

DESCRIPTION

TITLE OF INVENTION

SYSTEM, DEVICE, AND METHOD

5

TECHNICAL FIELD

[0001]

The present invention relates to a system, a device, and a method for displaying a state of a plant.

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BACKGROUND ART

[0002]

In the related art, a sensor is installed in a plant, and an operation status of the plant is monitored according to a measured value of the sensor. For example, Patent Literature 1 discloses that when an object on a display screen is selected, information related to the object from a sensor is displayed, so that an operator can intuitively grasp a detection target or a detection result of the sensor. Patent Literature 2 discloses that a plurality of alarm messages are displayed on an alarm monitoring screen, and when an operator presses a graph display on a display screen, graph information of a corresponding alarm message is displayed.

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CITATION LIST

PATENT LITERATURE

[0003]

Patent Literature 1: JP H04-308895 A

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Patent Literature 2: JP 2016-115195 A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004]

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In the configurations in the related art, although it is possible to monitor data of a sensor installed in a plant, it is necessary to monitor process data obtained from the sensor and confirm process data related to a deduction in order to resolve an occurrence event of an abnormality of the plant. Therefore, with the configurations in the related art, it may be

difficult to grasp a cause of the abnormality in the plant and a countermeasure for the abnormality.

[0005]

An object of an aspect of the present invention is to provide a system, a device, and a method capable of showing a state of a plant to an operator in an easy-to-understand manner when an abnormality occurs in the plant.

SOLUTION TO PROBLEM

[0006]

In order to solve the above problem, according to a first aspect of the present invention, there is provided a system for displaying a state of a plant. The system includes a first display function including displaying an abnormality display indicating an occurrence of an abnormality having a possibility of stopping the plant and prompting an operator to confirm the abnormality; a second display function including displaying image information indicating a position of a tube in an entire plant and a position of a sensor provided in the tube and indicating an abnormal state of the tube detected by the sensor in a prescribed mode when the abnormality display is selected by the operator in the first display function; and a third display function including displaying data of the sensor as a basis of the abnormal state indicated in the prescribed mode.

[0007]

According to the above aspect, when an abnormality occurs in the plant, since a state of the plant that should be grasped by an operator can be displayed in a stepwise and sequential manner, the state of the plant can be easily shown to the operator.

[0008]

A method according to the first aspect of the present invention is a method for displaying a state of a plant. The method includes displaying an abnormality display indicating an occurrence of an abnormality having a possibility of stopping the plant and prompting an operator to confirm the abnormality; receiving a selection of the abnormality display from the operator; displaying image information that indicates a position of a tube in the entire plant and a position of a sensor provided in the tube and displaying an abnormal state of the tube detected by the sensor in a prescribed mode when the abnormality display is selected by the operator; receiving a selection of the display in the prescribed mode from the operator; and displaying data of the sensor as a basis of the abnormal state indicated in the prescribed mode when the display of the abnormal state of the tube is selected by the operator.

[0009]

According to the above aspect, when an abnormality occurs in the plant, since a state of the plant that should be grasped by an operator can be displayed in a stepwise and sequential manner, the state of the plant can be easily shown to the operator.

[0010]

5 A device according to a second aspect of the present invention includes a display screen for displaying a state of a plant. The device is configured to display, in a first area of the display screen, an occurrence of an abnormality having a possibility of stopping the plant; and display, in a second area of the display screen, an occurrence history of an abnormality affecting an operation efficiency of the plant.

10 [0011]

According to this aspect, it is possible to easily recognize both a serious abnormality such as a bursting and an abnormality related to a decrease in the operation efficiency.

[0012]

15 It should be noted that the expression which is configured to display “an occurrence of an abnormality” includes not only a case where it is determined that an abnormality occurs but also a case where there is a high possibility that an abnormality will occur in the future.

[0013]

20 In addition, the expression which is configured to display “an occurrence history of an abnormality” includes a case in which the device is configured to display a history indicating it is determined that an abnormality occurs and a case in which the device is configured to display a history indicating that there is a high possibility that an abnormality will occur in the future.

[0014]

25 The occurrence history of the abnormality displayed in the second area may be displayed in a mode in which time information indicating an occurrence time of the abnormality and information indicating contents of the abnormality are arranged in an order of the occurrence time. The occurrence time of the abnormality includes not only a time when it is determined that an abnormality occurs, but also a time when it is determined that there is a high possibility that an abnormality will occur in the future.

30 [0015]

According to this aspect, since the time information indicating the occurrence time of the abnormality that affects the operation efficiency and a stable operation of the plant and the information indicating the contents of the abnormality are displayed in a state in which the occurrence time and the information are arranged in the order of the occurrence time, it is

possible to recognize occurrence times of a plurality of abnormalities that lead to a decrease in the operation efficiency.

[0016]

The plant may include a plurality of sensors, and the occurrence history of the abnormality displayed in the second area may be displayed in a mode in which the number of times that data obtained by these sensors indicates an abnormal value is arranged for each sensor.

[0017]

According to this aspect, since the number of times that a sensor shows an abnormal value can be displayed for each sensor, it is possible to easily specify a problematic sensor.

[0018]

The occurrence history of the abnormality displayed in the second area may include an occurrence history of an abnormality determined to occur based on data obtained from at least two of the sensors and an occurrence history of an abnormality determined to occur based on data obtained from a single one of the sensors.

[0019]

According to this aspect, since it is possible to display the occurrence history of the abnormality for which the occurrence is determined based on data obtained from at least two of the sensors, it is possible to improve detection accuracy of the abnormality.

[0020]

The plant may be composed of a plurality of components, and the device may be configured to display at least one of the components having a possibility of causing an abnormality that affects the operation efficiency and a stable operation in a fourth area of the display screen in a mode different from other components.

[0021]

According to this aspect, since at least one of the components having a possibility of causing an abnormality that affects the operation efficiency can be displayed in a mode different from the other components, it is possible to easily specify a problematic component.

[0022]

The device may be configured to display information indicating the operation efficiency of the plant in a fifth area of the display screen.

[0023]

According to this aspect, since the information indicating the operation efficiency of the plant can be displayed, it is possible to easily recognize a decrease in the operation efficiency due to the abnormality.

[0024]

5 A system according to the second aspect of the present invention includes a device having a display screen for displaying a state of a plant; and a control device configured to control the device, in which the device is configured to display, in a first area of the display screen, an occurrence of an abnormality having a possibility of stopping the plant, and display, in a second area of the display screen, an occurrence history of an abnormality affecting an
10 operation efficiency of the plant.

[0025]

According to this aspect, since it is possible to simultaneously display two pieces of information important for the operation of the plant on the display screen, it is possible to easily recognize both a serious abnormality such as a bursting and an abnormality related to a decrease
15 in the operation efficiency.

[0026]

A device according to a third aspect of the present invention includes a screen for displaying a state of a plant, in which the device is configured to display, in a first area of the screen, image information indicating a position of a tube in the entire plant and a position of a
20 sensor provided in the tube and display a state of the tube detected by the sensor in the first area in a prescribed mode; and display, in a second area of the screen, determination information that is used when the state of the tube is determined based on operation data of the plant.

[0027]

25 A system according to the third aspect of the present invention includes: a display device having a screen for displaying a state of a plant; and a control device configured to control the display device, in which the display device is configured to display, in a first area of the screen, image information indicating a position of a tube in the entire plant and a position of a sensor provided in the tube and display a state of the tube detected by the sensor in the first
30 area in a prescribed mode, and display, in a second area of the screen, determination information that is used when the state of the tube is determined based on operation data of the plant.

