normal state are displayed on the same p-h chart (for example, see Patent Literature 1). In Patent Literature 1, when it is determined from a non-overlap ratio between the refrigeration cycle charts that maintenance is necessary, the necessity of maintenance in an air-conditioning apparatus is displayed on a display device.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2015-92121

Summary of Invention

Technical Problem

[0006]

However, a difference in shape between the current refrigeration cycle chart and the refrigeration cycle chart in the normal state depends on factors of the abnormality and a degree of abnormality in the air-conditioning apparatus. Since various environments inside and outside the refrigerant circuit are reflected on the refrigeration cycle chart, it is difficult to diagnose the state of the air-conditioning apparatus based on the difference in shape or the non-overlap ratio between the refrigeration cycle charts. In other words, the configuration disclosed in Patent Literature 1 has a problem that the user cannot easily diagnose the factor of the abnormality and the degree of abnormality in the air-conditioning apparatus.

[0007]

Embodiments of the present invention seek to provide a state analyzer system and a state analysis device that may allow the user to easily diagnose the factor of the abnormality and the degree of abnormality in the air-conditioning apparatus.

Solution to Problem

[0008]

A state analyzer system according to an embodiment of the present invention includes: an air-conditioning apparatus including a refrigerant circuit including a

compressor and an expansion unit, a state detection unit configured to detect a state of refrigerant in the refrigerant circuit as state data, and a controller configured to control the compressor and the expansion unit; a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and control data, the control data indicating a content of control performed by the controller, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of a plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of the refrigerant and an enthalpy; a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which each of the plurality of pieces of specific state information is present when the air-conditioning apparatus operates under a normal state; and a display unit configured to display a diagnostic image including the plurality of pieces of specific state information determined by the specific state determination unit, and the plurality of normal regions determined by the normal region determination unit.

[0008a]

A state analyzer system according to another embodiment of the present invention includes: an air-conditioning apparatus including a refrigerant circuit including a compressor and an expansion unit, a state detection unit configured to detect a state of refrigerant in the refrigerant circuit as state data, and a controller configured to control the compressor and the expansion unit; a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and control data, the control data indicating a content of control performed by the controller, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of a plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of the refrigerant and an enthalpy; a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which each of the plurality of pieces of specific state information is present when the air-conditioning apparatus operates under a normal state; and a state diagnosis unit configured to, based on a positional relationship of each of the plurality of pieces of specific state information

and the corresponding one of the plurality of normal regions, determine whether the air-conditioning apparatus has an abnormality.

[0009]

A state analysis device according to another embodiment of the present invention is a state analysis device that analyzes a state of an air-conditioning apparatus by using state data and control data and allows a display unit, which is provided outside, to display an analysis result, the air-conditioning apparatus including a refrigerant circuit including a compressor and an expansion unit and a controller configured to control the compressor and the expansion unit, the state data indicating a state of refrigerant in the refrigerant circuit, the control data indicating a content of control performed by the controller, the state analysis device including: a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and the control data, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of the plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of refrigerant and an enthalpy; a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which the specific state information is present when the air-conditioning apparatus operates under a normal state; and a display processing unit configured to allow the display unit to display a diagnostic image including the plurality of pieces of

specific state information determined by the specific state determination unit, and the plurality of normal regions determined by the normal region determination unit.

Advantageous Effects of Invention

[0010]

According to embodiments of the present invention, it is possible to display specific state information corresponding to a specific position of a refrigerant circuit and a normal region within which specific state information is present during a normal operation of an air-conditioning apparatus, thereby allowing a user to visually recognize a position of the specific state information with respect to the normal region. Accordingly, the user can easily diagnose a factor of an abnormality and a degree of abnormality in the air-conditioning apparatus.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 a configuration diagram illustrating a state analyzer system according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a block diagram illustrating a functional configuration of the state analyzer system illustrated in Fig. 1.

[Fig. 3] Fig. 3 is an explanatory diagram illustrating a display example of specific state information and a normal region according to Embodiment 1 of the present invention when an air-conditioning apparatus is in a normal state.

[Fig. 4] Fig. 4 is an explanatory diagram illustrating a display example of specific state information and a normal region according to Embodiment 1 of the present invention when an abnormality in the amount of refrigerant is suspected.

[Fig. 5] Fig. 5 is an explanatory diagram illustrating a display example of specific state information and a normal region in Embodiment 1 of the present invention when an abnormality in heat transfer in a condenser is suspected.

