US 20170298944A1

(19) United States

(12) Patent Application Publication

NAKANIWA

(10) Pub. No.: US 2017/0298944 A1

(43) Pub. Date: Oct. 19, 2017

(54) **COMPRESSOR SYSTEM**

(71) Applicant: **MITSUBISHI HEAVY INDUSTRIES, LTD.**, Tokyo (JP)

(72) Inventor: **Akihiro NAKANIWA**, Tokyo (JP)

(73) Assignee: **MITSUBISHI HEAVY INDUSTRIES, LTD.**, Tokyo (JP)

(21) Appl. No.: **15/516,816**

(22) PCT Filed: **Nov. 10, 2015**

(86) PCT No.: **PCT/JP2015/081588**

§ 371 (c)(1),
(2) Date: **Apr. 4, 2017**

(30) **Foreign Application Priority Data**

Mar. 18, 2015 (JP) 2015-054250

Publication Classification

(51) **Int. Cl.**

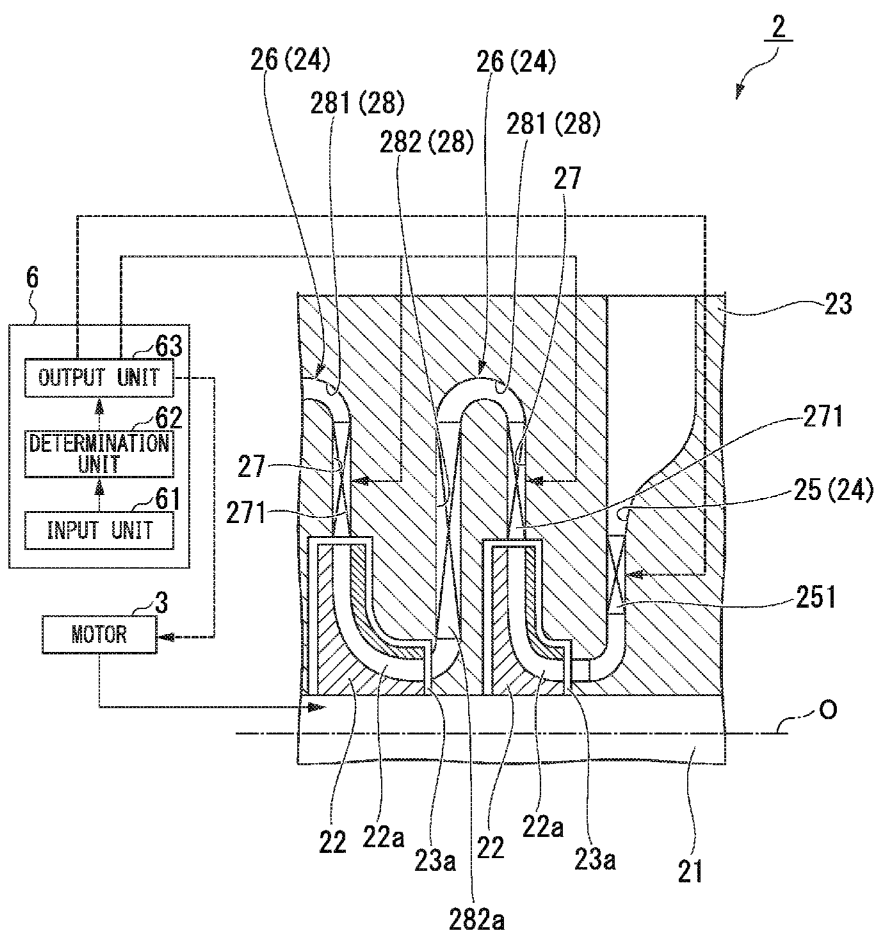
F04D 27/00 (2006.01)
F04D 25/06 (2006.01)
F04D 29/42 (2006.01)
F04D 17/10 (2006.01)
F04D 29/28 (2006.01)

(52) **U.S. Cl.**

CPC ***F04D 27/002*** (2013.01); ***F04D 29/4206*** (2013.01); ***F04D 17/10*** (2013.01); ***F04D 25/06*** (2013.01); *F04D 29/284* (2013.01)

(57) **ABSTRACT**

A compressor system includes a compressor that includes an impeller configured to compress a working fluid by rotation. The compressor includes a housing in which an inflow flow path and a discharge flow path are formed, a guide vane that is provided in the inflow flow path and has an angle that is changeable, a diffuser vane that is provided in the discharge flow path and has an angle that is changeable, and a control unit configured to control angles of the guide vane and the diffuser vane. The control unit controls an angle of at least one of the guide vane and the diffuser vane based on a requested PQ characteristic value and a rotational speed of the impeller.



