reference determination unit 64 compares the calculated difference with the first reference and performs determination, it is possible to easily determine whether the internal flow path FC is in a state in which cleaning is necessary. Based on the determination result, when a signal is sent from the first reference determination unit 64 to the supply start instruction unit 65 and the first supply valve 542 is opened through the first supply valve instruction unit 68, it is possible to start supply of the hydrate anti freezing agent to the first supply pipe 541. As a result, it is possible to start spraying of the hydrate anti freezing agent from the hydrate anti freezing agent spraying unit 541 a to the internal flow path FC and it is possible to perform cleaning of the internal flow path FC. Therefore, it is possible to determine whether the compressor 50 is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the internal flow path FC for which cleaning is necessary, the hydrate anti freezing agent supplied from the first supply pipe 541 and the second supply pipe 543 can be more efficiently used for cleaning the compressor 50 and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0083] The heating unit 55 configured to heat a hydrate anti freezing agent is provided in the second supply pipe 543. Therefore, it is possible to supply a high temperature hydrate anti freezing agent to the internal flow path FC. It is possible to improve solubility of sediments due to the hydrate anti freezing agent that is heated to a high temperature. Therefore, it is possible to increase a dissolution rate of sediments accumulated in the internal flow path FC and effectively clean the internal flow path FC.

[0084] When the difference calculation unit 63 calculates a difference between the acquired pressure values of the natural gas G on the inlet side and the outlet side

of the compressor 50, and the second reference determination unit 66 compares the calculated difference with the second reference that is set to a value greater than the first reference and performs determination, it is possible to easily determine again whether the internal flow path FC is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the internal flow path FC is in a state that is different from the state determined using the first reference (for example, whether greater cleaning is necessary for the internal flow path FC). Based on the determination result, a signal is sent from the second reference determination unit 66 to the heat supply instruction unit 67, the first supply valve 542 is closed through the first supply valve instruction unit 68, and the second supply valve 544 is opened through the second supply valve instruction unit 69. Therefore, it is possible to start supply of the hydrate anti freezing agent to the second supply pipe 543 in which the heating unit 55 is provided. As a result, it is possible to spray the hydrate anti freezing agent heated to a high temperature from the hydrate anti freezing agent spraying unit 541 a to the internal flow path FC, and it is possible to perform cleaning of the internal flow path FC more effectively. Therefore, it is possible to determine whether the compressor 50 is in a state that is different from the state in which the first reference is used for determination and cleaning is performed with high accuracy and it is possible to perform greater cleaning on the compressor 50 as necessary. Therefore, when the internal flow path FC is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor 50 more efficiently.

[0085] When monoethylene glycol whose hydrocarbon part has lipophilicity and whose hydroxyl groups and ether group have hydrophilicity is used as the hydrate anti freezing agent, it is possible to effectively clean both oil contamination and aquatic contamination in the internal flow path FC.

[0086] When part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit 53 to the compressed gas circulation unit 52 flows in the internal flow path FC of the compressor 50 for cleaning, there is no need to stop an operation of the compressor 50 in order to clean the compressor 50. Therefore, it is possible to efficiently clean the compressor 50 without causing a cleaning downtime.

[0087] According to the subsea production system 1 described above, it is also possible to reliably and efficiently clean the compressor 50 that is installed at a position at which maintenance is difficult, for example, in the seabed. Therefore, it is possible to prevent clogging due to sediments and it is possible to reliably send the natural gas G to the ship S through the compressor 50.

[0088] According to the cleaning method of the compressor 50 described above, a difference between the pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 acquired in the char-

acteristic value acquiring process S 100 is calculated in the difference calculating process S200 and it is determined whether a hydrate anti freezing agent has been supplied to the internal flow path FC in the hydrate anti freezing agent supply determining process S300. Then, in the first reference determining process S400, the calculated difference is compared with the first reference and determination is performed. Therefore, it is possible to easily determine whether the internal flow path FC is in a state in which cleaning is necessary. Based on the determination result, the first supply valve 542 is opened in the supply start process S500. Therefore, it is possible to start supply of the hydrate anti freezing agent to the first supply pipe 541. As a result, it is possible to start spraying of the hydrate anti freezing agent from the hydrate anti freezing agent spraying unit 541 a to the internal flow path FC and it is possible to perform cleaning of the internal flow path FC. Therefore, it is possible to determine whether the compressor 50 is in a state in which cleaning is necessary with high accuracy and it is possible to further limit supply of the hydrate anti freezing agent. Therefore, for the internal flow path FC for which cleaning is necessary, the hydrate anti freezing agent supplied from the first supply pipe 541 and the second supply pipe 543 can be more efficiently used for cleaning the compressor 50 and it is possible to further minimize a supply amount of the hydrate anti freezing agent.