[0028]

When such a configuration is adopted, image information indicating the position of the tube in the entire plant and the position of the sensor provided in the tube can be displayed in the first area of the screen, and the state of the tube detected by the sensor can be displayed in the prescribed mode. In addition, the determination information that is used when the state of the tube is determined based on the operation data of the plant can be displayed in the second area of the screen. Therefore, an operator who visually recognizes the screen of the device (the system) can grasp the position of the tube and the position of the sensor in the entire plant, and can also grasp the state of the tube determined or detected using different methods (both the sensor and the operation data of the plant). That is, the operator can efficiently grasp important information necessary for monitoring the tube by visually recognizing a single screen, and thus can make a comprehensive determination. As a result, the device (the system) can contribute to a stable operation of the plant. The “state of the tube” includes not only a state (an abnormal state) in which an abnormality such as a bursting or clogging occurs in the tube, but also a state (a normal state) in which such an abnormality does not occur. That is, the device (the system) can display not only an abnormal state of a tube but also a normal state of a tube.

[0029]

The device or system according to the third aspect of the present invention can be configured to display the determination information in the second area in time series. Examples of the determination information include a value obtained by calculating an abnormality degree of a tube based on the operation data, a value obtained by calculating a reliability degree of the state of the tube (the abnormality degree or the like) based on the operation data, and feature amount data that affects a state determination (a determination of the abnormality degree or the reliability degree) of the tube.

[0030]

When such a configuration is adopted, it is possible to grasp, in time series, the determination information related to the state of the tube determined based on the operation data of the plant.

[0031]

The device or system according to the third aspect of the present invention can be configured to display both a detection result of the state of the tube detected by the sensor and a determination result of the state of the tube determined based on the operation data of the plant in the same format and in time series in the third area of the screen. The device or

system may be configured to display a time axis in the second area and a time axis in the third area in conjunction with each other.

[0032]

When such a configuration is adopted, both the detection result of the state of the tube detected by the sensor and the determination result of the state of the tube determined based on the operation data of the plant can be displayed in the same format (for example, in a bar chart format) and in time series in the third area of the screen. Therefore, an operator can visually recognize and grasp tube state determination (detection) results that are obtained using different methods and are in the same format, and can make a comprehensive determination.

[0033]

The device or system according to the third aspect of the present invention may be configured to display detection information detected by a specific sensor in the fourth area in time series when the specific sensor is selected from sensors displayed in the first area.

[0034]

When such a configuration is adopted, the detection information detected by the selected sensor (specific sensor) among the sensors displayed in the first area of the screen can be grasped in time series.

[0035]

The device or system according to the third aspect of the present invention can be configured to display the detection information in the fourth area of a screen different from the screen.

[0036]

When such a configuration is adopted, the detection information detected by the selected sensor (specific sensor) among the sensors displayed in the first area of the screen can be displayed in the fourth area of the screen different from the screen having the first area and the like. Therefore, there is an advantage in that the detection information can be enlarged and displayed on the screen (the fourth area) different from the screen having the first area and the like, and a time history and the like of the detection information can be grasped in detail.

[0037]

A device according to a fourth aspect of the present invention includes a display screen for displaying a state of a plant. The device is configured to display, in a first area of the display screen, a graph of first process data related to the plant; and display, in a second area of the display screen which is adjacent to the first area, an explanatory text related to the first process data.

[0038]

According to this aspect, since the graph of the first process data is displayed in the first area of the display screen and the explanatory text related to the first process data is displayed in the adjacent second area, it is easy to understand what kind of event occurs and it is easy to understand what kind of countermeasure is required.

[0039]

In the above aspect, a graph of second process data related to the first process data may be displayed in the first area.

[0040]

According to this aspect, since not only a graph of the first process data but also a graph of the related second process data are displayed, it is possible to monitor the state of the plant from various angles.

[0041]

In the above aspect, another graph of the first process data different from the graph of the first process data may be displayed in the first area.

[0042]

According to this aspect, it is possible to monitor the state of the plant from various angles by displaying a plurality of types of graphs of the first process data.

[0043]

In the above aspect, the display screen may be configured to display, on the display screen, a first screen showing a warning when at least one of a plurality pieces of process data is in an abnormal state and configured to be display a second screen on the display screen by transitioning the display screen from the first screen to the second screen in response to the selection of the warning, and the second screen may include the first area and the second area.

[0044]

According to this aspect, an outline of the state of the plant can be confirmed through the plurality of pieces of process data on the first screen, and the state of the plant can be confirmed in detail through specific process data on the second screen.

[0045]

In the above aspect, a warning may be displayed in a third area of the first screen, and a graph of one or a plurality pieces of representative process data related to the plant may be displayed in a fourth area adjacent to the third area.

[0046]

According to this aspect, it is possible to quickly grasp a possibility of an abnormality by displaying the warning in the third area of the first screen, and it is possible to confirm the outline of the state of the plant by displaying the graph of the representative process data in the fourth area of the first screen.

5 [0047]

In the above aspect, the explanatory text may include a sentence describing a method of capturing an event from the graph.

[0048]

10 According to this aspect, it is possible to confirm a method of capturing an event from a graph, and it is easy to understand what kind of event occurs.

[0049]

In the above aspect, the explanatory text may include a sentence describing a method of optimizing a state of the first process data.

[0050]

15 According to this aspect, it is possible to confirm a method of optimizing the state of the first process data, and it is easy to understand what kind of countermeasure is required.

[0051]

20 A system according to the fourth aspect of the present invention includes: a device having a display screen for displaying a state of a plant; and a control device configured to control the device, in which the device is configured to display, in a first area of the display screen, a graph of first process data related to the plant, and display, in a second area of the display screen which is adjacent to the first area, an explanatory text related to the first process data.

[0052]

25 According to this aspect, since the graph of the first process data is displayed in the first area of the display screen and the explanatory text related to the first process data is displayed in the adjacent second area, it is easy to understand what kind of event occurs and it is easy to understand what kind of countermeasure is required.

[0053]

30 It should be noted that any combination of the above-described components and components and expressions of the present invention may be mutually replaced by a method, a device, a system, a computer program, a data structure, a recording medium, or the like, which is also effective as an aspect of the present invention.

ADVANTAGEOUS EFFECTS OF INVENTION

[0054]

According to the present invention, it is possible to show a state of a plant to an operator in an easy-to-understand manner when an abnormality occurs in the plant.

5 BRIEF DESCRIPTION OF DRAWINGS

[0055]

FIG. 1 is a schematic diagram showing an overall configuration of a plant according to an embodiment of the present invention.

10 FIG. 2 is a diagram showing functional blocks of a system according to the embodiment of the present invention.

FIG. 3 is a diagram showing a physical configuration of the system according to the present embodiment.

FIG. 4 is a diagram showing details of the functional blocks of the system according to the present embodiment.

15 FIG. 5 is a flowchart showing a method according to the embodiment of the present invention.

FIG. 6 is a diagram showing a display function of the system according to the present embodiment.

20 FIG. 7 is a diagram showing a display function of the system according to the present embodiment.

FIG. 8 is a diagram showing a display function of the system according to the present embodiment.

FIG. 9 is a diagram showing a display function of the system according to the present embodiment.

25 FIG. 10 is a diagram showing a display function of the system according to the present embodiment.

FIG. 11 is a diagram showing a display function of the system according to the present embodiment.