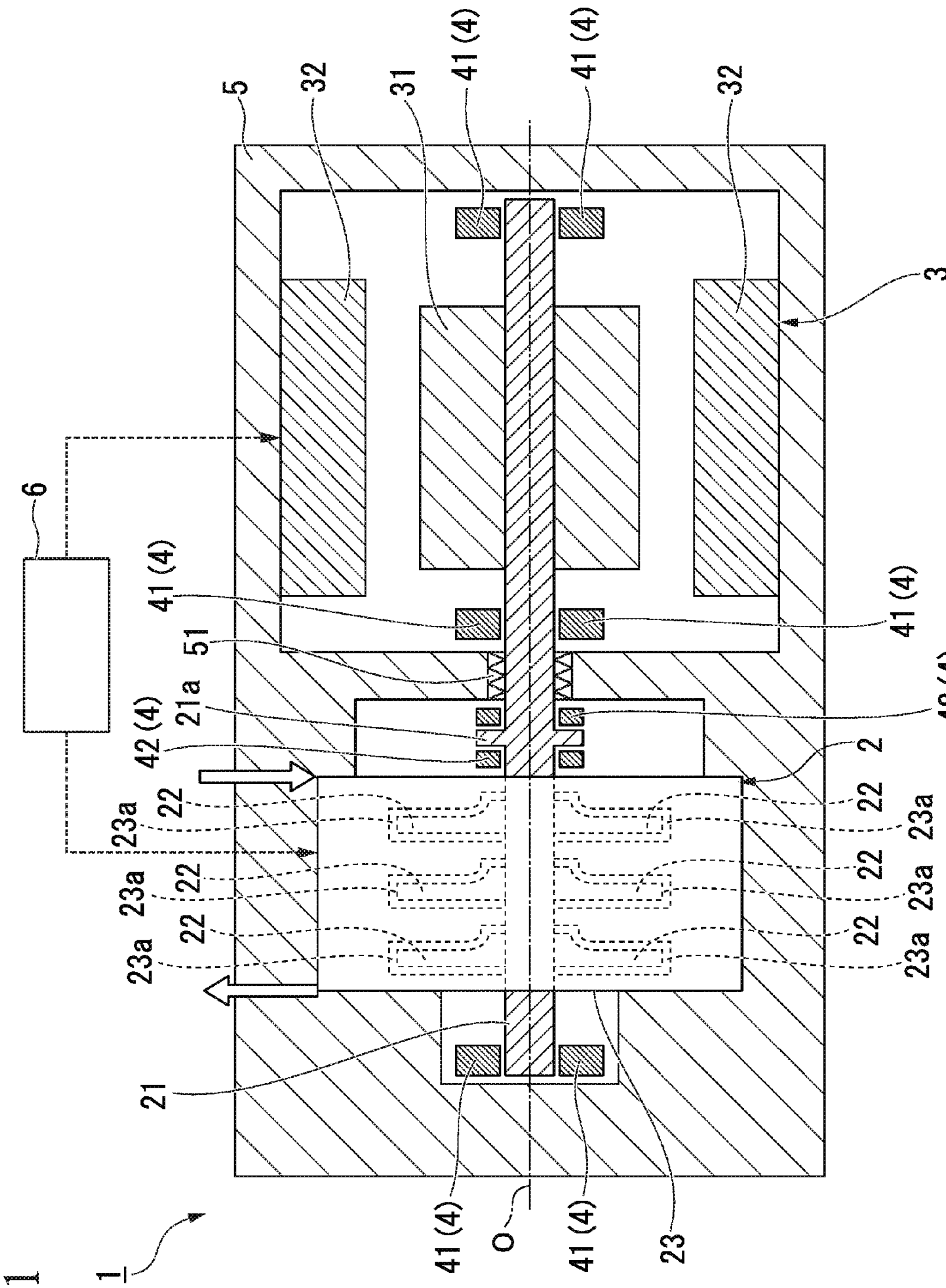


FIG. 1

FIG. 2

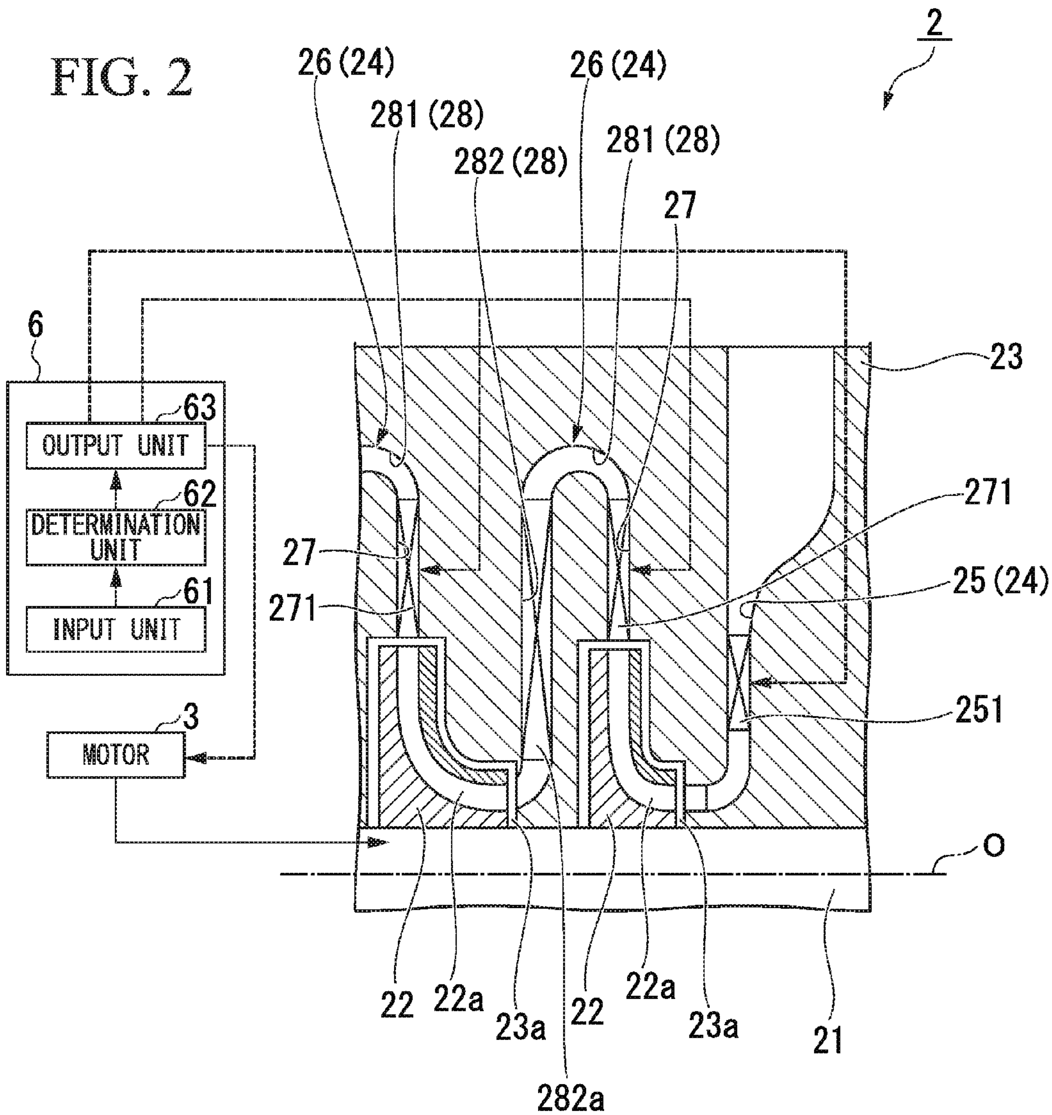
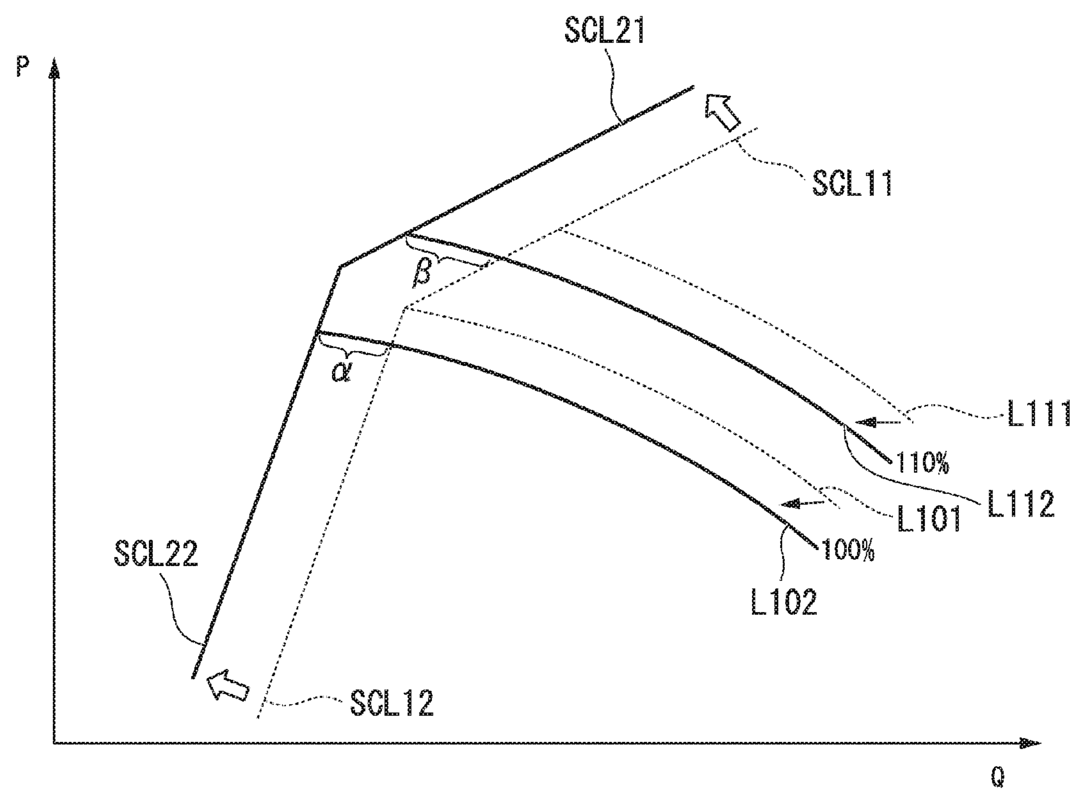