[0089] After it is determined whether a hydrate anti freezing agent has been supplied to the internal flow path FC in the hydrate anti freezing agent supply determining process S300, when the second reference determining process S600 is performed in the first reference determining process S400 based on the determination result, it is possible to determine a cleaning state of the compressor 50. Therefore, it is possible to more efficiently clean the compressor 50 according to the cleaning state of the compressor 50.

[0090] A difference between the pressure values of the natural gas G on the inlet side and the outlet side of the compressor 50 acquired in the characteristic value acquiring process S 100 is calculated in the difference calculating process S200 and the calculated difference is compared with the second reference that is set to a value greater than the first reference and determination is performed in the second reference determining process S600. Accordingly, it is possible to easily determine again whether the internal flow path FC is in a state in which cleaning is necessary. Therefore, for example, it is possible to easily determine whether the internal flow path FC is in a state that is different from the state determined using the first reference (for example, whether greater cleaning is necessary for the internal flow path FC). Based on the determination result, in the heat supply process S700, the first supply valve 542 is closed and the second supply valve 544 is opened. Therefore, it is possible to start supply of the hydrate anti freezing agent to the second supply pipe 543 in which the heating unit 55 is provided. As a result, it is possible to spray the

hydrate anti freezing agent heated to a high temperature from the hydrate anti freezing agent spraying unit 541a to the internal flow path FC, and it is possible to perform cleaning of the internal flow path FC more effectively.

Therefore, it is possible to determine whether the compressor 50 is in a state that is different from the state in which the first reference is used for determination and cleaning is performed with high accuracy and it is possible to perform greater cleaning on the compressor 50 as necessary. Therefore, when the internal flow path FC is in a state in which greater cleaning is necessary, it is possible to efficiently supply the heated hydrate anti freezing agent and clean the compressor 50 more efficiently.

[0091] The embodiments of the present invention have been described in detail above with reference to the drawings, but configurations and combinations thereof in the embodiments are only examples, and additions, omissions, substitutions and other modifications of the configurations can be made without departing from the scope of the present invention. In addition, the present invention is not limited to the embodiments and is only limited by the scope of the appended claims.

[0092] A characteristic value of a gas is not limited to a pressure value of the gas as in this embodiment, and may be a value at which there is a difference in a state before and after the gas is compressed by the compressor. For example, the characteristic value of the gas may be a value obtained by measuring a temperature of the gas, a value obtained by measuring a flow rate of the gas, and a value obtained by calculating an efficiency of the compressor 50.

[0093] The internal hydrate anti freezing agent supply unit 54 of this embodiment has a configuration in which there is branching into the first supply pipe 541 and the second supply pipe 543, is not limited to such a structure and may have any structure as long as the hydrate anti freezing agent can be supplied to the internal flow path FC of the compressor 50. For example, the internal hydrate anti freezing agent supply unit 54 may have a structure that includes only either the first supply pipe 541 or the second supply pipe 543.

[0094] When it is determined whether the first reference or the second reference is satisfied, determination of whether to supply the hydrate anti freezing agent may not be based on a single determination result as in this embodiment, but based on a plurality of determinations of whether the first reference or the second reference is satisfied. In such a configuration, it is possible to determine a contamination condition of the internal flow path FC with higher accuracy.

[Industrial Applicability]

[0095] According to the above-described compressor system, it is possible to efficiently clean the compressor by supplying the hydrate anti freezing agent to the internal flow path.