30 FIG. 12 is a diagram showing a display function of the system according to the present embodiment.

FIG. 13 is a diagram showing a display function of the system according to the present embodiment.

FIG. 14 is a diagram showing a display function of the system according to the present embodiment.

DESCRIPTION OF EMBODIMENTS

[0056]

Hereinafter, the present invention will be described through embodiments of the invention with reference to the drawings, the following embodiments do not limit the invention according to the claims, and all combinations of features described in the embodiments are not necessarily essential to the solution of the invention. The same or equivalent components, members, and processings shown in the drawings are denoted by the same reference numerals, and repeated description thereof will be appropriately omitted.

[0057]

FIG. 1 is a schematic diagram showing an overall configuration of a plant according to an embodiment of the present invention. First, a configuration of a plant 1 according to the present embodiment will be described with reference to FIG. 1. The plant 1 is, for example, a power plant (an incineration plant) including a circulating fluidized bed boiler (a circulating fluidized bed type), and includes a boiler that generates steam by combusting fuel while circulating a circulating material such as silica sand flowing at a high temperature. For example, fossil fuel such as coal and non-fossil fuel (wood biomass, waste tire, waste plastic, sludge, or the like) can be used as the fuel of the plant 1. The steam generated in the plant 1 is used to drive a turbine 100. A plant to which the present invention is applied is not limited to a power plant or an incineration plant including a boiler, and may be a plant capable of obtaining process data, such as a chemical plant or a wastewater treatment plant.

[0058]

The plant 1 is configured to combust fuel in a furnace 2, separate a circulating material from exhaust gas in a cyclone 3 that functions as a solid gas separation device, and return the separated circulating material into the furnace 2 to circulate the circulating material. The separated circulating material is returned to a lower portion of the furnace 2 via a circulating material recovery tube 4 connected to a lower portion of the cyclone 3. A lower portion of the circulating material recovery tube 4 and a lower portion of the furnace 2 are connected to each other via a loop seal portion 4a in which a flow path is narrowed. As a result, a predetermined amount of the circulating material is stored in the lower portion of the circulating material recovery tube 4. The exhaust gas from which the circulating material is removed by the cyclone 3 is supplied to a rear flue 5 via an exhaust gas flow path 3a.

[0059]

A boiler includes the furnace 2 for combusting fuel and a heat exchanger for generating steam or the like by using heat obtained by the combustion. A fuel supply port 2a for supplying fuel is provided in an intermediate portion of the furnace 2, and a gas outlet 2b for discharging combustion gas is provided in an upper portion of the furnace 2. Fuel supplied from a fuel supply device (not shown) to the furnace 2 is supplied into the furnace 2 through the fuel supply port 2a. A furnace wall tube 6 for heating boiler supply water is provided on a furnace wall of the furnace 2. The boiler supply water flowing through the furnace wall tube 6 is heated by the combustion in the furnace 2.

[0060]

In the furnace 2, air that is introduced from a lower air supply line 2c and is used for combustion and fluidization causes a solid matter containing the fuel supplied from the fuel supply port 2a to flow, and the fuel flows and combusts at, for example, about 800°C to 900°C. Combustion gas generated in the furnace 2 is introduced into the cyclone 3 together with the circulating material. The cyclone 3 separates the circulating material and the gas by a centrifugal separation action, returns the separated circulating material to the furnace 2 through the circulating material recovery tube 4, and sends out the combustion gas from which the circulating material is removed from the exhaust gas flow path 3a to the rear flue 5.

[0061]

In the furnace 2, a part of the circulating material called an in-furnace bed material stays at the bottom of the furnace 2. The bed material may include a bed material having a coarse particle diameter unsuitable for circulation and fluidization or an exhaust impurity, and a poor flow may occur due to the unsuitable bed material serving as the circulating material. Therefore, in order to prevent the poor flow, the in-furnace bed material is continuously or intermittently discharged to the outside from a discharge port 2d provided in the bottom portion in the furnace 2. The discharged bed material is supplied to the furnace 2 again or is discarded after an unsuitable material such as metals and coarse particles is removed in a circulation line (not shown). The circulating material of the furnace 2 circulates in a circulation system including the furnace 2, the cyclone 3, and the circulating material recovery tube 4.

[0062]

The rear flue 5 has a flow path through which gas discharged from the cyclone 3 flows to a rear stage. As an exhaust heat recovery unit that recovers heat of exhaust gas, the rear flue 5 includes a superheater 10 that generates superheated steam and an economizer 12 that preheats boiler supply water. Exhaust gas flowing through the rear flue 5 is cooled by exchanging heat with steam or boiler supply water flowing through the superheater 10 and the

economizer 12. A steam drum 8 for storing the boiler supply water that passed through the economizer 12 is provided, and the steam drum 8 is connected to the furnace wall 6.

[0063]

The economizer 12 transfers heat of the exhaust gas to the boiler supply water to preheat the boiler supply water. The economizer 12 is connected to a pump 7 by a tube 21 on one hand, and is connected to the steam drum 8 by a tube 22 on the other hand. The boiler supply water that is supplied from the pump 7 to the economizer 12 via the tube 21 and is preheated by the economizer 12 is supplied to the steam drum 8 via the tube 22.

[0064]

A precipitation tube 8a and the furnace wall tube 6 are connected to the steam drum 8. The boiler supply water in the steam drum 8 precipitates through the precipitation tube 8a, is introduced into the furnace wall tube 6 at a lower side of the furnace 2, and flows toward the steam drum 8. The boiler supply water in the furnace wall tube 6 is heated by combustion heat generated in the furnace 2, and is evaporated in the steam drum 8 to generate steam.

[0065]

A saturated steam tube 8b for discharging internal steam is connected to the steam drum 8. The saturated steam tube 8b connects the steam drum 8 and the superheater 10. Steam in the steam drum 8 is supplied to the superheater 10 via the saturated steam tube 8b. The superheater 10 superheats the steam using heat of exhaust gas to generate superheated steam. The superheated steam passes through a tube 10a, is supplied to the turbine 100 outside the plant 1, and is used for power generation.

[0066]

Pressure and temperature of the steam discharged from the turbine 100 are lower than pressure and temperature of the steam discharged from the superheater 10. Although not particularly limited, the pressure of the steam supplied to the turbine 100 is about 10 MPa to 17 MPa, and the temperature of the steam is about 530 °C to 570 °C. The pressure of the steam discharged from the turbine 100 is about 3 MPa to 5 MPa, and the temperature of the steam is about 350 °C to 400 °C.

[0067]

A condenser 102 is provided downstream of the turbine 100. The steam discharged from the turbine 100 is supplied to the condenser 102, is condensed in the condenser 102, is returned to saturated water, and then is supplied to the pump 7. A generator that converts kinetic energy obtained by rotating the turbine 100 into electric energy is connected to the turbine 100.

[0068]

A pump 7a supplies makeup water so as to keep a water level of the condenser 102 constant. A makeup water flow rate u_1 of makeup water replenished by the pump 7a is shown in FIG. 1.