[Fig. 6] Fig. 6 is an explanatory diagram illustrating a display example of specific state information and a normal region in Embodiment 1 of the present invention when an abnormality in heat transfer in an evaporator is suspected.

CLAIMS

[Claim 1]

A state analyzer system comprising:

an air-conditioning apparatus including

a refrigerant circuit including a compressor and an expansion unit,

a state detection unit configured to detect a state of refrigerant in the refrigerant circuit as state data, and

a controller configured to control the compressor and the expansion unit;

a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and control data, the control data indicating a content of control performed by the controller, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of a plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of the refrigerant and an enthalpy ;

a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which each of the plurality of pieces of specific state information is present when the air-conditioning apparatus operates under a normal state; and

a display unit configured to display a diagnostic image including the plurality of pieces of specific state information determined by the specific state determination unit, and the plurality of normal regions determined by the normal region determination unit.

[Claim 2]

The state analyzer system of claim 1, further comprising:

a state diagnosis unit configured to, based on a positional relationship of each of the plurality of pieces of specific state information and a corresponding one of the plurality of normal regions, determine whether the air-conditioning apparatus has an abnormality.

[Claim 3]

The state analyzer system of claim 2, wherein

the state diagnosis unit determines that the air-conditioning apparatus has the abnormality when at least one of the plurality of pieces of specific state information is present outside of the corresponding one of the normal regions.

[Claim 4]

The state analyzer system of claim 2 or 3, wherein

the display unit displays information indicating that the abnormality occurs in the air-conditioning apparatus when at least one of the plurality of pieces of specific state information is present outside of the corresponding one of the normal regions.

[Claim 5]

The state analyzer system of any one of claims 2 to 4, wherein

the state diagnosis unit is configured to identify a factor of the abnormality in the air-conditioning apparatus, based on the positional relationship of each of the specific plurality of pieces of state information and the corresponding one of the plurality of normal regions, and

the display unit displays information indicating the factor of the abnormality in the air-conditioning apparatus identified by the state diagnosis unit.

[Claim 6]

A state analyzer system comprising:

an air-conditioning apparatus including

a refrigerant circuit including a compressor and an expansion unit,

a state detection unit configured to detect a state of refrigerant in the refrigerant circuit as state data, and

a controller configured to control the compressor and the expansion unit;

a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and control data, the control data

indicating a content of control performed by the controller, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of a plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of the refrigerant and an enthalpy;

a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which each of the plurality of pieces of specific state information is present when the air-conditioning apparatus operates under a normal state; and

a state diagnosis unit configured to, based on a positional relationship of each of the plurality of pieces of specific state information and the corresponding one of the plurality of normal regions, determine whether the air-conditioning apparatus has an abnormality.

[Claim 7]

The state analyzer system of claim 6, wherein

the state diagnosis unit determines that the air-conditioning apparatus has the abnormality when at least one of the plurality of pieces of specific state information is present outside of the corresponding one of the normal regions.

[Claim 8]

The state analyzer system of claim 7, further comprising:

an output unit configured to output a result processed by the state diagnosis unit, wherein

the output unit outputs information indicating that the abnormality occurs in the air-conditioning apparatus when at least one of the plurality of pieces of specific state information is present outside of the corresponding one of the normal regions.

[Claim 9]

The state analyzer system of any one of claims 6 to 8, further comprising:

an output unit configured to output information on a result processed by the state diagnosis unit, wherein

the state diagnosis unit is configured to identify a factor of the abnormality in the air-conditioning apparatus, based on the positional relationship of each of the plurality of pieces of specific state information and the corresponding one of the normal regions, and

the output unit outputs information indicating the factor of the abnormality in the air-conditioning apparatus identified by the state diagnosis unit.

[Claim 10]

The state analyzer system of claim 5 or 9, wherein

the refrigerant circuit includes a condenser and an evaporator, and

the state diagnosis unit identifies, as the factor of the abnormality in the air-conditioning apparatus, at least one of:

an abnormality in an amount of refrigerant enclosed in the refrigerant circuit;

an abnormality in the condenser or the evaporator;

an abnormality in the compressor;

an abnormality in which liquid refrigerant flows into the compressor;

an abnormality in the expansion unit; and

an abnormality in which the refrigerant circuit has a clogging portion.

[Claim 11]

The state analyzer system of any one of claims 5, 9 and 10, wherein

the refrigerant circuit includes a condenser and an evaporator,

the air-conditioning apparatus has fans each being attached to the condenser and the evaporator, and

the state diagnosis unit identifies, as the factor of the abnormality in the air-conditioning apparatus, at least one of:

an abnormality in the fan attached to the condenser; and

an abnormality in the fan attached to the evaporator.