[Reference Signs List]

[0096]

1	Subsea production system
S	Ship
F	Oil gas field
W	Production well
PF	Production fluid
M	Manifold
FL	Flow line
R	Riser
GR	Gas pipeline
OR	Oil pipeline
AR	Pipeline for a hydrate anti freezing agent
AL	Umbilical line
SM	Subsea module
2	Main heat exchanger
3	Separator
4	Pump system
41	Pump
42	Liquid circulation unit
43	Compressed liquid circulation unit
5	Compressor system
50	Compressor
SL	Shaft line
501	Casing
502	Rotation shaft
503	Impeller
503a	Disk
503b	Blade
503c	Cover
FC	Internal flow path
FC1	Compression flow path
FC2	Casing flow path
51	Gas circulation unit
511	Inlet side characteristic value measuring unit
52	Compressed gas circulation unit
521	Outlet side characteristic value measuring unit
53	Hydrate anti freezing agent supply unit
54	Internal hydrate anti freezing agent supply unit
541	First supply pipe
541a	Hydrate anti freezing agent spraying unit
42	First supply valve
543	Second supply pipe
544	Second supply valve
55	Heating unit
60	Control unit
61	First input unit
62	Second input unit
63	Difference calculation unit
64	First reference determination unit
65	Supply start instruction unit
66	Second reference determination unit
67	Heat supply instruction unit
68	First supply valve instruction unit
69	Second supply valve instruction unit
70	Cleaning termination instruction unit

S100	Characteristic value acquiring process
S200	Difference calculating process
S300	Hydrate anti freezing agent supply determining process
5 S400	First reference determining process
S500	Supply start process
S600	Second reference determining process
S700	Heat supply process

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Claims**1.** A compressor system comprising:

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a compressor including a casing, a rotation shaft supported in the casing, and an impeller that rotates together with the rotation shaft and compresses a gas;

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a compressed gas circulation unit in which the gas compressed by the compressor circulates; a hydrate anti freezing agent supply unit configured to supply a hydrate anti freezing agent that prevents hydration of the gas to the compressed gas circulation unit; and

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an internal hydrate anti freezing agent supply unit configured to supply part of the hydrate anti freezing agent supplied from the hydrate anti freezing agent supply unit to an internal flow path formed of the impeller and the casing.

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2. The compressor system according to claim 1, comprising

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a control unit configured to perform supply control such that, when predetermined conditions are satisfied, the internal hydrate anti freezing agent supply unit starts supply of the hydrate anti freezing agent to the internal flow path.

3. The compressor system according to claim 2, wherein the control unit includes

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a first reference determination unit configured to determine whether a difference between characteristic values of the gas on an inlet side of the compressor and an outlet side of the compressor satisfies a predetermined first reference; and

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a supply start instruction unit configured to send an instruction to the internal hydrate anti freezing agent supply unit to start supply of the hydrate anti freezing agent to the internal flow path when the first reference determination unit determines that the first reference is satisfied.

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4. The compressor system according to any one of claims 1 to 3, comprising

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a heating unit configured to heat the hydrate anti freezing agent, wherein the internal hydrate anti freezing agent supply unit supplies the hydrate anti freezing agent heat-

ed by the heating unit to the internal flow path.

5. The compressor system according to claim 3, comprising
 a heating unit configured to heat the hydrate anti
 freezing agent, 5
 wherein the control unit includes
 a second reference determination unit configured to
 determine whether a difference between character- 10
 istic values of the gas on the inlet side of the com-
 pressor and the outlet side of the compressor satis-
 fies a predetermined second reference after supply
 of the hydrate anti freezing agent to the internal flow
 path starts; and
 a heat supply instruction unit configured to send an 15
 instruction to the internal hydrate anti freezing agent
 supply unit to supply the hydrate anti freezing agent
 heated by the heating unit to the internal flow path
 when the second reference determination unit de-
 termines that the second reference is satisfied. 20

6. A subsea production system comprising:

the compressor system according to any one of
 claims 1 to 5; and 25
 a separator configured to separate a production
 fluid drawn from a production well into the gas
 and a liquid and supply the result to the com-
 pressor. 30

7. A compressor cleaning method in which a compres-
 sor including a casing, a rotation shaft supported in
 the casing and an impeller that rotates together with
 the rotation shaft and compresses a gas is cleaned,
 the method comprising: 35

a first reference determining process of deter-
 mining whether a difference between character-
 istic values of the gas on an inlet side of the
 compressor and an outlet side of the compres- 40
 sor satisfies a predetermined first reference; and
 a supply start process in which, when it is deter-
 mined that the first reference is satisfied in the
 first reference determining process, supply of a
 hydrate anti freezing agent that prevents hydra- 45
 tion of the gas compressed by the compressor
 to an internal flow path formed of the impeller
 and the casing starts.