5 [0069]

Process data (operation data of the plant 1) handled in the present embodiment may be any data related to the plant 1. For example, the process data may be data obtained by measuring a state of the plant 1 using a sensor, and more specifically, may include measured values such as a temperature, a pressure, and a flow rate of the plant 1. FIG. 1 shows a boiler supply water flow rate u_2 of boiler supply water supplied from the pump 7 to the economizer 12. Further, FIG. 1 shows a boiler outlet steam flow rate u_3 of steam supplied from the superheater 10 to the turbine 100 and a saturated steam flow rate u_4 of saturated steam supplied from the steam drum 8 to the superheater 10. The makeup water flow rate u_1 may be controlled so as to follow the saturated steam flow rate u_4 . Further, the boiler supply water flow rate u_2 may be controlled so as to follow an adjustment while monitoring both the boiler outlet steam flow rate u_3 (or a superheated steam flow rate) and a liquid level of the steam drum 8.

[0070]

When a fracture occurs in the plant 1, the makeup water flow rate u_1 increases, or a flow rate difference between the boiler supply water flow rate u_2 and the boiler outlet steam flow rate u_3 increases. A distributed control system (DCS) 20 monitors whether an abnormality occurs in the process data of the plant 1 such as the makeup water flow rate u_1 , the boiler supply water flow rate u_2 , the boiler outlet steam flow rate u_3 , and the saturated steam flow rate u_4 .

25 [0071]

Although the makeup water flow rate u_1 , the boiler supply water flow rate u_2 , the boiler outlet steam flow rate u_3 , and the saturated steam flow rate u_4 are described as the process data, the process data related to the plant 1 may be other kinds of data. The process data related to the plant 1 may be other kinds of data such as a temperature and a pressure.

30 [0072]

Next, a system 30 according to the embodiment of the present invention will be described with reference to FIGS. 2 to 4.

[0073]

FIG. 2 is a diagram showing functional blocks of the system 30 according to the present embodiment. FIG. 3 is a diagram showing a physical configuration of the system 30 according to the present embodiment. FIG. 4 is a diagram showing details of the functional blocks of the system 30 in FIG. 2.

[0074]

The DCS 20 is a distributed control system for controlling the plant 1. As shown in FIG. 2, the DCS 20 obtains process data from a sensor or the like provided in the plant 1 and supplies a control signal for controlling the plant 1 to the plant 1 based on the process data.

[0075]

The system 30 includes a control unit 31 and a device 32. The control unit 31 obtains the process data from the DCS 20, generates a control signal for displaying a state of the plant on a display screen of the device 32 based on the process data, and supplies the control signal to the device 32.

[0076]

The device 32 includes a display screen for displaying the state of the plant. The device 32 displays the state of the plant on the display screen based on the control signal obtained from the control unit 31. The display screen of the device 32 will be described later.

[0077]

As shown in FIG. 3, the system 30 physically includes a central processing unit (CPU) 30a corresponding to a calculation unit, a random access memory (RAM) 30b corresponding to a storage unit, a read only memory (ROM) 30c corresponding to a storage unit, a communication unit 30d, an input unit 30e, and a display unit 30f, and these components are connected to one another via a bus so as to be able to transmit data to and receive data from one another. Although a case where the system 30 is implemented by one computer is described in the present embodiment, the system 30 may be implemented by a combination of a plurality of computers. For example, in addition to the display unit 30f, a display configuring a different display unit for displaying other kinds of information may be provided. In addition, the display system 30 may be implemented by a tablet terminal. When the display system 30 is implemented by a tablet terminal, the display system 30 can be carried around, and for example, the display system 30 can be used while patrolling the plant 1. The configuration shown in FIG. 3 is an example, and the system 30 may have a configuration other than the configuration shown in FIG. 3, or a part of the configuration may not be provided. In addition, a part of the configuration may be provided at a remote location. For example, the control unit 31 including the CPU 30a and the like may be provided at a remote location. In

this case, the device 32 including the display unit 30f and the like may be configured to obtain a control signal generated by the control unit 31 provided at a remote location via a network.

[0078]

The CPU 30a is a calculation unit that performs a control related to the execution of a program stored in the RAM 30b or the ROM 30c, and calculates and processes data. The CPU 30a is a calculation unit that executes a program (a monitoring program) for displaying a graph and an explanatory text of the process data of the plant 1. The CPU 30a receives various kinds of data from the input unit 30e and the communication unit 30d, displays a calculation result of data on the display unit 30f, and stores the calculation result in the RAM 30b.

[0079]

The RAM 30b can rewrite data in the storage unit, and may be implemented by a semiconductor storage element such as a DRAM and an SRAM. The RAM 30b may store data such as a program to be executed by the CPU 30a and the process data of the plant 1. The program and the process data are merely examples, and the RAM 30b may store data other than the program and the process data, or may not store some of the program and the process data.

[0080]

The ROM 30c can read data from a storage unit, and may be implemented by an HDD or a semiconductor storage element such as a flash memory. The ROM 30c may store, for example, a computer program for executing various processings to be described in the present embodiment and data that is not rewritten. The data that is not rewritten includes, for example, information related to the plant 1, specifications of components of the plant 1, and the like.

[0081]

The communication unit 30d is an interface that connects the system 30 to another device. The communication unit 30d may be connected to a communication network such as the Internet.

[0082]

The input unit 30e receives an input of data from a user, and may include, for example, a keyboard and a touch panel.

[0083]

The display unit 30f has a display screen that visually displays the calculation result of the CPU 30a, and may be implemented by, for example, a liquid crystal display (LCD). The display unit 30f may display a graph and an explanatory text of the process data. In

addition, the display unit 30f may be provided in a manner of displaying one screen by connecting a plurality of displays.

[0084]

The computer program for executing the various processings described in the present embodiment may be provided by being stored in a computer-readable storage medium such as the ROM 30c, or may be provided via a communication network connected by the communication unit 30d. In the system 30, various operations included in the present embodiment are implemented by the CPU 30a executing the monitoring program. These physical configurations are merely examples, and may not necessarily be independent configurations. For example, the system 30 may include a large-scale integration (LSI) in which the CPU 30a and the RAM 30b or the ROM 30c are integrated.

[0085]

As shown in FIG. 4, the system 30 includes a login display function 40, an abnormality display function 42, an abnormality detailed display function 44, a sensor data detailed display function 46, an abnormality history display function 48, a guide display function 50, and an evaluation item display function 52.

[0086]

The login display function 40 displays information necessary for an operator to log in to the system 30. The information necessary for the login is, for example, a user ID and a password of the operator. The login display function 40 receives an input of the user ID and the password from the operator, and accordingly, the abnormality display function 42 is to be executed.

[0087]

The abnormality display function 42 displays an abnormality display indicating an occurrence of an abnormality having a possibility of stopping the plant 1 and a warning display indicating an occurrence of a warning when the process data related to the plant is in a predetermined state. Here, the abnormality display includes not only a case where an abnormality occurs but also a case where there is a high possibility that an abnormality will occur. Similarly, the warning display includes not only a case where a warning is generated but also a case where there is a high possibility of a warning will occur. The warning display indicates a case where the process data falls out of a range of a predetermined threshold, and displays an occurrence of a state in which an operation of the plant 1 is affected, such as a decrease in the operation efficiency of the plant 1.

[0088]

The abnormality detailed display function 44 displays image information indicating a position of a tube in the entire plant 1 and a position of a sensor provided in the tube, and displays an abnormal state of the tube detected by the sensor in a prescribed mode. The abnormality detailed display function 44 displays, for example, detailed information capable of specifying a cause and a countermeasure for the abnormality display displayed by the abnormality display function 42.

