

(54) [Title of the Invention] WORKING FLUID

(57) [Abstract]

[Object] The present invention provides a working fluid that hardly affects the stratospheric ozone layer and is an alternative to R22.

[Configuration] A working fluid contains three types of chlorofluorocarbons of pentafluoroethane (C_2HF_5), propane (C_3H_8), and tetrafluoroethane ($C_2H_2F_4$) in a composition range of the pentafluoroethane of approximately 55 to approximately 85% by weight, the propane of 0 to approximately 10% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight, and particularly desirably in a composition range of the pentafluoroethane of approximately 55 to approximately 80% by weight, the propane of 0 to approximately 6% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight.

[Claims]

[Claim 1] A working fluid, containing: at least three types of chlorofluorocarbons of 55 to 85% by weight of pentafluoroethane; 10% by weight or less of propane; and 15 to 45% by weight of tetrafluoroethane.

[Claim 2] A working fluid, containing: 55 to 80% by weight of pentafluoroethane; 6% by weight or less of propane; and 15 to 45% by weight of tetrafluoroethane.

[Detailed Description of the Invention]

[0001]

[Technical Field of Application] The present invention relates to a working fluid to be used in a heat pump device such as for an air conditioner and a refrigerator.

[0002]

[Related Art] In the related art, in a heat pump device such as for an air conditioner and a refrigerator, halogenated hydrocarbon referred to as chlorofluorocarbons (hereinafter, referred to as ROO or ROOO) is known as a working fluid, and a condensation temperature and/or a vaporization temperature are generally used in a range of approximately 0 to approximately 50°C, as a use temperature. Among them, chlorodifluoromethane (CHClF_2 , R22) is widely used as a working fluid for a domestic air conditioner, an air conditioner for

a building, and a large refrigerator.

[0003]

[Problems to be Solved by the Invention] However, recently, the destruction of the stratospheric ozone layer due to chlorofluorocarbon has become a global environmental problem, and for chlorofluorocarbons having large stratospheric ozone destruction ability (hereinafter, referred to as specific chlorofluorocarbon), the use amount and the production amount are already restricted by an international treaty, and in the future, the use and the production of the specific chlorofluorocarbon may be abolished. R22 has a small ozone destruction coefficient of 0.05 (stratospheric ozone destruction ability when the stratospheric ozone destruction ability of the trichlorofluoromethane (CCl_3F) is set to 1, hereinafter, referred to as ODP), the use amount is expected to increase in the future even though it is not the specific chlorofluorocarbon, and an increase in the use amount and the production amount of R22 is expected to increase an influence on the human living environment in the current situation where refrigeration and air-conditioning equipment widely spread. Accordingly, there is a strong demand for the early development of the working fluid as an alternative to R22 to be regarded to have slight destruction ability even though the

stratospheric ozone destruction ability is small.

[0004] The present invention has been made in consideration of the problems described above, and an object thereof is to provide a working fluid that hardly affects the stratospheric ozone layer and is an alternative to R22.

[0005]

[Means for Solving the Problems] In order to attain the object described above, the present invention contains at least: three types of chlorofluorocarbons of pentafluoroethane (C_2HF_5), propane (C_3H_8), and tetrafluoroethane ($C_2H_2F_4$), in a composition range of the pentafluoroethane of approximately 55 to approximately 85% by weight, the propane of 0 to approximately 10% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight, and particularly desirably in a composition range of the pentafluoroethane of approximately 55 to approximately 80% by weight, the propane of 0 to 6% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight.

[0006]

[Action and Effect] Examples of a single refrigerant having approximately the same boiling point as R22 (a boiling point of $-40.8^{\circ}C$) include propane (a boiling point of $-42.1^{\circ}C$), and

it is known that propane is flammable, but can be substantially non-flammable by setting a composition range of a mixture to 0 to approximately 10% by weight, and more desirably, can be almost non-flammable by setting the composition range to 0 to approximately 6% by weight.