2
26 (24)
26 (24)
281 (28)
282 (28)
281 (28)
27
6
63
OUTPUT UNIT
62
DETERMINATION UNIT
61
INPUT UNIT
3
MOTOR
23
271
25 (24)
27
271
251
O
22
22a
23a
22
22a
23a
21
282a

FIG. 3



COMPRESSOR SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to a compressor system.

[0002] Priority is claimed on Japanese Patent Application No. 2015-054250, filed Mar. 18, 2015, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] A compressor system in which a motor and a compressor are integrated includes a compressor configured to compress a gas such as air or the like and a motor configured to drive the compressor. In the compressor system, a rotation shaft that extends from a casing of the compressor and a rotation shaft of a motor that similarly extends from a casing of the motor are connected. The rotation of the motor is transmitted to the compressor. The rotation shafts of the motor and the compressor are supported by a plurality of bearings and thus reliably rotate.

[0004] Such a compressor system is used for, for example, a subsea production system as in Non Patent Literature 1 or a Floating Production Storage and Offloading (FPSO) unit as in Non Patent Literature 2. When the compressor system is used for the subsea production system, the compressor system is installed in the seabed. The compressor system sends production fluids mixed with crude oils and natural gases that are drawn from production wells drilled to a depth of several thousand meters in the seabed to the sea surface. When the compressor system is used for the FPSO unit, the compressor system is installed in a marine facility such as a ship.

CITATION LIST

Non Patent Literature

[Non Patent Literature 1]

[0005] Mitsubishi Heavy Industries Technical Review Vol. 34 No. 5 P310-P313

[Non Patent Literature 2]

[0006] Turbomachinery International September/October 2014 P18-P24

SUMMARY OF INVENTION

Technical Problem

[0007] Incidentally, in a compressor system used for the subsea production system and the FPSO unit, production fluids mixed with crude oils and natural gases drawn from production wells in the seabed flow into the compressor as fluids. There is a possibility of characteristics of the production fluids being changed due to a change of a content of oil of crude oil or the like during drawing. When characteristics of production fluids change, the range in which the compressor can operate changes. As a result, operation conditions of the compressor change.

[0008] The present invention provides a compressor system capable of responding to changing operation conditions.

Solution to Problem

[0009] In order to address the above problems, the present invention proposes the following solutions.

[0010] A compressor system according to a first aspect of the present invention includes a motor including a rotor configured to rotate about an axis and a stator that is disposed on an outer circumference side of the rotor; and a compressor including an impeller that rotates together with the rotor and compresses a working fluid, wherein the compressor includes a housing in which an inflow flow path through which a working fluid flows into the impeller and a discharge flow path through which a working fluid pressure-fed by the impeller circulates are formed; a guide vane that is provided in the inflow flow path and has an angle that is changeable; a diffuser vane that is provided in the discharge flow path and has an angle that is changeable; and a control unit configured to control angles of the guide vane and the diffuser vane, and wherein the control unit controls an angle of at least one of the guide vane and the diffuser vane based on requested PQ characteristic values that are required pressure and flow rate values and a rotational speed of the impeller.