[0089]

The sensor data detailed display function 46 displays sensor data that serves as a basis of the abnormal state displayed by the abnormality detailed display function 44 in the prescribed mode. The sensor data also serves as the process data of the plant 1. The sensor data detailed display function 46 displays, for example, detailed information capable of specifying a cause and a countermeasure for the abnormality detailed display displayed by the abnormality detailed display function 44.

[0090]

The abnormality history display function 48 displays a history of the abnormality display displayed by the abnormality display function 42. The guide display function 50 displays a graph of process data corresponding to the warning display of the abnormality display function 42 and an explanatory text of process data corresponding to the warning display in a manner in which the graph and the explanatory text are arranged adjacent to each other. The evaluation item display function 52 displays an evaluation item for evaluating the state of the plant 1.

[0091]

Arrows of respective functional blocks shown in FIG. 4 indicate transitions of respective functions based on an instruction from the operator. That is, in the system 30, the abnormality display function 42 transitions to any one of the abnormality detailed display function 44, the guide display function 50, and the evaluation item display function 52 based on an instruction from the operator. Similarly, in the system 30, the abnormality detailed display function 44 transitions to one of the sensor data detailed display function 46 and the abnormality history display function 48 based on an instruction from the operator. In the system 30, the evaluation item display function 52 transitions to the guide display function 50 based on an instruction from the operator. In a case where the functions transition in the system 30, a display of a previous function may be replaced with a display of a subsequent function, or a display of a subsequent function may be displayed together with a display of a previous function.

[0092]

Specific operations of various functional blocks of the system 30 described above will be described in more detail in the description using a method and a display screen to be described later.

5 [0093]

Hereinafter, an example of a method using the system 30 will be described as a method according to an embodiment of the present invention. FIG. 5 is a flowchart showing a method according to the present embodiment. FIGS. 6 to 14 show examples of display screens displayed by the functional blocks of the system 30. In the following, a case in which a
10 bursting of the plant 1 occurs will be described as an aspect of an abnormality having a possibility of stopping the plant 1.

[0094]

In FIG. 5, the abnormality display function 42 of the system 30 displays an abnormality display indicating the occurrence of an abnormality having a possibility of
15 stopping the plant 1, and prompts an operator to confirm the abnormality (S10). Specifically, the control unit 31 of the system 30 displays an abnormality display indicating the occurrence of an abnormality based on a plurality of pieces of process data obtained by the DCS 20 from the plant 1.

[0095]

20 Here, an example of a display screen DP1 displayed by the abnormality display function 42 will be described with reference to FIG. 6. The display screen DP1 includes areas R10 to R15 and an evaluation item display 60.

[0096]

In the area R10, a “plant operation support system” is displayed as a name of the
25 system 30, and a “dashboard” is displayed as a status of a current screen. According to the display in the area R10, it is possible to easily grasp a status indicating that the current screen belongs to which system.

[0097]

The upper left area R11 of the display screen DP1 displays information indicating the
30 occurrence of an abnormality having a possibility of stopping the plant 1 and time information of the occurrence of the abnormality. In FIG. 6, information “bursting” is displayed in a character of a large size as an example of the information indicating the occurrence of an abnormality having a possibility of stopping the plant 1. Below the information “bursting”, character information “2019/08/07 14:00” is displayed as current time information. The

current time information is automatically updated, for example, every predetermined period of time (for example, every minute). Alternatively, the current time information may be manually updated by an operation of an operator. According to the information displayed in the area R11, an operator of the plant 1 can recognize that a serious abnormality having a possibility of stopping the plant 1, such as a bursting, occurred at 2:00 p.m. on August 7, 2019. In a modification, the time information immediately below the information “bursting” may be a time point at which the abnormality occurred.

[0098]

In the present embodiment, the information “bursting” includes a case where it is determined that a bursting occurs (for example, a case where it is determined that there is a high possibility that a bursting will occur within a predetermined time in the future and it is determined that there is a sign of a bursting. The same applies hereinafter). Whether there is a bursting can be determined by comparing process data obtained from a single sensor with a predetermined threshold. Further, whether there is a bursting can be determined based on process data obtained from a plurality of sensors in accordance with a predetermined algorithm. The sensors include, for example, a plurality of acoustic emission (AE) sensors provided in a metal structure (a furnace wall tube, a metal surface connected to the tube, or the like) capable of transmitting generated elastic waves without impairing characteristics of the generated elastic waves, and include various sensors that are provided in various places of the plant 1 and are used for detecting a temperature, a pressure, a flow rate, a valve opening degree, a damper opening degree, a liquid level, vibration, sound, and other state quantities of the plant 1. In the present embodiment, the information “bursting” is displayed, for example, not only in a case where the process data obtained from a single AE sensor indicates an abnormal value exceeding a predetermined threshold. In addition, the information “bursting” is displayed in a case where, even when the process data obtained from a single AE sensor does not exceed a predetermined threshold, process data obtained from a plurality of types of sensors, such as a plurality of AE sensors or an AE sensor and another type of sensor, is processed in accordance with a predetermined algorithm, and it is determined that there is a high possibility that a bursting will occur according to a predetermined conditional expression. Therefore, it is possible to stably and accurately detect a bursting in an early stage as compared with a case where the process data obtained from each sensor is determined based on knowledge and experience of an operator.

[0099]

The predetermined algorithm may be based on a mathematical expression or a mathematical model derived by selecting a plurality of sensors that affect a predetermined abnormality based on know-how, empirical rules, or the like and performing a multivariate analysis or the like on process data (which may include process data before the occurrence of an abnormality) of the plurality of sensors when the predetermined abnormality occurs. The predetermined algorithm may be an algorithm dynamically generated in accordance with a predetermined learning model obtained by machine learning, which will be described later.

[0100]

In a case where it is determined that no bursting occurs (including a case where it is determined that there is no possibility that a bursting will occur within 24 hours in the future and it is determined that there is no sign of a bursting. The same applies thereafter.), or in a case where it is determined that a bursting occurred in the past, but a prescribed measure is taken thereafter, and it is determined that no bursting occurs, for example, the character “bursting” may be displayed and a background color may be changed (for example, the background color may be changed from red to green), or the character “bursting” may be changed to non-display. Therefore, when the information “bursting” is displayed or the background color of the information “bursting” is, for example, red in the area R11, an operator of the plant 1 can easily recognize that a bursting of the plant 1 continues until a current time displayed immediately below the information “bursting” or a state in which there is a high possibility that a bursting will occur in the near future continues.

[0101]

When it is determined that a bursting occurs, a display of the information “bursting” may be emphasized by a method such as blinking, and when it is determined that no bursting occurs, a display of the information “bursting” may be weakened. When it is determined that a bursting occurs, a sound effect such as a warning sound or a voice may be output. In addition, information indicating a probability of an occurrence of an abnormality having a possibility of stopping the plant 1 may be simultaneously displayed in the area R11. For example, red may be used as the background color of the area R11 when the probability is high, and green may be used as the background color of the area R11 when the probability is low. In this manner, a level of the probability may be intuitively grasped based on a level of the color. In order to identifiably display a plurality of types of abnormalities, character information indicating a name of an occurred abnormality may be displayed. When it is determined that no abnormality occurs, character information indicating that no abnormality occurs, such as “none”, may be displayed.

[0102]

When an operator looks at the area R11, the operator can easily recognize an occurrence of an abnormality having a possibility of stopping the plant 1, such as a bursting (including a state in which there is a high possibility that a bursting will occur in the near future).

