and dissolving and removing the salt. The feed of cleaning water makes it possible to eliminate the differential pressure within a short period of time.

For example, NPL 1 describes a sublimation operation method in which a precipitated salt is sublimed by increasing the temperature of a distillation tower within a short period of time and discharged into a distillation tower-top system.

In addition, for example, PTL 1 describes a hydrocarbon oil distillation method in which, in a distillation treatment of hydrocarbon oil, water is introduced into a distillation tower, thereby removing water-soluble salts in the tower.

Citation List

Patent Literature

[0003]

PTL 1: US 5656152 B

Non Patent Literature

[0004]

NPL 1: GRACE DAVISON CATALAGRAM, ISSUE, 2010, No. 107, pp. 34 to 39

Summary ~~of Invention~~

Technical Problem

[0005]

Conventionally, methods for eliminating a differential pressure caused by salting-out such as the sublimation operation method and the cleaning water application method are carried out in a case where an increase in the differential pressure in a distillation tower is observed and the degree of such an increase is determined to be in a problematic situation. That is, since an increase in the differential pressure is not responded until abnormality in the distillation tower becomes apparent, a problem has been that the response becomes a late action and worsening of the situation such as a decrease in the amount treated or the progress of facility corrosion is allowed. In some cases, it takes several days to several months to confirm that an increase in differential pressure is obvious, and corrosion or contamination by a corrosion product that has progressed during the confirmation of the increase in differential pressure cannot be properly responded by the sublimation operation. In addition, since the corrosion product

itself is highly corrosive, there is a concern that facilities may be additionally corroded during water cleaning.

In addition, while the use of a salt remover, a dispersant or the like makes it possible to reduce a risk of differential pressure or corrosion caused by a precipitated salt, in a case where corrosion has already progressed due to a precipitated salt, there is no solution.

[0006]

The present ~~invention~~ disclosure has been made in consideration of such circumstances, and an objective of the present invention is to provide a distillation tower management system, a distillation tower state analysis method, and a distillation tower management method that are capable of predicting abnormality in distillation towers before the abnormality becomes apparent (in other words, detecting the warning of abnormality in distillation towers) and capable of taking preventive actions.

Solution to Problem

[0007]

In order to solve the above-described problems, the present inventors have conducted intensive studies and consequently found that the warning of abnormality can be detected by acquiring the operation information of a distillation tower and analyzing a change in the operation information.

The present ~~invention~~ disclosure has been completed based on such a finding.

[0008]

The present disclosure refers to subject matter as defined in the attached set of claims. That is, the present disclosure ~~relates to~~describes the following~~s~~.

(1) A distillation tower management system including a measurement unit that is at least one selected from the group consisting of a pressure measurement unit that measures pressures at a plurality of different sites in a height direction of a distillation tower, a temperature measurement unit that measures a tower top portion temperature of the distillation tower, and a chlorine measurement unit that measures a feed rate of chlorine fed to the distillation tower and a discharge rate of chlorine discharged from the distillation tower, an operation data unit that produces operation data containing measurement data measured with the measurement unit, an analysis unit that analyzes a state of the distillation tower from the operation data and produces analysis data regarding the state of the distillation tower, and a control unit that produces, based on the

control data production step of producing, with a control unit based on the analysis data, control data regarding a differential pressure-eliminating agent that is added to the distillation tower, in which, in a case where the measurement step is the pressure measurement step, the operation data production step includes a differential pressure data production step of producing operation data containing differential pressure data regarding a differential pressure between pressures at a plurality of sites measured with the pressure measurement unit, in a case where the measurement step is the temperature measurement step, the operation data production step includes a temperature difference data production step of producing operation data containing temperature difference data regarding a temperature difference between the tower top portion temperature and a salting-out temperature obtained by calculation, and, in a case where the measurement step is the chlorine measurement step, the operation data production step includes a chlorine rate difference data production step of producing operation data containing chlorine rate difference data regarding a difference in chlorine rate between the chlorine feed rate and the chlorine discharge rate.

(7) The distillation tower management method according to (6), in which, in the analysis data production step, predicted alteration of a future differential pressure is analyzed with the analysis unit from differential pressure alteration that is obtained from the differential pressure data.