[0011] In such a configuration, it is possible to control an angle of at least one of the guide vane and the diffuser vane based on the requested PQ characteristic value and the rotational speed of the impeller. Therefore, it is possible to decrease at least one of an angle at which a working fluid that flows into the impeller from the inflow flow path flows and an angle at which a working fluid that flows into the discharge flow path from the impeller flows. Therefore, a surge control line can be changed to improve PQ characteristics during operation and it is possible to increase an operation range of the compressor.

[0012] In a compressor system according to a second aspect of the present invention, in the first aspect, when a rotational speed of the impeller is less than a predetermined reference, the control unit may control an angle of the guide vane so that a relative angle with respect to a direction in which the working fluid that flows into the impeller from the inflow flow path flows becomes smaller.

[0013] In such a configuration, when a rotational speed of the impeller is less than a predetermined reference, a relative angle of the guide vane with respect to a direction in which a working fluid that flows into the impeller from the inflow flow path which is a side in which a working fluid flows into the impeller flows becomes smaller. Therefore, it is possible to efficiently improve PQ characteristics. As a result, when an angle of the guide vane is adjusted, it is possible to efficiently increase an operation range of the compressor in a low pressure and low flow rate area.

[0014] In a compressor system according to a third aspect of the present invention, in the first aspect, when a rotational speed of the impeller is greater than a predetermined reference, the control unit may control an angle of the diffuser vane so that a relative angle with respect to a direction in which the working fluid that flows into the discharge flow path from the impeller flows becomes smaller.

[0015] In such a configuration, when a rotational speed of the impeller is greater than a predetermined reference, a relative angle of the diffuser vane with respect to an angle at which a working fluid that flows into the discharge flow path which is a side in which a working fluid from the impeller is discharged flows becomes smaller. Therefore, it is possible to efficiently improve PQ characteristics. As a result, it is possible to efficiently increase an operation range of the compressor in a high pressure and high flow rate area.

[0016] In a compressor system according to a fourth aspect of the present invention, in any one of the first to third aspects, when the requested PQ characteristic value satisfies a requirement of a predetermined reference, the control unit may control an angle of the guide vane so that a relative angle with respect to a direction in which the working fluid that flows into the impeller from the inflow flow path becomes smaller.

[0017] In such a configuration, it is possible to change an angle to improve PQ characteristics only as necessary and it is possible to efficiently increase an operation range of the compressor.

[0018] In a compressor system according to a fifth aspect of the present invention, in any one of the first to third aspects, when the requested PQ characteristic value satisfies a requirement of a predetermined reference, the control unit may control an angle of the diffuser vane so that a relative angle with respect to a direction in which the working fluid that flows into the discharge flow path from the impeller flows becomes smaller.

[0019] In such a configuration, it is possible to change an angle to improve PQ characteristics only as necessary and it is possible to efficiently increase an operation range of the compressor.

Advantageous Effects of Invention

[0020] According to the compressor system of the present invention, when an angle of at least one of the guide vane and the diffuser vane is controlled, it is possible to respond to changing operation conditions by widening an operation range of the compressor.

BRIEF DESCRIPTION OF DRAWINGS

[0021] FIG. **1** is a schematic diagram describing a compressor system according to an embodiment of the present invention.

[0022] FIG. **2** is a schematic diagram showing an internal structure of a compressor according to an embodiment of the present invention.

[0023] FIG. **3** is a diagram of a relationship between a flow rate and a pressure in a compressor according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0024] Hereinafter, an embodiment according to the present invention will be described with reference to FIG. **1** to FIG. **3**.

[0025] A compressor system **1** is provided in the seabed for a subsea production system that is one for ocean oil and gas field development methods and is provided on the sea surface for a Floating Production Storage and Offloading (FPSO) unit. The compressor system **1** pressure-feeds a production fluid such as oils and gases harvested from oil gas field production wells that are located several hundreds to thousands of meters from the seabed as a working fluid.

[0026] As shown in FIG. **1**, the compressor system **1** includes a compressor **2**, a motor **3**, a bearing **4**, a casing **5**, and a control unit **6**. The compressor **2** includes a shaft **21** that extends in an O axis direction (in a horizontal direction in FIG. **1**) as a rotation shaft. The motor **3** includes a rotor **31** that is directly connected to the shaft **21**. The bearing **4** supports the shaft **21**. The casing **5** accommodates the motor **3** and the compressor **2**. The control unit **6** controls the motor **3** and the compressor **2**.

[0027] The compressor **2** is accommodated inside the casing **5**. The compressor **2** compresses a working fluid when the shaft **21** rotates about an O axis together with the rotor **31**. The compressor **2** of this embodiment includes the shaft **21**, an impeller **22**, and the housing **23**. The shaft **21** extends in the O axis direction. The impeller **22** is fixed to an outer circumference surface of the shaft **21** and compresses a working fluid by rotating together with the rotor **31**. The housing **23** covers the impeller **22** from the outside.

[0028] The shaft **21** is a rotation shaft that extends in the O axis direction. The shaft **21** is supported by the casing **5** to be rotatable about the O axis. The shaft **21** passes through the housing **23** in the O axis direction. The shaft **21** has ends both of which extend from the housing **23**. The shaft **21** extends in the O axis direction in the casing **5** to be described below.

[0029] The impeller **22** rotates together with the shaft **21** and compresses a working fluid that passes an impeller flow path **22*a*** formed therein to generate a compressed fluid. A plurality of impellers **22** are fixed to the outer circumference surface of the shaft **21** side by side with spaces therebetween in the O axis direction. Also, FIG. **1** shows an example in which the plurality of impellers **22** is provided. However, in the compressor **2**, at least one impeller **22** may be provided.

[0030] As shown in FIG. **2**, through the impeller flow path **22*a***, a working fluid is circulated from an inlet portion of the impeller **22** to an outlet portion of the impeller **22**. The inlet portion of the impeller **22** is formed at an end that faces an upstream side (the right side in FIG. **1** and FIG. **2**) that is one side of the impeller **22** in the O axis direction. The outlet portion of the impeller **22** is formed at an end that faces outward in a radial direction with respect to the O axis of the impeller **22**.