5 The abnormality having a possibility of stopping the plant 1 is not limited to a bursting. For example, an abnormal tube in which the inside of the tube is closed by a scale (inorganic substances brought into the tube by supplying water or the like) as deposition progresses inside the tube or the like of the superheater can be detected as an abnormality having a possibility of stopping the plant 1.

10 [0103]

The area R11 includes an explanatory text 62 related to the “bursting”. The explanatory text 62 includes a sensor that detected the occurrence of a bursting, a detection method of the sensor, a type of process data, a cause or a countermeasure of a bursting, an action to be taken subsequently by an operator, or the like. The explanatory text 62 may include, for example, contents for prompting an operator to select the “bursting” display in the area R11. Since the explanatory text 62 related to an abnormality display is displayed adjacent to the abnormality display, the operator can easily grasp a current state of the plant 1, an action to be taken subsequently, and the like.

[0104]

20 The lower left area R12 of the display screen DP1 displays, as “latest alarm information”, a warning display indicating the occurrence of a warning when process data related to the plant is in a predetermined state. The warning display displays a predetermined state of process data that affects the operation efficiency of the plant 1. For example, the warning display displays a state in which the process data is not data having a possibility of stopping the plant 1, such as a bursting, but data indicating a decrease in the operation efficiency of the plant 1. In the area R12, an occurrence history of the warning display is displayed in a state in which time information indicating an occurrence time of the warning display and information indicating contents of the warning display are arranged in the order of the occurrence time. For example, time information “2019/08/07 13:15:00” and information indicating contents of a warning “boiler efficiency (loss method)” are displayed in association with each other in a first row of the area R12. Based on the information displayed in the area R12, the operator of the plant 1 can recognize that a warning of the plant 1, that is, a decrease in the boiler efficiency under a heat loss method, occurs at 1:15 p.m. and zero seconds on August 7, 2019. Similarly, the operator of the plant 1 can recognize a history of the time

information indicating an occurrence time of a predetermined state of other pieces of process data that affects the operation efficiency of the plant 1 and information indicating contents of the predetermined state.

[0105]

5 An alarm in the area R12 is displayed in a case where it is determined that a warning occurs (for example, a case where it is determined that a predetermined state of the process data that affects the operation efficiency will occur within a predetermined time in the future). Similar to an abnormality of the plant 1, such as a bursting, a warning of the process data is displayed in a case where the occurrence of a warning is determined based on process data
10 obtained from a single sensor and in a case where the occurrence of a warning is determined based on process data obtained from a plurality of sensors in accordance with a predetermined algorithm (including an algorithm dynamically generated in accordance with a predetermined model obtained by machine learning). At the current time, an alarm indicating that a warning continues may be displayed, for example, in red, and an alarm indicating completion of
15 confirmation for a warning may be displayed, for example, in black.

[0106]

When one item displayed in a list in the area R12 is selected by an operator, display screens DP5a to DP5d are displayed by the guide display function 50. Details of the display function and the display screens will be described later (see FIGS. 10 to 13).

[0107]

20 According to the areas R11 and R12 of the display screen DP1, the system 30 has a function of simultaneously displaying a serious abnormality having a possibility of stopping the plant 1 and a warning affecting the operation efficiency of the plant 1 in different areas and in different modes. Therefore, an operator can easily recognize both a serious abnormality having a possibility of stopping the plant 1 and a warning affecting the operation efficiency.
25 For a serious abnormality having a possibility of stopping the plant 1, whether such an abnormality occurs at the current time is displayed, and for a warning affecting the operation efficiency, an occurrence history of a warning is displayed. Therefore, an operator can easily recognize whether a serious abnormality occurs at the current time by looking at the area R11.
30 When the operator looks at the area R12, the operator can easily recognize whether a warning affecting an operation efficiency occurs for a plurality of times. With regard to the warning affecting the operation efficiency, since time information indicating an occurrence time of the warning and information indicating contents of the warning are displayed in a state of being arranged in the order of the occurrence time, it is possible to easily grasp an occurrence

frequency of the warning that affects the operation efficiency and contents of various warnings (including abnormalities that occur in components other than the boiler) that affect the operation efficiency. The area R11 may not display a history of a warning affecting the operation efficiency of the plant 1 and a history of a serious abnormality having a possibility of stopping the plant 1. In general, an operator needs to monitor an extremely large number of events and parameters in order to appropriately operate a plant including the plant 1. Therefore, it is preferable to display information in a manner of efficiently and quickly transmitting information having a high degree of importance to the operator and not transmitting information having a low degree of importance. With a configuration in which information having a low degree of importance is not displayed, an operator can easily recognize whether a serious abnormality occurs at the current time by looking at the area R11. [0108]

The area R13 is provided in a space between the area R11 and the area R12 at the center of the left side of the display screen DP1. The area R13 displays a plurality of components configuring the plant 1 as “device and component specific” information. A component having a possibility of causing a warning that affects the operation efficiency is displayed in a different mode from the other components. [0109]

Specifically, a “plant”, a “boiler”, a “turbine”, a “generator”, and an “auxiliary machine” are displayed as components of the plant 1. The “boiler” corresponds to a component configuring a boiler such as the furnace 2. The “turbine” corresponds to a component configuring a turbine such as the turbine 100. The “auxiliary machine” corresponds to a component that is not a main component such as a boiler, such as the pump 7 and the pump 7a. In addition, a component that configures the plant 1 and has a possibility of causing a warning, such as a “generator”, may be set as an appropriate component. The process data that causes a warning affecting the operation efficiency is specified, and based on the process data, a component (for example, the “boiler” and the “generator”) in which a warning occurs at the current time is displayed in, for example, a red background color, a component (for example, the “plant” and the “turbine”) in which no warning occurs is displayed in, for example, a green background color, and a component (for example, the “auxiliary machine”) in which no evaluation item is set is displayed in gray. Further, an alarm indicating that a warning continues may be displayed in red in the area R12, and a component corresponding to the alarm may be displayed in a red background color in the area R13. In

this manner, a component that causes a warning affecting the operation efficiency can be easily specified.

[0110]

When an operator looks at the area R13, the operator can easily recognize a component having a possibility of causing a warning that affects the operation efficiency among components configuring the plant 1. When an operator looks at the area R12 and the area R13, the operator can specify a component in which a warning continues at the current time even though the warning occurs for a plurality of times based on the area R12. Even though an operator cannot estimate a component having a possibility of causing a warning that affects the operation efficiency only based on the area R12, the operator can recognize such a component by looking at the area R13.

[0111]

The lower right area R15 of the display screen DP1 displays an occurrence history of an abnormality in a mode in which the number of times that data obtained by a sensor indicates an abnormal value is arranged for each sensor. Specifically, a Pareto diagram in which the number of abnormalities determined by the DCS 20 within a predetermined time, for example, within the past 24 hours, is totalized for each sensor and is arranged in descending order is shown as “DCS alarm totalization” information. An “alarm 1”, an “alarm 2”, and the like in FIG. 6 may be configured to display identification information of a specific sensor. For example, identification information of an AE sensor provided at a specific position may be displayed as the alarm 1. An item name detected by a specific sensor may be displayed as the alarm 1. For example, information for identifying the makeup water flow rate u1 may be displayed as the alarm 1.

[0112]

The DCS 20 is configured to compare process data obtained from a single sensor with a predetermined threshold and determine that an abnormality occurs when the process data indicates an abnormal value exceeding the threshold. It should be noted that the DCS 20 is not configured to determine whether there is an abnormality based on process data obtained from a plurality of sensors in accordance with a predetermined algorithm.