Advantageous Effects ~~of Invention~~

[0009]

According to the present ~~invention~~disclosure, it is possible to provide a distillation tower management system, a distillation tower state analysis method, and a distillation tower management method that are capable of predicting abnormality in distillation towers before the abnormality becomes apparent and capable of taking preventive actions.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a block diagram of a distillation tower management system and a distillation tower facility according to an embodiment of the present invention.

[0024]

The analysis unit 30 is capable of analyzing the predicted alteration of a future temperature difference from the temperature difference alteration between the tower top portion temperature and the salting-out temperature that is obtained from the temperature difference data 201. The temperature difference alteration that is obtained from the temperature difference data 201 may be grasped from the value of a change in the temperature difference per unit time or may be grasped by graphing the temperature difference alteration that is obtained from the temperature difference data 201. An example of the analysis data 300 produced with the analysis unit 30 by analyzing the operation data containing the temperature difference data 201 is shown in Fig. 3. Fig. 3 is a graph showing the number of operation days along the horizontal axis and temperatures along the vertical axis. That is, Fig. 3 is a graph showing the temperature difference alteration between the tower top portion temperature and the salting-out temperature. The analysis unit 30 carries out at least one of a group consisting of moving average, exponential mean, linear approximation, non-linear approximation, multivariate analysis and the other free set values based on the temperature difference alteration that has been thus far obtained, thereby analyzing the predicted alteration of a future temperature difference from the temperature difference alteration that has been thus far obtained. Specifically, the analysis unit 30 analyzes the predicted alteration of the future temperature difference from the slopes of graphs showing the temperature difference alteration that is obtained from the temperature difference data 201. In addition, the analysis unit 30 sets a case where the tower top portion temperature is ~~below~~ greater than or equal to the salting-out temperature as a state in which the operation of the distillation tower 103 is hindered and predicts whether or not the tower top portion temperature is below the salting-out temperature in the predicted alteration obtained by analysis.

As a result of analyzing the predicted alteration of the future temperature difference from the temperature difference alteration, for example, in a case where the tower top portion temperature is predicted to be below the salting-out temperature, the temperature difference is evaluated as "A", which means that the temperature difference is favorable. In the case of "A evaluation", a change in the operation specification (the kind of the differential pressure-eliminating agent, the amount of the differential pressure-eliminating agent added and the

rate difference alteration that is obtained from the chlorine rate difference data 202. In addition, the analysis unit 30 sets a case where the chlorine rate difference between the chlorine feed rate and the chlorine discharge rate becomes a certain value or more as a state in which the operation of the distillation tower 103 is hindered and predicts whether or not the chlorine rate difference between the chlorine feed rate and the chlorine discharge rate becomes the certain value or more in the predicted alteration obtained by analysis.

As a result of analyzing the predicted alteration of the future ~~temperature~~ chlorine rate difference from the chlorine difference alteration, for example, in a case where the chlorine rate difference between the chlorine feed rate and the chlorine discharge rate is predicted to be below the certain value, the chlorine rate difference is evaluated as "A", which means that the chlorine rate difference is favorable. In the case of "A evaluation", a change in the operation specification (the kind of the differential pressure-eliminating agent, the amount of the differential pressure-eliminating agent added and the like) of the distillation tower 103 is not recommended. On the other hand, as a result of analyzing the predicted alteration of the future ~~temperature~~ chlorine rate difference from the chlorine difference alteration, for example, in a case where there is a concern that the chlorine rate difference between the chlorine feed rate and the chlorine discharge rate may reach the certain value, the chlorine rate difference is evaluated as "B", which means that attention needs to be paid to the chlorine rate difference, and, in a case where the chlorine rate difference between the chlorine feed rate and the chlorine discharge rate is highly likely to reach the certain value, the chlorine rate difference is evaluated as "C", which means that an action needs to be taken regarding the chlorine rate difference. In the case of "B evaluation" or "C evaluation", a change in the operation specification of the distillation tower 103 is recommended.

The predicted alteration of the future chlorine rate difference can be made more accurate using a result obtained by learning, such as machine learning or deep learning.