[0031] The housing **23** is an exterior of the compressor **2**. The housing **23** accommodates the impeller **22** therein. The housing **23** is accommodated inside the casing **5**. In the housing **23**, a plurality of internal spaces **23*a*** whose diameters are repeatedly reduced and increased are provided. The impeller **22** is accommodated in the internal space **23*a***. In the internal space **23*a***, the impeller **22** is disposed with a predetermined space between itself and the housing **23**. In the housing **23**, a housing flow path **24** is formed. Through the housing flow path **24**, a working fluid is circulated from the impeller **22** that is disposed on an upstream side in the O axis direction to the impeller **22** adjacent on a downstream side (the left side in FIG. **1** and FIG. **2**) that is the other side in the O axis direction.

[0032] As shown in FIG. **2**, the housing flow path **24** includes a suction flow path **25**, an intermediate flow path **26**, and a discharge flow path (not shown). The suction flow path **25**, through which a working fluid flows into the impeller **22** from the outside, is disposed on the furthest upstream side in the O axis direction. The intermediate flow path **26** is formed between the plurality of impellers **22**. Through the discharge flow path (not shown), a working fluid compressed by the impeller **22** disposed on the furthest downstream side in the O axis direction is discharged to the outside.

[0033] The suction flow path **25** is formed at a position on the upstream side relative to the impeller **22** that is disposed on the furthest upstream side in the O axis direction. The suction flow path **25** is an inflow flow path through which a working fluid flows into the impeller **22** disposed on the furthest upstream side in the O axis direction. The suction flow path **25** extends inward in the radial direction from an opening formed in a circumferential direction on the upstream side in the O axis direction of the housing **23**. Through the suction flow path **25**, a working fluid is circulated to an inlet of the impeller flow path **22***a*. An inlet guide vane **251** (a guide vane) is provided in the suction flow path **25**. The inlet guide vane **251** changes a direction of a working fluid suctioned from the outside of the housing **23** to a desired direction and guides the working fluid to the impeller flow path **22***a*.

[0034] The inlet guide vane **251** has an angle that is changeable by an operating mechanism (not shown). The desired direction in the inlet guide vane **251** is, for example, a direction in which pre-rotation is applied to the working fluid suctioned from the outside. The desired direction in the inlet guide vane **251** is, for example, a direction inclined toward the front side of the impeller **22** in a rotation direction as it advances in the radial direction. The inlet guide vane **251** of this embodiment has an angle that is adjusted based on a signal from the control unit **6** such that a relative angle with respect to a direction in which a working fluid that flows into the impeller flow path **22***a* flows becomes smaller.

[0035] The intermediate flow path **26** is formed to connect adjacent impellers **22** in the O axis direction. The intermediate flow path **26** does not communicate with the outside of the housing **23** and is formed inside the housing **23**. The intermediate flow path **26** includes a diffuser flow path **27** and a return flow path **28**. The diffuser flow path **27** extends outward in the radial direction from an outlet portion of the impeller flow path **22***a*. The return flow path **28** is connected to the diffuser flow path **27** and extends to the inlet portion of the impeller flow path **22***a* of the adjacent impeller **22**.

[0036] The diffuser flow path **27** has an inlet that faces the outlet portion of the impeller flow path **22***a*. Through the diffuser flow path **27**, a working fluid discharged from the impeller flow path **22***a* is circulated outward in the radial direction. The diffuser flow path **27** is a discharge flow path through which a working fluid pressure-fed by the impeller **22** circulates. In the diffuser flow path **27**, a diffuser vane **271** is provided. The diffuser vane **271** changes a direction of the working fluid discharged from the impeller flow path **22***a* to a desired direction.

[0037] The diffuser vane **271** has an angle that is changeable by an operating mechanism (not shown). The desired direction in the diffuser vane **271** is a direction in which a dynamic pressure of a circulating working fluid is restored as a static pressure. The desired direction in the diffuser vane **271** is a direction inclined toward the front side of the impeller **22** in a rotation direction as it advances in the radial direction. The diffuser vane **271** of this embodiment has an angle that is adjusted based on a signal from the control unit **6** such that a relative angle with respect to a direction in which a working fluid that flows into the diffuser flow path **27** from the impeller flow path **22***a* flows becomes smaller.

[0038] The return flow path **28** is an inflow flow path through which a working fluid that has circulated in the diffuser flow path **27** flows into the impeller flow path **22***a*. The return flow path **28** includes a curved flow path **281** and a linear flow path **282**. The curved flow path **281** is connected to an outer end of the diffuser flow path **27** in the radial direction. The linear flow path **282** is connected to an end of the curved flow path **281**.

[0039] The curved flow path **281** is continuously formed with respect to the outside of the diffuser flow path **27** in the radial direction. The curved flow path **281** extends outward in the radial direction and then curves inward in the radial direction. In the curved flow path **281**, a flow of the working fluid that moves outward in the radial direction is changed to a flow that moves inward in the radial direction.

[0040] The linear flow path **282** extends inward in the radial direction from the curved flow path **281** to an inlet portion of the impeller flow path **22***a*. The linear flow path **282** is continuously formed with respect to a side opposite to a portion connected to the diffuser flow path **27** of the curved flow path **281**. In the linear flow path **282**, a return vane **282***a* that changes a direction of a working fluid that has circulated in the diffuser flow path **27** to a desired direction is provided.

[0041] As shown in FIG. **1**, the motor **3** is accommodated in the casing **5** with a space in the O axis direction between itself and the compressor **2**. The motor **3** includes a rotor **31** and a stator **32**. The rotor **31** is fixed to be integrated with the shaft **21**. The stator **32** is disposed on an outer circumference side of the rotor **31**.

[0042] The rotor **31** is integrated with the shaft **21** and rotatable about the O axis. The rotor **31** is directly connected to an outer circumference side of the shaft **21**, which is the outside in a circumferential direction with respect to the O axis so that it integrally rotates with the shaft **21** of the compressor **2** without intervening of gears and the like. The rotor **31** includes, for example, a rotor core (not shown) in which an induced current flows when the stator **32** generates a rotating magnetic field.