8. The compressor cleaning method according to claim 50
 7, comprising
 a second reference determining process in which,
 after supply of the hydrate anti freezing agent to the
 internal flow path starts, it is determined whether a
 difference between characteristic values of the gas 55
 on an inlet side of the compressor and an outlet side
 of the compressor satisfies a predetermined second
 reference; and

a heat supply process in which, when it is determined
 that the second reference is satisfied in the second
 reference determining process, the heated hydrate
 anti freezing agent is supplied to the internal flow
 path.

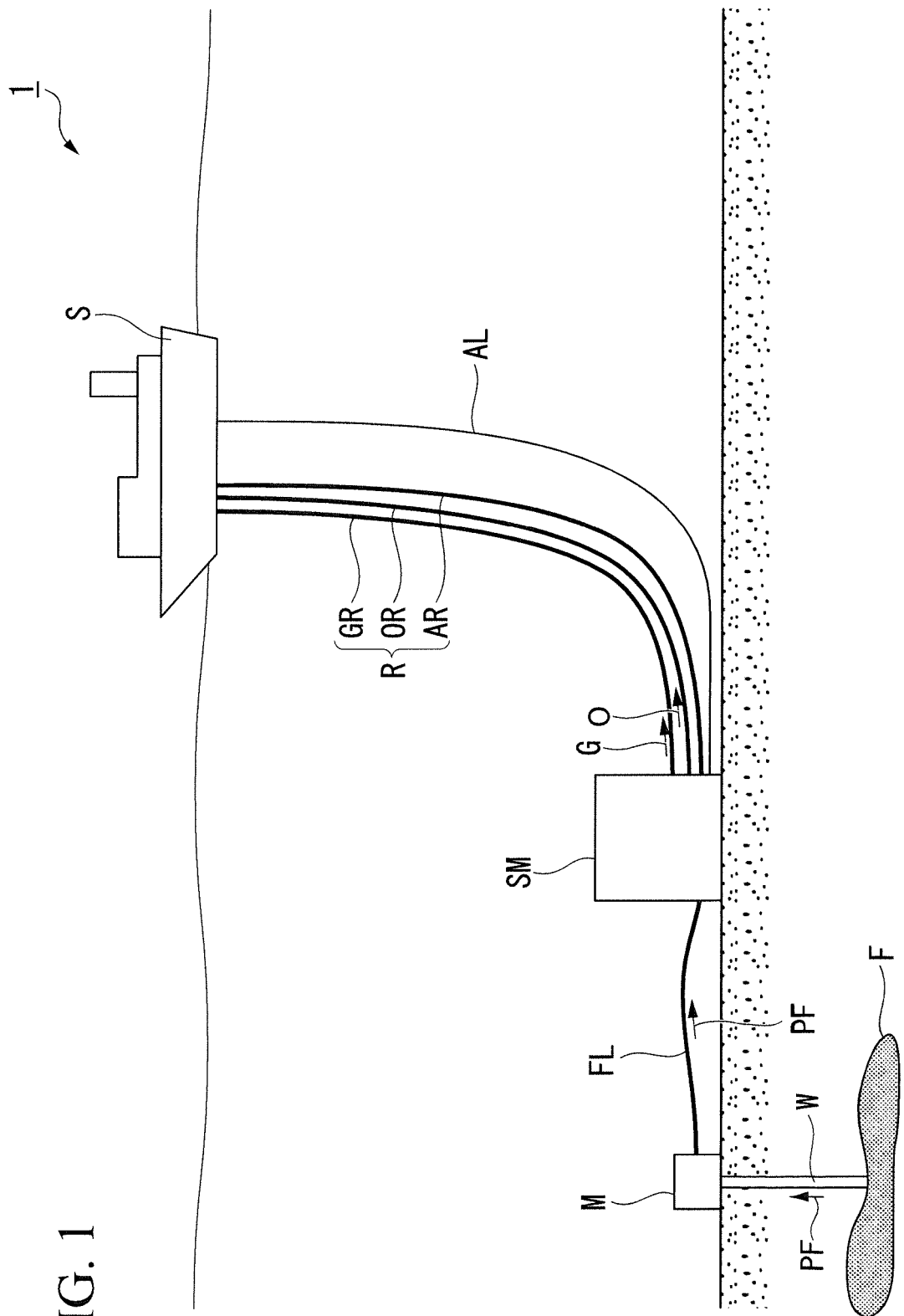


FIG. 1

FIG. 2

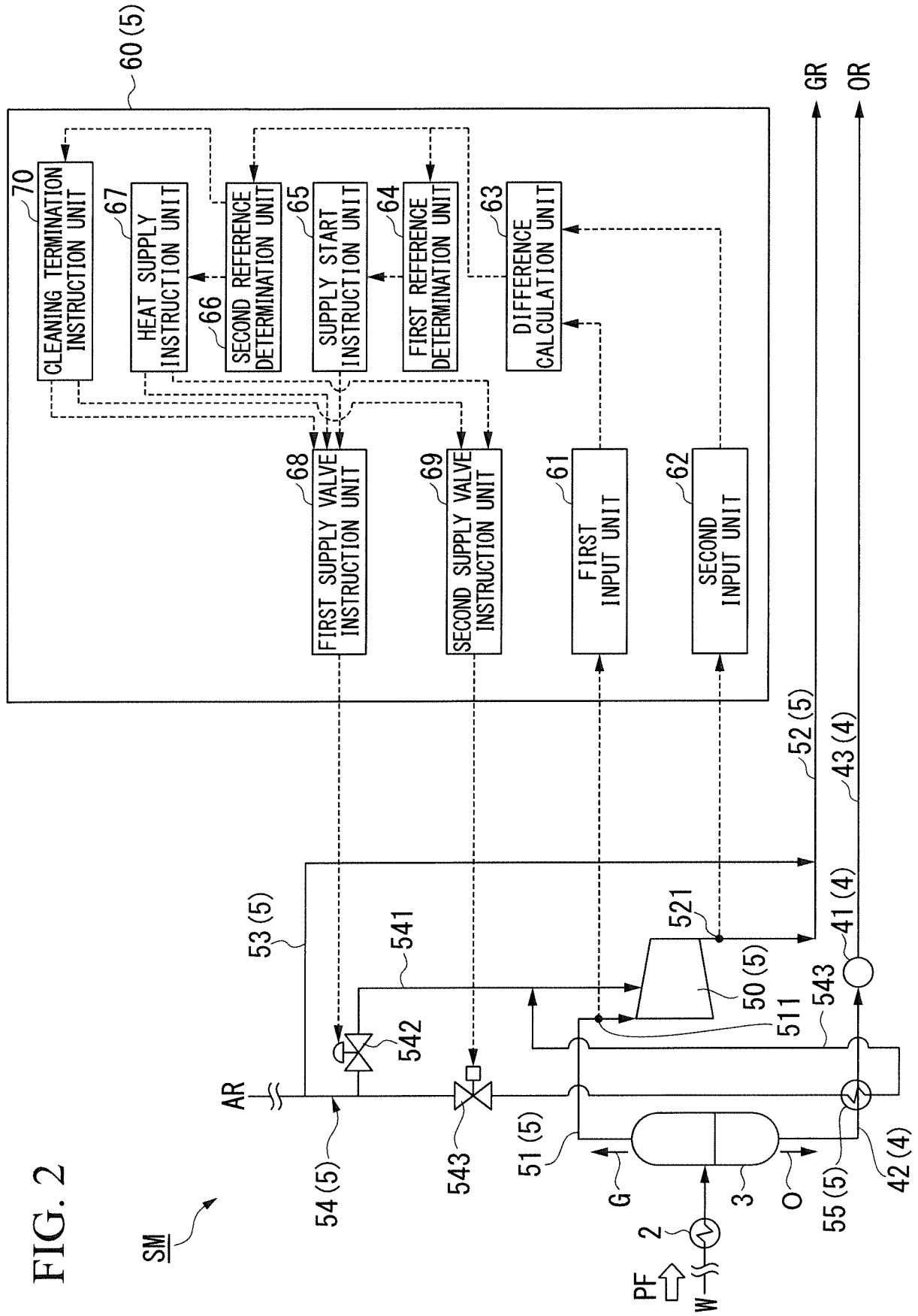


FIG. 3

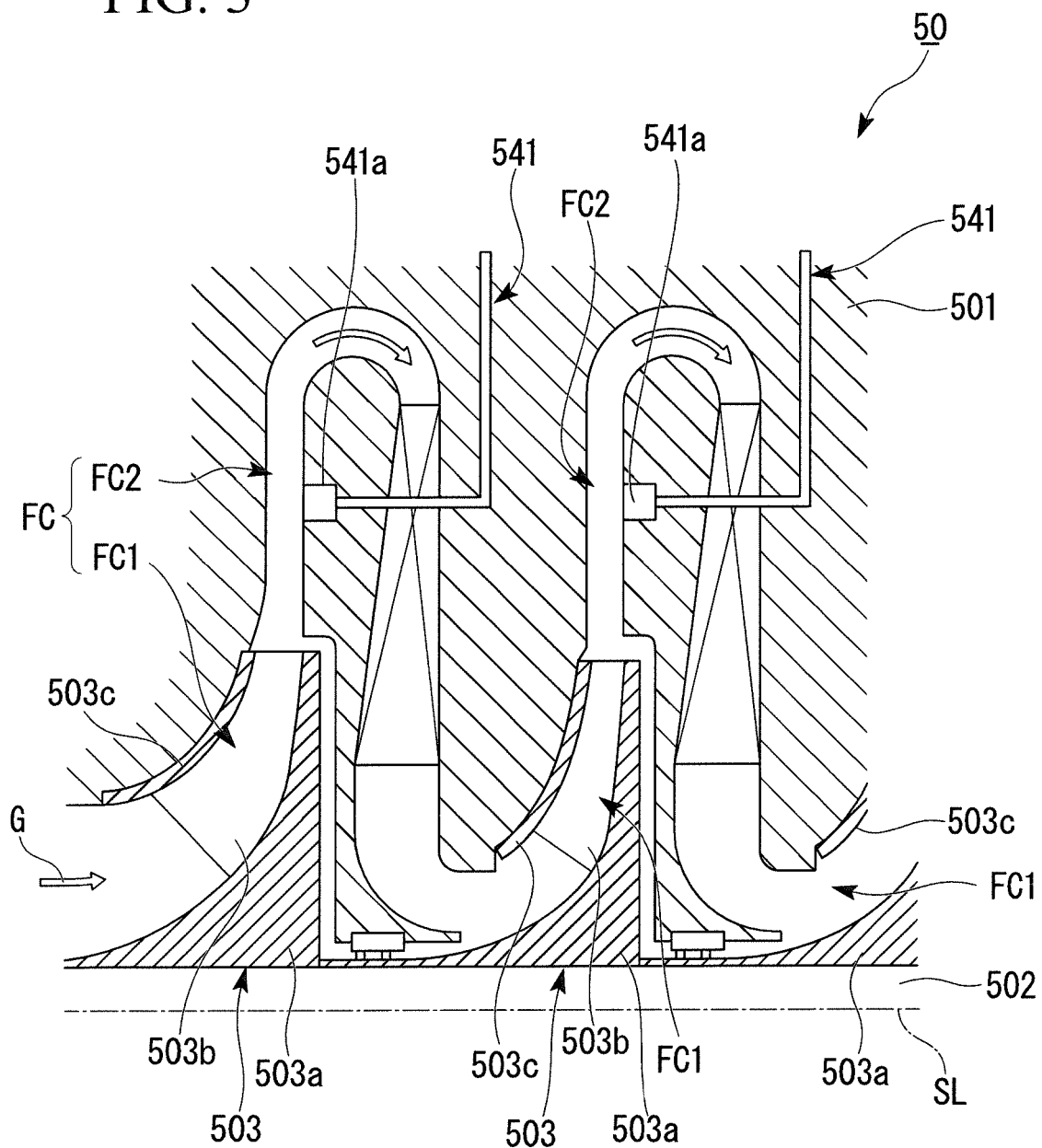
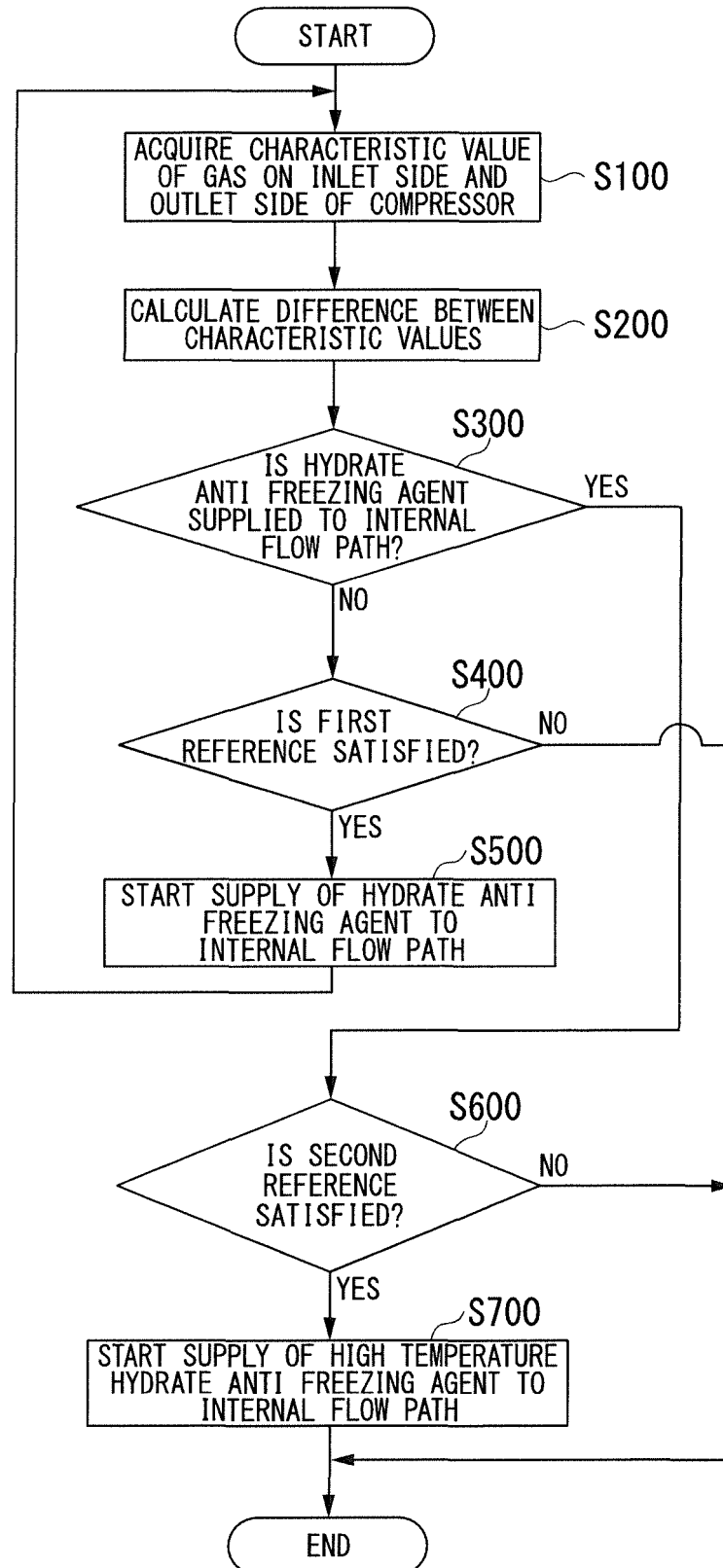


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/051529

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/70(2006.01)i, F04D27/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D29/70, F04D27/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/185801 A1 (STATOIL PETROLEUM AS), 19 December 2013 (19.12.2013), entire text; all drawings & CA 2876328 A1	1-8
A	WO 2007/004886 A1 (AKER KVAERNER SUBSEA AS), 11 January 2007 (11.01.2007), entire text; all drawings & US 2009/0050326 A1 & NO 20053296 A	1-8
A	JP 2014-128104 A (Mitsubishi Heavy Industries, Ltd.), 07 July 2014 (07.07.2014), entire text; all drawings (Family: none)	1-8

☒ 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

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08 April 2015 (08.04.15)Date of mailing of the international search report
21 April 2015 (21.04.15)Name and mailing address of the ISA/
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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-153568 A (Mitsubishi Heavy Industries, Ltd.), 11 August 2011 (11.08.2011), entire text; all drawings & US 2012/0186605 A1 & WO 2011/093384 A1 & EP 2530332 A1	1-8

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- WO 2013185801 A [0005]