[0026]

<Control unit>

The control unit 40 produces, based on the analysis data 300, control data 400 regarding the differential pressure-eliminating agent that is added to the distillation tower 103. The control data 400 is data containing the kind of the

S2 and an analysis data production step S3 as shown in Fig. 5. Hereinafter, the distillation tower ~~management~~ state analysis method according to the present embodiment will be described with reference to Fig. 1 and Fig. 5.

[0030]

<Measurement step>

The measurement step S1 includes at least one selected from the group consisting of a pressure measurement step S10 of measuring pressures at a plurality of different sites in the height direction of the distillation tower 103 with the pressure measurement unit 11, a temperature measurement step S11 of measuring the tower top portion temperature of the distillation tower 103 with the temperature measurement unit 12 and a chlorine measurement step S12 of measuring the feed rate of chlorine fed to the distillation tower 103 and the discharge rate of chlorine discharged from the distillation tower 103 with the chlorine measurement unit 13.

[0031]

<<Pressure measurement step>>

In a case where the measurement step S1 includes the pressure measurement step S10, specifically, the pressure at the tower top portion of the distillation tower 103 and the lower portion pressure in at least any of the plurality of side refluxes such as the first side reflux 131, the second side reflux 132 and the third side reflux 133 are measured with the pressure measurement unit 11. A method for measuring the pressures with the pressure measurement unit 11 may be a method in which pressures in the distillation tower 103 are directly measured or may be a method in which pressures correlating with the pressures in the tower are measured. Regarding the measurement of the pressures with the pressure measurement unit 11, the pressures in the distillation tower 103 may be continuously measured or intermittently measured.

The pressure measurement unit 11 stores the measured pressures in a storage unit (not shown) through the network 50. As the storage unit, for example, storage media such as a ROM, a RAM and a hard disc can be used. The pressure measurement unit 11 is connected to the communication network 50, whereby, with the Internal of Things (IoT), it is possible to carry out remote control, remote monitoring, data transmission and the like, and it is enabled to exchange information between the configuration elements of the distillation tower management system 1.

obtained from the temperature difference data 201 based on the operation data containing the temperature difference data 201. The analysis unit 30 produces a graph showing the temperature difference alteration, like Fig. 3, based on, for example, the operation data containing the temperature difference data 201 and analyzes the predicted alteration of the future temperature difference from the graph showing the temperature difference alteration. Specifically, the analysis unit 30 analyzes the predicted alteration of the future temperature difference from the slopes of graphs showing the temperature difference alteration that is obtained from the temperature difference data 201. In addition, the analysis unit 30 sets a case where the tower top portion temperature is below the salting-out temperature as a state in which the operation of the distillation tower 103 is hindered, determines whether or not the tower top portion temperature is ~~below~~ greater than or equal to the salting-out temperature in the predicted alteration obtained by analysis, and produces the analysis data 300 containing the determination result.

The analysis unit 30 stores the produced analysis data 300 in the storage unit (not shown) through the network 50.

[0040]

A case where the state of the distillation tower 103 is analyzed using the operation data containing the chlorine rate difference data 202 in the analysis data production step S3 will be described.

First, the analysis unit 30 acquires operation data containing the chlorine rate difference data 202 produced by the operation data production step S2 that is stored in the storage unit.

Next, the analysis unit 30 analyzes the predicted alteration of a future temperature difference from the chlorine rate difference alteration that is obtained from the chlorine rate difference data 202 based on the operation data containing the chlorine rate difference data 202. The analysis unit 30 produces a graph showing the chlorine rate difference alteration, like Fig. 4, based on, for example, the operation data containing the chlorine rate difference data 202 and analyzes the predicted alteration of the future temperature difference from the graph showing the chlorine rate difference alteration. Specifically, the analysis unit 30 analyzes the predicted alteration of the future chlorine rate difference from the slopes of graphs showing the chlorine rate difference alteration that is obtained from the chlorine rate difference data 202. In addition, the analysis unit 30 sets a case where the chlorine rate difference between the chlorine feed

CLAIMS

[Claim 1]