[0007] According to the present invention, the working fluid is a mixture containing pentafluoroethane (ODP = 0), propane (ODP = 0), and tetrafluoroethane (ODP = 0), which is chlorofluorocarbons having no chlorine in the molecular structure and almost no ozone destruction ability, by the combination described above, and thus, an influence on the stratospheric ozone layer can be reduced to be almost eliminated, compared to R22. In particular, propane is flammable, but pentafluoroethane and tetrafluoroethane are non-flammable, and pentafluoroethane and tetrafluoroethane are mixed to limit the composition range of propane, and thus, the flammability can be reduced, and it is the first time that the range of a composition as an alternative to R22 is specified, as with the present invention.

[0008] Further, according to the present invention, it is possible to provide a working fluid having a vapor pressure equivalent to that of R22 at approximately 0 to approximately 50°C which is a use temperature of a heat pump device such as

for an air conditioner and a refrigerator, and which can be used in a current apparatus as an alternative to R22. Thus, an ODP in the combination and composition ranges described above is also expected to be 0, resulting in a highly promising working fluid as an alternative to R22. Moreover, since such a mixture becomes a non-azeotropic mixture and has a temperature gradient in the condensation process and the evaporation process, it is possible to expect a higher coefficient of performance than R22 by constructing a Rolenz cycle in which a temperature difference with a heat source fluid is decreased.

[0009] Also, in general, chlorofluorocarbons having stratospheric ozone destruction ability tend to have a large effect of global warming according to the magnitude of the ODP value thereof, but since the working fluid according to the present invention contains a mixture of three or more types of only chlorofluorocarbons with an ODP of 0, the effect of global warming is estimated to be similar to R22 or less than R22, which makes it possible to reduce the contribution to global warming that has recently become a global problem.

[0010]

[Embodiment] Hereinafter, an embodiment of a working fluid according to the present invention will be described with

reference to the drawings.

[0011] Fig. 1 illustrates an equilibrium state of a working fluid containing a mixture of three types of chlorofluorocarbons of pentafluoroethane (R125), propane (R290), and 1,1,1,2-tetrafluoroethane (R134a) at a constant temperature and a constant pressure using a triangular coordinate. In this triangular coordinate, a single substance is arranged in the descending order of a boiling point in a counterclockwise direction with the upper vertex in each vertex of a triangle as a base point, and the composition ratio (weight ratio) of each component at a certain point on the coordinate plane is represented by a ratio of a distance between the point and each side of the triangle. Further, at this time, the distance between the point and the side of the triangle corresponds to the composition ratio of the substance marked at the vertex of the triangular coordinate on a side opposite to the side of the triangle. In Fig. 1, a reference numeral 1 indicates a gas-liquid equilibrium line of the mixture at a temperature of 0°C and a pressure of 4.044 kg/cm²G, and the temperature and the pressure correspond to a saturated state of R22. The upper line of the gas-liquid equilibrium line (corresponding to R22 0°C) 1 represents a saturated gas phase line, the lower line of the gas-liquid equilibrium line

(corresponding to R22 0°C) 1 represents a saturated liquid phase line, and a gas-liquid equilibrium state is formed in a range interposed between the two lines. In addition, a reference numeral 2 indicates a gas-liquid equilibrium line of the mixture at a temperature of 50°C and a pressure of 18.782 kg/cm²G, and the temperature and the pressure also correspond to the saturated state of R22. If only R23 is used at 50°C, the temperature is over a critical temperature, but by making this mixture, a saturated state is present, and thus the mixture can be used in a heat pump device such as for an air conditioner and a refrigerator at a use temperature of approximately 0 to approximately 50°C. As can be seen from the drawings, when the composition range of R290 is limited to 0 to approximately 10% by weight, the composition ranges of R125, R290, and R134a that are approximately 55 to approximately 75% by weight, 0 to approximately 10% by weight, and approximately 25 to approximately 45% by weight, respectively, are desirable, because it has a vapor pressure substantially equal to that of R22 at a use temperature of approximately 0 to approximately 50°C, and is almost non-flammable. Further, when the composition range of R290 is limited to 0 to approximately 6% by weight, the composition ranges of R125, R290, and R134a that are each approximately

55 to approximately 65% by weight, 0 to approximately 6% by weight, and approximately 30 to approximately 45% by weight, respectively, are particularly desirable, because it has a vapor pressure substantially equal to that of R22 at all use temperatures between 0°C and 50°C, and is almost non-flammable.