[0113]

When an operator looks at the area R15, the operator can recognize an item having a high risk of developing into a failure because a frequency of an abnormality is high.

[0114]

The operator can estimate information related to a cause of an abnormality affecting the operation efficiency by comparing the “latest alarm information” displayed in the area R12 or the information displayed in the area R11 with the “DCS alarm totalization” displayed in the area R15. For example, in a case where “bursting” is displayed in the area R1, when a predetermined sensor that is installed in the boiler and affects a bursting indicates a plurality of abnormalities in the area R15, it is possible to estimate that an abnormality causing the bursting occurs in the vicinity of the sensor. In a case where a warning of “SH heat absorption amount” occurs for a plurality of times in the area R12, when a predetermined sensor that is installed in the furnace and affects the operation efficiency indicates a plurality of abnormalities in the area R15, it is possible to estimate that an abnormality causing a decrease in the operation efficiency occurs in the vicinity of the sensor.

[0115]

The upper right area R14 of the display screen DP1 displays information indicating operation performance of the plant 1. For example, the area R14 displays one or a plurality of trend graphs in which a vertical axis represents an index important for a stable operation and a horizontal axis represents time. In FIG. 6, for example, four trend graphs of “boiler efficiency (loss method) [%-LHV]”, “power generation end efficiency [%]” (an example of “information indicating the operation efficiency”), “generator power [MW]”, and “transmission power [MW]” are shown. An index displayed in the area R14 can be freely selected by an operator.

[0116]

Accordingly, when information for operating the plant 1 is displayed in a limited area of the display screen DP1, among various abnormalities that may occur in the plant 1, an abnormality having a possibility of stopping the plant 1 is displayed in the area R11 that is an area independent of areas for displaying other abnormalities, and a warning affecting the operation efficiency of the plant 1 is displayed in the area R12 different from the area R11. With regard to the operation efficiency, since the occurrence history is displayed, it is possible to grasp an overall tendency of the operation efficiency. The operator can easily recognize whether an abnormality having a possibility of stopping the plant occurs and whether a warning affecting the operation efficiency occurs. Since the number of times that data obtained by each sensor indicates an abnormal value is displayed for each sensor in the area R15, it is possible to estimate a cause of the abnormality having a possibility of stopping the plant and the warning affecting the operation efficiency. According to the information displayed in the

area R14, it is possible to easily recognize a component having a possibility of causing a warning that affects the operation efficiency.

[0117]

The evaluation item display 60 is displayed, for example, below the area R12, and is displayed as an “evaluation item list” for prompting an operator to confirm a plurality of evaluation item lists. The evaluation item display 60 prompts an operator to confirm an evaluation item for evaluating a state of the plant, and when the evaluation item display 60 is selected by the operator on the display screen DP1, the evaluation item display function 52 displays an evaluation item display screen DP6 for evaluating the state of the plant. Details of the display function and the display screen will be described later (see FIG. 14).

[0118]

Returning to the flowchart shown in FIG. 5, the abnormality display function 42 receives the selection of the abnormality display from the operator (S11). For example, when the operator selects the abnormality display “bursting” displayed in the area R11 of the display screen DP1 shown in FIG. 6, the abnormality detailed display function 44 displays details of the abnormality (S12).

[0119]

Here, an example of a display screen DP2 displayed by the abnormality detailed display function 44 will be described with reference to FIG. 7. The display screen DP2 includes areas R20 to R24, a screen update display 72, an abnormality confirmation display 74, and an abnormality history display 76.

[0120]

The area R20 displays a “plant operation support system” as a name of the system 30, and “bursting details” as a status of a current screen. According to the display in the area R20, it is possible to easily grasp a status indicating that the current screen belongs to which system.

[0121]

The area R21 at the right side of the display screen DP2 displays image information indicating positions of tubes in the entire plant 1 and positions of sensors provided in the tubes (denoted by “circled numbers 1 to 7” in FIG. 7 and denoted by numbers “(1) to (7)” in the present specification). The positions of the tubes in the entire plant 1 in the area R21 correspond to those in the plant 1 shown in FIG. 1. In the present embodiment, positions of three tubes configuring the superheater 10 of the plant 1 and positions of three AE sensors (sensors (1), (2), and (3)) respectively provided in the three tubes in the entire plant 1, and positions of two tubes configuring the economizer 12 and positions of two AE sensors (sensors

(4) and (5)) respectively provided in the two tubes in the entire plant 1 are displayed in the area R21 of the display screen DP2. In the present embodiment, positions of the furnace wall tube 6 adjacent to the furnace 2 of the plant 1 and positions of AE sensors (sensors (6) and (7)) respectively provided in an upper portion and a lower portion of the furnace wall tube 6 in the entire plant 1 are also displayed in the area R21 of the display screen DP2. These tubes (the tubes of the superheater 10, the tubes of the economizer 12, and the furnace wall tube 6) and the AE sensors (1) to (7) corresponding to the tubes are examples, and other tubes and AE sensors can also be displayed in the area R21. In addition, the AE sensor is provided in a furnace wall tube or on a metal surface connected to the tube, and is provided in a metal structure capable of transmitting generated elastic waves without impairing characteristics of the generated elastic waves.

[0122]

The area R21 is configured to display a state of a tube detected by an AE sensor in a prescribed mode. For example, in a case where it is determined that a bursting occurs in a corresponding tube (a tube of the superheater 10) since process data (an AE parameter extracted by performing a signal processing on an AE signal (waveform)) obtained from a specific AE sensor (for example, the sensor (1)) among the AE sensors (1) to (7) displayed in the area R21 indicates an abnormal value exceeding a predetermined threshold, the abnormality detailed display function 44 displays the specific AE sensor (the sensor (1)) by blinking, or displays the specific AE sensor (the sensor (1)) in a color different from colors of the other AE sensors (the sensors (2) to (7)).

[0123]

The abnormality detailed display function 44 displays, in a time series manner, determination information used when a state of a tube is determined in accordance with a predetermined algorithm based on the process data related to the plant 1 (operation data of the plant 1) in the area R22 of the display screen DP2. In the present embodiment, process data different from process data (an AE parameter extracted by performing a signal processing on an AE signal (waveform)) obtained by the AE sensors (the sensors (1) to (7)) is processed in accordance with a predetermined algorithm to calculate a bursting occurrence possibility (an abnormality degree) and calculate a level of reliability (a reliability degree) of the process data and the algorithm used for the calculation. The abnormality degree and the reliability degree are examples of the determination information. The abnormality detailed display function 44 displays a time chart in which both the abnormality degree and the reliability degree are shown in vertical axes and most recent 24 hours are shown in a horizontal axis at an upper side of the

area R22 of the display screen DP2. At the upper side of the area R22 shown in FIG. 7, a broken line indicates a time chart of the abnormality degree, and a solid line indicates a time chart of the reliability degree. An operator can specify a time zone in which a bursting may occur by visually recognizing the time charts of both the abnormality degree and the reliability degree. For example, in the example shown in FIG. 7, the operator can determine that a bursting may occur after 11:00 during which both the abnormality degree and the reliability degree have high values.