A distillation tower management system comprising:

a measurement unit that is at least one selected from the group consisting of a pressure measurement unit that measures pressures at a plurality of different sites in a height direction of a distillation tower, a temperature measurement unit that measures a tower top portion temperature of the distillation tower, and a chlorine measurement unit that measures a feed rate of chlorine fed to the distillation tower and a discharge rate of chlorine discharged from the distillation tower;

an operation data unit that produces operation data containing measurement data measured with the measurement unit;

an analysis unit that analyzes a state of the distillation tower from the operation data and produces analysis data regarding the state of the distillation tower; and

a control unit that produces, based on the analysis data, control data regarding a differential pressure-eliminating agent that is added to the distillation tower,

wherein, (1) in a case where the measurement unit is the pressure measurement unit, the operation data unit produces operation data containing differential pressure data regarding a differential pressure between pressures at a plurality of sites measured with the pressure measurement unit, and the analysis unit makes differential pressure alteration that is obtained from the differential pressure data into a graph showing the number of operation days along the horizontal axis and differential pressures along the vertical axis, and analyzes predicted alteration of a future differential pressure from the slope of the graph showing the differential pressure alteration that is obtained from the differential pressure data,

(2) in a case where the measurement unit is the temperature measurement unit, the operation data unit produces operation data containing temperature difference data regarding a temperature difference between the tower top portion temperature measured with the temperature measurement unit and a salting-out temperature obtained by calculation, and the analysis unit makes temperature difference alteration that is obtained from the temperature difference between the tower top portion temperature and the salting-out

temperature into a graph showing the number of operation days along the horizontal axis and temperatures along the vertical axis, and analyzes predicted alteration of a future temperature difference from the slope of the graph showing the temperature difference alteration that is obtained from the temperature difference data, and

(3) in a case where the measurement unit is the chlorine measurement unit, the operation data unit produces operation data containing chlorine rate difference data regarding a difference in chlorine rate between the chlorine feed rate and the chlorine discharge rate measured with the chlorine measurement unit, and the analysis unit makes chlorine rate difference alteration into a graph showing the number of operation days along the horizontal axis and the amounts of chlorine along the vertical axis, and analyzes predicted alteration of a future chlorine rate difference from the slope of the graph showing the chlorine rate difference alteration that is obtained from the chlorine difference data.

~~[Claim 2]~~

~~The distillation tower management system according to claim 1,~~

~~wherein the analysis unit analyzes predicted alteration of a future differential pressure from differential pressure alteration that is obtained from the differential pressure data.~~

[Claim ~~3~~2]

The distillation tower management system according to claim 1 ~~or 2~~,

wherein the differential pressure-eliminating agent is at least one of a salt remover and a salt dispersant.

[Claim ~~4~~3]

A distillation tower state analysis method comprising:

a measurement step that is at least one selected from the group consisting of a pressure measurement step of measuring pressures at a plurality of different sites in a height direction of a distillation tower with a pressure measurement unit, a temperature measurement step of measuring a tower top portion temperature of the distillation tower with a temperature measurement unit, and a chlorine measurement step of measuring a feed rate of chlorine fed to the distillation tower and a discharge rate of chlorine discharged from the distillation tower with a chlorine measurement unit;

an operation data production step of producing, with an operation data unit, operation data containing measurement data measured by the measurement step; and

an analysis data production step of analyzing a state of the distillation tower from the operation data and producing analysis data regarding the state of the distillation tower with an analysis unit,

wherein, (1) in a case where the measurement step is the pressure measurement step, the operation data production step comprises a differential pressure data production step of producing operation data containing differential pressure data regarding a differential pressure between pressures at a plurality of sites measured with the pressure measurement unit, , and the analysis data production step comprises steps of making differential pressure alteration that is obtained from the differential pressure data into a graph showing the number of operation days along the horizontal axis and differential pressures along the vertical axis, and analyzing predicted alteration of a future differential pressure from the slope of the graph showing the differential pressure alteration that is obtained from the differential pressure data,