[0043] A gap in the circumferential direction is provided between the stator **32** and the rotor **31** to cover the rotor **31** from the outer circumference side. The stator **32** includes a plurality of stator cores (not shown) that are disposed in, for example, the circumferential direction of the rotor **31**, and a stator winding (not shown) wound on the stator core. When a current flows from the outside, the stator **32** generates a rotating magnetic field and rotates the rotor **31**. The stator **32** is fixed into the casing **5**.

[0044] The bearing **4** is accommodated inside the casing **5** and rotatably supports the shaft **21**. The bearing **4** of this embodiment includes a plurality of journal bearings **41** and thrust bearings **42**.

[0045] The journal bearing **41** supports a load on the shaft **21** in the radial direction. Journal bearings **41** are disposed at both ends of the shaft **21** in the O axis direction to sandwich the motor **3** and the compressor **2** in the O axis direction. The journal bearing **41** is also disposed between an area in which the compressor **2** is provided and an area in which the motor **3** is provided, which is on the motor **3** side relative to a sealing member **51** to be described below.

[0046] The thrust bearing **42** supports a load on the shaft **21** in the O axis direction through a thrust collar **21***a* that is formed at the shaft **21**. The thrust bearing **42** is disposed between the area in which the compressor **2** is provided and the area in which the motor **3** is provided and is on the compressor **2** side relative to the sealing member **51** to be described below.

[0047] The casing **5** accommodates the compressor **2** and the motor **3** therein. The casing **5** has a cylindrical shape along the O axis. An inner surface of the casing **5** protrudes toward the shaft **21** between the compressor **2** and the motor **3** in the O axis direction. The casing **5** is provided on a portion from which the sealing member **51** sealing a gap between the area in which the compressor **2** is provided and the area in which the motor **3** is provided protrudes.

[0048] The control unit **6** controls the compressor **2** and the motor **3** so that the compressor **2** is operated according to predetermined operation conditions. The control unit **6** controls angles of the inlet guide vane **251** and the diffuser vane **271**. The control unit **6** controls the rotational speed of the rotor **31** of the motor **3**. As shown in FIG. **2**, the control unit **6** includes an input unit **61**, a determination unit **62**, and an output unit **63**. In the input unit **61**, a requested PQ characteristic value that is a requested pressure and flow rate value and a requested rotational speed that is a requested rotational speed of the impeller **22** are input. The determination unit **62** determines whether the input requested PQ characteristic value and the requested rotational speed satisfy requirements of predetermined references. The output unit **63** sends a signal to the motor **3**, the inlet guide vane **251**, and the diffuser vane **271** based on the determination result of the determination unit **62**.

[0049] The input unit **61** outputs the input requested PQ characteristic value and requested rotational speed to the determination unit **62**.

[0050] The determination unit **62** determines whether the requested rotational speed satisfies a requirement of a predetermined reference and determines whether the requested PQ characteristic value is within an initial operation range. The determination unit **62** sends an instruction to the output unit **63** of an extent to which to adjust an angle of the inlet guide vane **251** or the diffuser vane **271** based on the determination result.

[0051] Here, the initial operation range is a range in which the compressor **2** in an initial setting state can operate without causing a surge. In curves showing a relationship between a pressure and a flow rate of the compressor **2** shown in FIG. **3**, the initial operation range indicates an area on the right side relative to surge control lines SCL **11** and SCL **12** and surge control lines SCL **21** and SCL **22**. The surge control lines SCL **11** and SCL **12** are determined by the inlet guide vane **251** and the diffuser vane **271** whose angles are set to initial values. The surge control lines SCL **21** and SCL **22** are determined by the inlet guide vane **251** and the diffuser vane **271** after angles are changed, which will be described below. Also, in an area on the left side relative to such surge control lines, surge occurs.

[0052] Specifically, the determination unit **62** of this embodiment determines whether the input requested rotational speed is less than a predetermined first reference. The determination unit **62** determines whether the input requested rotational speed is greater than a predetermined second reference.

[0053] Here, the first reference refers to a rotational speed at which the compressor **2** operates in an area in which a pressure and a flow rate are lower than those in a state at 100% of the rotational speed when a rotational speed during a rated operation is set to 100%. On the other hand, the second reference refers to a rotational speed at which the compressor **2** operates in an area in which a pressure and a flow rate are higher than those in a state at 100% of the rotational speed.

[0054] In this embodiment, the first reference is set to 100% of the rotational speed. In this embodiment, the second reference is set to 110% of the rotational speed.

[0055] When the input requested rotational speed is less than 100% of the rotational speed serving as the first reference, the determination unit **62** sends an instruction to the output unit **63** to adjust the inlet guide vane **251**. When it is determined that the requested rotational speed is less than the first reference, the determination unit **62** determines whether the input requested PQ characteristic value is within an area on the right side relative to the low side surge control line SCL **12** of an area having a low pressure and a low flow rate in the initial operation range. Therefore, for example, when the requested PQ characteristic value is a value of an area α in FIG. **3**, it is determined that the requested PQ characteristic value exceeds the low side surge control line SCL **12**. In this case, the determination unit **62** sends an instruction to the output unit **63** to adjust an angle of the inlet guide vane **251** so that a relative angle with respect to a direction in which a working fluid that flows into the impeller flow path **22*a*** from the suction flow path **25** flows becomes smaller.

[0056] When the input requested rotational speed is greater than 110% of the rotational speed serving as the second reference, the determination unit **62** sends an instruction to the output unit **63** to adjust the diffuser vane **271**. When it is determined that the requested rotational speed is greater than the second reference, the determination unit **62** determines whether the input requested PQ characteristic value is within an area on the right side relative to the high side surge control line SCL **11** of an area having a high pressure and a high flow rate in the initial operation range. Therefore, for example, when the requested PQ characteristic value is a value of an area **13** in FIG. **3**, it is determined that the requested PQ characteristic value exceeds the high side surge control line SCL **11**. In this case, the determination unit **62** sends an instruction to the output unit **63** to adjust an angle of the diffuser vane **271** so that a relative angle with respect to a direction in which a working fluid that flows into the diffuser flow path **27** from the impeller flow path **22*a*** flows becomes smaller.