[Claim 12]

The state analyzer system of claim 8 or 9, wherein

the output unit includes a display unit configured to display a diagnostic image including the plurality of pieces of specific state information determined by the specific state determination unit and the plurality of normal regions determined by the normal region determination unit.

[Claim 13]

The state analyzer system of any one of claims 1 to 5, 12, wherein

the display unit displays the diagnostic image including, not only the plurality of pieces of specific state information and the plurality of normal regions but also an isothermal line indicating a temperature of an environment in which the air-conditioning apparatus is installed.

[Claim 14]

The state analyzer system of any one of claims 1 to 5 and 12 to 13, further comprising:

a storage unit configured to store the state data and the control data, wherein

the specific state determination unit accumulates

the plurality of pieces of specific state information in the storage unit or a server apparatus provided outside the air-conditioning apparatus for a preset certain period, and

the display unit displays the diagnostic image including a plurality of current pieces of specific state information and a plurality of past pieces of the specific state information.

[Claim 15]

The state analyzer system of any one of claims 1 to 5 and 12 to 14 wherein

the display unit is provided in at least one of a remote controller, a centralized management apparatus, a mobile phone, and a personal computer that are informationally connected to the air-conditioning apparatus.

[Claim 16]

The state analyzer system of any one of claims 1 to 15, further comprising:

a storage unit configured to store the state data and the control data, wherein

the normal region determination unit determines the normal region by using the state data and the control data accumulated in the storage unit.

[Claim 17]

The state analyzer system of any one of claims 1 to 16, wherein

the state data and the control data are accumulated in a server apparatus provided outside the air-conditioning apparatus, and

the normal region determination unit determines the normal region by using the state data and the control data accumulated in the server apparatus.

[Claim 18]

The state analyzer system of any one of claims 1 to 17, wherein

the normal region determination unit determines the normal region by using information on design specifications of the air-conditioning apparatus.

[Claim 19]

The state analyzer system of any one of claims 1 to 18, wherein

the normal region determination unit determines the normal region based on machine learning using the state data and the control data.

[Claim 20]

The state analyzer system of any one of claims 1 to 19, wherein

the normal region determination unit determines, as each of the normal regions, a plurality of regions to be determined depending on a degree of the abnormality in the air-conditioning apparatus,

wherein in each of the normal regions, a point of relatively large degree of abnormality of the air-conditioning apparatus is on outside, around points of relatively small degree of abnormality on inside.

[Claim 21]

The state analyzer system of claim 20, wherein

the refrigerant circuit includes a condenser,

the specific state determination unit determines each of the specific state information including:

inlet information indicating a state of refrigerant at an inlet of the compressor;

outlet information indicating a state of refrigerant at an outlet of the compressor; and

condensation information indicating a state of refrigerant at an outlet of the condenser, and

the normal region determination unit determines each of the normal regions including:

an inlet region where the inlet information is present when the air-conditioning apparatus operates under the normal state;

an outlet region where the outlet information is present when the air-conditioning apparatus operates under the normal state; and

a condensation region where the condensation information is present when the air-conditioning apparatus operates under the normal state.

[Claim 22]

The state analyzer system of any one of claims wherein

a state of the air-conditioning apparatus is analyzed when a state analysis is requested from an outside.

[Claim 23]

The state analyzer system of any one of claims 1 to 21, wherein

a state of the air-conditioning apparatus is analyzed at regular time intervals.

[Claim 24]

A state analysis device that analyzes a state of an air-conditioning apparatus by using state data and control data and allows a display unit, which is provided outside, to display an analysis result, the air-conditioning apparatus including a refrigerant circuit including a compressor and an expansion unit and a controller configured to control the compressor and the expansion unit, the state data indicating a state of refrigerant in the refrigerant circuit, the control data indicating a content of control performed by the controller, the state analysis device comprising:

a specific state determination unit configured to determine a plurality of pieces of specific state information by using the state data and the control data, the plurality of pieces of specific state information each representing, as a point, a state of the refrigerant at each of a plurality of specific positions in the refrigeration circuit, and being located in a state space defined by a pressure of refrigerant and an enthalpy;

a normal region determination unit configured to determine, by using the state data and the control data, a plurality of normal regions in the state space within which each of the plurality of pieces of specific state information is present when the air-conditioning apparatus operates under a normal state; and

a display processing unit configured to allow the display unit to display a diagnostic image including the plurality of pieces of specific state information determined by the specific state determination unit, and a plurality of normal regions determined by the normal region determination unit.