(2) in a case where the measurement step is the temperature measurement step, the operation data production step comprises a temperature difference data production step of producing operation data containing temperature difference data regarding a temperature difference between the tower top portion temperature and a salting-out temperature obtained by calculation, and the analysis data production step comprises steps of making temperature difference alteration that is obtained from the temperature difference between the tower top portion temperature and the salting-out temperature into a graph showing the number of operation days along the horizontal axis and temperatures along the vertical axis, and analyzing predicted alteration of a future temperature difference from the slope of the graph showing the temperature difference alteration that is obtained from the temperature difference data, and

in a case where the measurement step is the chlorine measurement step, the operation data production step comprises a chlorine rate difference data production step of producing operation data containing chlorine rate difference data regarding a difference in chlorine rate between the chlorine feed rate and the chlorine discharge rate, and the analysis data production step comprises steps of making chlorine rate difference alteration into a graph showing the

number of operation days along the horizontal axis and the amounts of chlorine along the vertical axis, and analyzing predicted alteration of a future chlorine rate difference from the slope of the graph showing the chlorine rate difference alteration that is obtained from the chlorine difference data.

~~[Claim 5]~~

~~The distillation tower state analysis method according to claim 4,~~

~~wherein, in the analysis data production step, predicted alteration of a future differential pressure is analyzed with the analysis unit from differential pressure alteration that is obtained from the differential pressure data.~~

[Claim ~~6~~4]

A distillation tower management method comprising:

a measurement step that is at least one selected from the group consisting of a pressure measurement step of measuring pressures at a plurality of different sites in a height direction of a distillation tower with a pressure measurement unit, a temperature measurement step of measuring a tower top portion temperature of the distillation tower with a temperature measurement unit, and a chlorine measurement step of measuring a feed rate of chlorine fed to the distillation tower and a discharge rate of chlorine discharged from the distillation tower with a chlorine measurement unit;

an operation data production step of producing, with an operation data unit, operation data containing measurement data measured by the measurement step;

an operation data production step comprising a differential pressure data production step of producing, with an operation data unit, operation data containing differential pressure data regarding a differential pressure between pressures at a plurality of sites measured with the pressure measurement unit;

an analysis data production step of analyzing a state of the distillation tower from the operation data and producing analysis data regarding the state of the distillation tower with an analysis unit; and

a control data production step of producing, with a control unit based on the analysis data, control data regarding a differential pressure-eliminating agent that is added to the distillation tower,

wherein,

(1) in a case where the measurement step is the pressure measurement step, the operation data production step comprises a differential pressure data production

step of producing operation data containing differential pressure data regarding a differential pressure between pressures at a plurality of sites measured with the pressure measurement unit, and the analysis data production step comprises steps of making differential pressure alteration that is obtained from the differential pressure data into a graph showing the number of operation days along the horizontal axis and differential pressures along the vertical axis, and analyzing predicted alteration of a future differential pressure from the slope of the graph showing the differential pressure alteration that is obtained from the differential pressure data,

(2) in a case where the measurement step is the temperature measurement step, the operation data production step comprises a temperature difference data production step of producing operation data containing temperature difference data regarding a temperature difference between the tower top portion temperature and a salting-out temperature obtained by calculation, and the analysis unit comprises steps of making temperature difference alteration that is obtained from the temperature difference between the tower top portion temperature and the salting-out temperature into a graph showing the number of operation days along the horizontal axis and temperatures along the vertical axis, and analyzing predicted alteration of a future differential pressure from the slope of the graph showing the temperature difference alteration that is obtained from the temperature difference data, and

(3) in a case where the measurement step is the chlorine measurement step, the operation data production step comprises a chlorine rate difference data production step of producing operation data containing chlorine rate difference data regarding a difference in chlorine rate between the chlorine feed rate and the chlorine discharge rate, and the analysis unit comprises steps of making chlorine rate difference alteration into a graph showing the number of operation days along the horizontal axis and the amounts of chlorine along the vertical axis, and analyzing predicted alteration of a future chlorine rate difference from the slope of the graph showing the chlorine rate difference alteration that is obtained from the chlorine difference data.

~~[Claim 7]~~

~~The distillation tower management method according to claim 6,~~

~~wherein, in the analysis data production step, predicted alteration of a future differential pressure is analyzed with the analysis unit from differential pressure alteration that is obtained from the differential pressure data.~~