[0057] When the input requested rotational speed is greater than the first reference and less than the second reference, the determination unit **62** sends an instruction to the output unit **63** not to adjust an angle of the inlet guide vane **251** or the diffuser vane **271**. When the input requested PQ characteristic value does not exceed the initial operation range, the determination unit **62** sends an instruction to the output unit **63** not to adjust an angle of the inlet guide vane **251** or the diffuser vane **271**.

[0058] Based on the requested rotational speed input from the input unit **61** through the determination unit **62**, the output unit **63** sends an instruction to the motor **3** to change a rotational speed of the rotor **31**. Based on the determination result of the determination unit **62**, the output unit **63** sends an instruction to the inlet guide vane **251** or the diffuser vane **271** to change an angle. Also, an amount of change in the angle of the inlet guide vane **251** or the diffuser vane **271** may be appropriately set based on a difference between the requested PQ characteristic value and a current PQ characteristic value.

[0059] In this embodiment, when the instruction from the output unit **63** is received, an angle of the inlet guide vane **251** is adjusted. Therefore, as shown in FIG. **3**, a position of the low side surge control line SCL **12** in a low pressure and low flow rate area is changed to that of SCL **22**. When the instruction from the output unit **63** is received, an angle of the diffuser vane **271** is adjusted. Therefore, a position of the high side surge control line SCL **11** in a high pressure and high flow rate area is changed to that of SCL **12**.

[0060] According to the compressor system **1** described above, based on the requested PQ characteristic value and requested rotational speed input to the input unit **61** of the control unit **6**, a current is supplied to the stator **32** by an external device such as a generator (not shown). A rotating magnetic field is generated based on the supplied current, and the rotor **31** of the motor **3** starts rotating together with the shaft **21** at the requested rotational speed. When the shaft **21** rotates at a high speed, in the compressor **2**, a working fluid that flows into the compressor **2** from the upstream side in the O axis direction is compressed by the impeller **22** that rotates together with the shaft **21**, and a compressed fluid for which the requested PQ characteristic value is satisfied is discharged from the downstream side in the O axis direction.

[0061] Here, for example, when a quantity of state of a content of oil in a production fluid while the compressor system **1** operates varies, characteristics of the working fluid that flows into the compressor **2** change and a discharge pressure of the compressor **2** changes. Therefore, the requested PQ characteristic value and the requested rotational speed are input to the input unit **61** of the control unit **6** such that a constant discharge pressure of the compressor **2** is maintained. When the requested PQ characteristic value and the requested rotational speed are input, the output unit **63** sends an instruction to the motor **3** to change a rotational speed of the rotor **31** according to the requested rotational speed. As a result, a rotational speed of the impeller **22** is adjusted through the rotor **31**. At the same time, in the determination unit **62**, when it is determined that the requested rotational speed is less than the first reference, it is determined whether the requested PQ characteristic value exceeds the low side surge control line SCL **12**. When the requested rotational speed is less than the first reference and the requested PQ characteristic value exceeds the low side surge control line SCL **12**, the determination unit **62** sends a signal to the output unit **63** to adjust an angle of the inlet guide vane **251**. The inlet guide vane **251** that has received the signal from the output unit **63** adjusts an angle such that a relative angle with respect to a direction in which a working fluid that flows into the impeller flow path **22*a*** from the suction flow path **25** flows becomes smaller. When an angle of the inlet guide vane **251** is changed, a position of the low side surge control line SCL **12** is changed to that of SCL **22**. At the same time, an operation area of 110% of the rotational speed is changed from a line L**111** to a line L**112**. Therefore, it is possible to improve PQ characteristics in a low pressure and low flow rate area.

[0062] When it is determined that the requested rotational speed is greater than the second reference, the determination unit **62** determines whether the requested PQ characteristic value exceeds the high side surge control line SCL **11**. When the requested rotational speed is greater than the second reference and the requested PQ characteristic value exceeds the high side surge control line SCL **11**, the determination unit **62** sends a signal to the output unit **63** to adjust an angle of the diffuser vane **271**. The diffuser vane **271** that has received the signal from the output unit **63** adjusts an angle such that a relative angle with respect to a direction in which a working fluid that flows into the diffuser flow path **27** from the impeller flow path **22*a*** flows becomes smaller. When an angle of the diffuser vane **271** is changed, a position of the high side surge control line SCL **11** is changed to that of the SCL **12**. At the same time, an operation area of 110% of the rotational speed is changed from the line L**111** to the line L**112**. Therefore, it is possible to improve PQ characteristics in a high pressure and high flow rate area.

[0063] That is, a surge control line can be changed to improve PQ characteristics during operation. Therefore, even if a quantity of state of a working fluid that flows in the impeller flow path **22*a*** is changed, it is possible for the compressor **2** to perform an operation for setting a discharge pressure to be constant over a wide range. Accordingly, it is possible to respond to changing operation conditions by widening an operation range of the compressor **2**.

[0064] When the requested rotational speed is low, the impeller **22** rotates at a low rotational speed. Therefore, the compressor **2** operates in a low pressure and low flow rate area. That is, when the requested rotational speed is low, efficiency of compression of a working fluid by the impeller **22** is low. Therefore, a volumetric flow rate of the working fluid that circulates in the impeller flow path **22*a*** increases. Therefore, when the requested rotational speed is low, a direction in which a working fluid that flows in the impeller flow path **22*a*** flows greatly influences an operation range of the compressor **2**. Therefore, when the requested rotational speed is less than the predetermined first reference, a relative angle of the inlet guide vane **251** with respect to a direction in which a working fluid that flows into the impeller flow path **22*a*** from the suction flow path **25** which is a side in which a working fluid flows into the impeller flow path **22*a*** flows becomes smaller. Therefore, it is possible to efficiently improve PQ characteristics. That is, when an angle of the inlet guide vane **251** is adjusted, it is possible to increase an operation range of the compressor **2** more efficiently than when the diffuser vane **271** is adjusted in a low pressure and low flow rate area.