[0012] The composition of the working fluid at a point A₁ to a point F₁ in Fig. 1 is shown in (Table 1).

[0013]

[Table 1]

	A ₁	B ₁	C ₁	D ₁	E ₁	F ₁
R125 (% by weight)	65.6	65.3	64.6	56.4	56.6	56.8
R290 (% by weight)	2.1	3.2	6.0	4.6	3.5	2.2
R134a (% by weight)	32.4	31.5	29.4	39.0	39.9	41.0

[0014] The point A₁ to the point C₁ are on a saturated gas phase line of the gas-liquid equilibrium line (corresponding to R22 50°C) 2, the point D₁ to the point F₁ are on a saturated liquid phase line of the gas-liquid equilibrium line (corresponding to R22 50°C) 2, and the points are in a range interposed between both lines of the saturated gas phase line of the gas-liquid equilibrium line (corresponding to R22 0°C) 1 and the saturated liquid phase line of the gas-liquid equilibrium line (corresponding to R22 0°C) 1, and thus, a gas-liquid equilibrium state is formed at a temperature of 0°C

and a pressure of 4.044 kg/cm²G (corresponding to the saturated state of R22). Thus, a working fluid having the composition shown in Table 1 can obtain a condensation temperature and a vaporization temperature substantially equal to R22 by realizing a saturated state or a gas-liquid equilibrium state under the condition of saturated vapor pressure of R22 at 0°C and 50°C, and operating at the saturated vapor pressure of R22 at the same temperature at a use temperature of approximately 0 to approximately 50°C.

[0015] Here, only the points on the gas-liquid equilibrium line (corresponding to R22 50°C) 2 will be described, but the same applies to a working fluid having points inside the point A₁ to the point F₁, that is, a composition in which a gas-liquid equilibrium state is formed at a temperature of 0°C and a pressure of 4.044 kg/cm²G and a temperature of 50°C and a pressure of 18.782 kg/cm²G (both corresponding to the saturated state of R22), and thus, a condensation temperature and a vaporization temperature substantially equal to R22 can be obtained at a use temperature of approximately 0 to approximately 50°C.

[0016] Fig. 2 illustrates an equilibrium state of a working fluid containing a mixture of three types of chlorofluorocarbons of R125, R290, and 1,1,2,2-

tetrafluoroethane (R134) at a constant temperature and a constant pressure using a triangular coordinate. In Fig. 2, a reference numeral 3 indicates a gas-liquid equilibrium line of the mixture at a temperature of 0°C and a pressure of 4.044 kg/cm²G, and a reference numeral 4 indicates a gas-liquid equilibrium line of the mixture at a temperature of 50°C and a pressure of 18.782 kg/cm²G. In this case, when the composition range of R290 is limited to 0 to approximately 10% by weight, the composition ranges of R125, R290, and R134 that are approximately 60 to approximately 85% by weight, 0 to approximately 10% by weight, and approximately 15 to approximately 35% by weight, respectively, are desirable, because it has a vapor pressure substantially equal to that of R22, and is almost non-flammable, and when the composition range of R290 is limited to 0 to approximately 6% by weight, the composition ranges of R125, R290, and R134 that are approximately 70 to approximately 80% by weight, 0 to approximately 6% by weight, and approximately 15 to approximately 30% by weight, respectively, are particularly desirable.

[0017] The composition of the working fluid at a point A₂ to a point F₂ in Fig. 2 is shown in (Table 2).

[0018]

[Table 2]

	A ₂	B ₂	C ₂	D ₂	E ₂	F ₂
R125 (% by weight)	79.3	78.5	78.0	68.0	68.6	69.2
R290 (% by weight)	2.4	3.8	4.8	5.3	4.1	2.6
R134 (% by weight)	18.3	17.7	17.2	26.7	27.3	28.2

[0019] The point A₂ to the point C₂ are on a saturated gas phase line of the gas-liquid equilibrium line (corresponding to R22 50°C) 4, the point D₂ to the point F₂ are on a saturated liquid phase line of the gas-liquid equilibrium line (corresponding to R22 50°C) 4, and the points are in a range interposed between both lines of the saturated gas phase line of the gas-liquid equilibrium line (corresponding to R22 0°C) 3 and the saturated liquid phase line of the gas-liquid equilibrium line (corresponding to R22 0°C) 3, and thus, a gas-liquid equilibrium state is formed at a temperature of 0°C and a pressure of 4.044 kg/cm²G (corresponding to the saturated state of R22). Thus, a working fluid having the composition shown in Table 2 can obtain a condensation temperature and a vaporization temperature substantially equal to R22 by realizing the saturated state or the gas-liquid equilibrium state under the condition of saturated vapor pressure of R22 at 0°C and 50°C, and operating at the saturated vapor pressure of R22 at the same temperature at a use temperature of

approximately 0 to approximately 50°C.

[0020] Here, only the points on the gas-liquid equilibrium line (corresponding to R22 50°C) 4 will be described, but the same applies to a working fluid having points inside the point A₂ to the point F₂, that is, a composition in which a gas-liquid equilibrium state is formed at a temperature of 0°C and a pressure of 4.044 kg/cm²G and a temperature of 50°C and a pressure of 18.782 kg/cm²G (both corresponding to the saturated state of R22), and thus, a condensation temperature and a vaporization temperature substantially equal to R22 can be obtained at a use temperature of approximately 0 to approximately 50°C.

[0021] In the embodiment described above, the working fluid contains the mixture of three types of chlorofluorocarbons, the working fluid is also capable of containing a mixture of four or more types of chlorofluorocarbons including a structural isomer, and in such a case, the composition range of the pentafluoroethane of approximately 55 to approximately 85% by weight, the propane of 0 to approximately 10% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight is desirable, because it has a vapor pressure substantially equal to R22 at a use temperature of approximately 0 to approximately 50°C, and is almost non-

flammable. Further, the composition range of the pentafluoroethane of approximately 55 to approximately 80% by weight, the propane of 0 to approximately 6% by weight, and the tetrafluoroethane of approximately 15 to approximately 45% by weight is particularly desirable, because it has a vapor pressure substantially equal to that of R22 at all use temperatures between 0°C and 50°C, and is almost non-flammable. In particular, an ODP in the combination and the composition ranges described above is also expected to be 0, resulting in a highly promising working fluid as an alternative to R22. In addition, since such a mixture becomes a non-azeotropic mixture and has a temperature gradient in the condensation process and the evaporation process, it is possible to expect a higher coefficient of performance than R22 by constructing a Rolenz cycle in which a temperature difference with a heat source fluid is decreased.

[0022]

[Effects of the Invention] As is apparent from the description, the present invention is in that a working fluid is a mixture comprising 3 or more kinds of fluorocarbons, that is, 2 kinds of fluorocarbons containing no chlorine in the molecular structure and one kind of fluorocarbon having both chlorine and hydrogen in the molecular structure and having extremely

small ozone destruction ability, and the composition range is specified, which has effects as follows:

(1) It is possible to enlarge the range of selection of the working fluid, which is much smaller and almost free from the influence on the stratospheric ozone layer than R22.

(2) Since a non-flammable pentafluoroethane and tetrafluoroethane are selected as the chlorofluorocarbons having almost no ozone destruction ability, it is possible to reduce the combustibility of propane selected as the chlorofluorocarbon having almost no ozone destruction ability.

(3) It has a vapor pressure of the same degree as R22 at the use temperature of the device and can be used in a current device as an alternative to R22.

(4) Using the nature of the temperature gradient of the non-azeotropic mixture, a higher coefficient of performance than R22 can be expected.

[Brief Description of Drawings]

[Fig. 1] Fig. 1 is a triangular coordinate diagram illustrating an equilibrium state of a working fluid containing a mixture of three types of chlorofluorocarbons at a constant temperature and a constant pressure.

[Fig. 2] Fig. 2 is a triangular coordinate diagram illustrating an equilibrium state of a working fluid

containing a mixture of three types of chlorofluorocarbons at a constant temperature and a constant pressure.

[Reference Numerals]

- 1 Gas-liquid equilibrium line (corresponding to R22 0°C)
- 2 Gas-liquid equilibrium line (corresponding to R22 50°C)
- 3 Gas-liquid equilibrium line (corresponding to R22 0°C)
- 4 Gas-liquid equilibrium line (corresponding to R22 50°C)