[0065] When the requested rotational speed is high, the compressor **2** operates in a high pressure and high flow rate area. That is, when the requested rotational speed is high, efficiency of compression of the working fluid is high. Therefore, a volumetric flow rate of a working fluid that circulates in the impeller flow path **22*a*** becomes smaller. Therefore, in a high pressure and high flow rate area, an angle at which a working fluid discharged from the impeller flow path **22*a*** flows into the diffuser flow path **27** greatly influences an operation range of the compressor **2**. Therefore, when the requested rotational speed is greater than the predetermined second reference, a relative angle of the diffuser vane **271** with respect to an angle at which a working fluid that flows into the diffuser flow path **27** which is a discharge side of a working fluid from the impeller flow path **22*a*** flows becomes smaller. Therefore, it is possible to efficiently improve PQ characteristics. That is, when an angle of the diffuser vane **271** is adjusted, it is possible to increase an operation range of the compressor **2** more efficiently than when the inlet guide vane **251** is adjusted in a high pressure and high flow rate area.

[0066] Angles of the inlet guide vane **251** and the diffuser vane **271** are determined only when the requested PQ characteristic value exceeds the initial operation range. Therefore, it is possible to change an angle to improve PQ characteristics only as necessary and it is possible to efficiently increase an operation range of the compressor **2**.

[0067] 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.

[0068] Note that the guide vane is not limited to the inlet guide vane **251** that is provided in the suction flow path **25** as in this embodiment. Any guide vane that is provided in the inflow flow path and can change a direction of a working fluid that flows in the impeller flow path **22***a* to a desired direction may be used. For example, the guide vane may be the return vane **282***a* that is provided in the linear flow path **282** of the return flow path **28**.

[0069] While a configuration in which the inlet guide vane **251** serving as a guide vane and the diffuser vane **271** are disposed together is used in this embodiment, the present invention is not limited to such a configuration. That is, in the compressor **2**, only the guide vane may be provided or only the diffuser vane **271** may be provided.

[0070] When the plurality of impellers **22** are provided, the guide vane and the diffuser vane **271** are not necessarily provided in all of the impellers **22**. The guide vane and the diffuser vane **271** may be disposed only around the impeller **22** of a stage for which an operation range is to be adjusted.

[0071] In the determination unit **62** of this embodiment, as a reference for determining whether a value is within a predetermined operation range, the first reference and the second reference that are different from each other are used, and the present invention is not limited thereto. For example, one reference may be used to determine whether a value is within the predetermined operation range.

INDUSTRIAL APPLICABILITY

[0072] According to the above compressor system, when an angle of at least one of the guide vane and the diffuser vane is controlled, it is possible to respond to changing operation conditions by widening an operation range of the compressor.

REFERENCE SIGNS LIST

[0073] **1** Compressor system
[0074] O Axis
[0075] **2** Compressor
[0076] **21** Shaft
[0077] **22** Impeller
[0078] **22***a* Impeller flow path
[0079] **23** Housing
[0080] **23***a* Internal space
[0081] **24** Housing flow path
[0082] **25** Suction flow path
[0083] **251** Inlet guide vane
[0084] **26** Intermediate flow path
[0085] **27** Diffuser flow path
[0086] **271** Diffuser vane
[0087] **28** Return flow path
[0088] **281** Curved flow path
[0089] **282** Linear flow path
[0090] **282***a* Return vane
[0091] **3** Motor
[0092] **31** Rotor
[0093] **32** Stator
[0094] **33** Gap
[0095] **4** Bearing
[0096] **41** Journal bearing
[0097] **42** Thrust bearing
[0098] **5** Casing
[0099] **51** Sealing member
[0100] **6** Control unit
[0101] **61** Input unit
[0102] **62** Determination unit
[0103] **63** Output unit

1. A compressor system comprising:
a motor including a rotor configured to rotate about an axis and a stator disposed on an outer circumference side of the rotor; and
a compressor including an impeller rotating together with the rotor and compressing a working fluid,
wherein the compressor includes
a housing in which an inflow flow path through which a working fluid flows into the impeller and a discharge flow path through which a working fluid pressure-fed by the impeller circulates are formed;
a guide vane provided in the inflow flow path and having an angle that is changeable;
a diffuser vane provided in the discharge flow path and having an angle that is changeable; and
a control unit configured to control angles of the guide vane and the diffuser vane, and
wherein the control unit controls an angle of the guide vane based on a requested PQ characteristic value that is a requested pressure and flow rate value and a rotational speed of the impeller.

2. The compressor system according to claim **1**,
wherein, when a rotational speed of the impeller is less than a predetermined reference, the control unit controls an angle of the guide vane so that a relative angle with respect to a direction in which the working fluid flowing into the impeller from the inflow flow path flows becomes smaller.

3. (canceled)

4. The compressor system according to claim **1**,
wherein, when the requested PQ characteristic value satisfies a requirement of a predetermined reference, the control unit controls an angle of the guide vane so that a relative angle with respect to a direction in which the working fluid flowing into the impeller from the inflow flow path flows becomes smaller.

5. (canceled)

6. A compressor system comprising:
a motor including a rotor configured to rotate about an axis and a stator disposed on an outer circumference side of the rotor; and
a compressor including an impeller rotating together with the rotor and compressing a working fluid,
wherein the compressor includes
a housing in which an inflow flow path through which a working fluid flows into the impeller and a discharge flow path through which a working fluid pressure-fed by the impeller circulates are formed;
a guide vane provided in the inflow flow path and having an angle that is changeable;

a diffuser vane provided in the discharge flow path and having an angle that is changeable; and

a control unit configured to control angles of the guide vane and the diffuser vane, and

wherein the control unit controls an angle of at least one of the guide vane and the diffuser vane based on a requested PQ characteristic value that is a requested pressure and flow rate value and a rotational speed of the impeller, and

wherein, when a rotational speed of the impeller is less than a predetermined reference, the control unit controls an angle of the guide vane so that a relative angle with respect to a direction in which the working fluid flowing into the impeller from the inflow flow path flows becomes smaller.

* * * * *