[0124]

As shown in FIG. 7, the abnormality detailed display function 44 displays, at a lower side of the area R22, a time chart of two types of parameters α and β (feature amount data affecting the determination of the abnormality degree and the reliability degree) having correlations with the abnormality degree and the reliability degree. The parameters α and β are examples of the determination information. In FIG. 7, a dashed line shows a time chart of the parameter α having a correlation with the abnormality degree, and a two-dot chain line shows a time chart of the parameter β having a correlation with the reliability degree. An operator visually recognizes the time chart of the abnormality degree and the reliability degree displayed at the upper side of the area R22 and the time chart of the two types of parameters α and β arranged at the lower side of the area R22, thereby performing a comprehensive determination regarding the occurrence of a bursting. The parameters α and β are derived from, for example, a calculation formula in a process leading to the calculation of the abnormality degree and the reliability degree, and accordingly, the parameters α and β may be used to check accuracy of the abnormality degree and the reliability degree. Although there is one graph having a correlation with the determination information in the example shown in FIG. 7, a plurality of graphs may be displayed.

[0125]

The abnormality detailed display function 44 is configured to display both a detection result of a state of a tube detected by an AE sensor and a determination result of the state of the tube determined based on process data different from the process data (an AE parameter extracted by performing a signal processing on an AE signal (waveform)) obtained by the AE sensor in the same format in the area R23 of the display screen DP2. The abnormality detailed display function 44 according to the present embodiment displays the detection result of the AE sensor in the most recent 24 hours regarding whether a bursting occurs in the tube in time series using a horizontally long bar chart at an upper side of the area R23 (displayed as an “AE method”). The abnormality detailed display function 44 displays the determination result

based on the process data and the algorithm in the most recent 24 hours regarding whether a bursting occurs in the tube in time series using a horizontally long bar chart at a lower side of the area R23 (displayed as “logic”). That is, in the present embodiment, both the detection result obtained by the AE method and the determination result obtained by logic are displayed in time series using a bar chart of the same format. In the present embodiment, a time axis in each time chart displayed in the area R22 and a time axis in each bar chart displayed in the area R23 are displayed in conjunction with each other.

[0126]

In each bar chart, a hatched area with “horizontal lines” indicates a time zone in which it is determined (detected) that a bursting occurs and an operator has already confirmed the fact, and a white area in which an exclamation mark is displayed indicates a time zone in which it is determined (detected) that a bursting occurs and the operator has not yet confirmed the fact. On the other hand, a hatched area with “right-upward diagonal lines” indicates a time zone in which it is determined (detected) that no bursting occurs and the operator has not yet confirmed the fact, and a hatched area of “black” indicates a time zone in which it is determined (detected) that no bursting occurs and the operator has already confirmed the fact. The operator visually recognizes both bar charts, and can determine that there is a high possibility that a bursting occurs in mainly time zones (for example, around 14:00, around 8:00, or the like) during which white areas in which exclamation marks are displayed overlap each other.

[0127]

The operator can grasp a specific AE sensor (for example, the sensor (1)) corresponding to a tube in which a bursting occurs at the current time according to the display in the area R21 of the display screen DP2, and can grasp a time history of a bursting occurrence according to the display in the area R23 of the display screen DP2. Therefore, the operator can grasp how much time has elapsed after a bursting occurs in the tube corresponding to the specific AE sensor (for example, the sensor (1)) by visually recognizing both the area R21 and the area 23.

[0128]

In the example shown in the present embodiment, both of the determination results of the AE method and the logic method indicate that a bursting occurs at the current time “14:00”, and thus the abnormality display function 42 displays an abnormality display indicating the occurrence of the bursting in the area R11 of the previous display screen DP1. In this case, the explanatory text 62 in the area R11 of the display screen DP1 may display that both of the determination results of the AE method and the logic method indicate the occurrence of a

bursting. The abnormality display displayed by the abnormality display function 42 is not limited to be displayed in a case where both the AE method and the logic method indicate the occurrence of a bursting, and may be displayed in a case one of the AE method and the logic method indicates the occurrence of a bursting. In this case, the explanatory text 62 in the area R11 of the display screen DP1 may display whether a method of determining the occurrence of the bursting is the AE method or the logic method.

[0129]

In the area R24 of the display screen DP2, an explanatory text 70 related to a “bursting” is displayed. The explanatory text 70 on the display screen DP2 may indicate contents of an abnormality in more details than the explanatory text 62 on the previous display screen DP1. For example, when the occurrence of a bursting is detected by the AE method, the explanatory text 70 may indicate a specific AE sensor that is the basis of an abnormality display indicating the occurrence of the bursting, and may include contents for prompting an operator to confirm data of the specific AE sensor. As described above, since the explanatory text 70 related to an abnormality display is displayed on the display screen DP2 showing details of the abnormality display, the operator can easily grasp a current state of the plant 1, an action to be taken subsequently, and the like, from a more detailed viewpoint than that on the display screen DP1.

[0130]

When the screen update display 72 is selected by an operator on the display screen DP2, display contents of the display screen DP2 is updated. In this manner, the operator can grasp contents of the latest display screen DP2 without transitioning to a different display such as the display screen DP1.

[0131]

When the bursting confirmation display 74 is selected by the operator on the display screen DP2, the system 30 determines that the occurrence of the bursting is confirmed by the operator, and when the display screen DP2 is returned to the display screen DP1 shown in FIG. 6, the system 30 can display the abnormality display indicating the occurrence of the bursting having a possibility of stopping the plant 1 in a different mode. In this case, for example, the character “bursting” may not be displayed, or a highlighted display of “bursting” may be weakened on the display screen DP1. In addition, a sound effect such as a warning sound or a voice accompanying with the abnormality display may be stopped.

[0132]

When the operator selects the bursting history display 76 on the display screen DP2, a display screen DP4 is displayed by the abnormality history display function 48. Details of the display function and the display screen will be described later (see FIG. 9).

[0133]

Returning to the flowchart shown in FIG. 5, the abnormality detailed display function 44 receives a selection from the operator for the display of the abnormal state of the tube corresponding to the specific AE sensor (the sensor (1)) indicating an abnormal value in the area R21 of the display screen DP2 (S13). For example, when the display of a specific AE sensor (for example, the sensor (1)) among the AE sensors ((1) to (7)) displayed in the area R21 on the display screen DP2 is selected by the operator, the sensor data detailed display function 46 displays data of the specific AE sensor (for example, the sensor (1)) which is the basis of the abnormal state indicating the occurrence of a bursting (S14).

[0134]

Here, an example of a display screen DP3 displayed by the sensor data detailed display function 46 will be described with reference to FIG. 8. The display screen DP3 includes areas R30 to R34.

[0135]

In the area R30, “bursting details” is displayed as a status of the current screen. According to the display in the area R30, it is possible to easily grasp which status the current screen is.

[0136]

The area R31 at an upper side of the display screen DP3 receives an input of date and time, a sensor number, and a Y axis adjustment. In the area R32 at a lower side of the display screen DP3, the sensor data detailed display function 46 displays data of a specific AE sensor (for example, the sensor (1)) that is a basis of an abnormal state indicating the occurrence of a bursting in time series. In the example shown in FIG. 8, the area R32 of the display screen DP3 displays a time chart in which process data (an AE parameter extracted by performing a signal processing on an AE signal (waveform)) detected by a specific AE sensor (the sensor (1)) is shown on a vertical axis and the most recent 24 hours are shown on a horizontal axis. When a bursting occurs, a large amount of energy (elastic waves) is emitted as compared with a normal operation. Therefore, for example, an operator can visually recognize the time-series graph displayed in the area R32 of the display screen DP3 and determine that a bursting occurs in a time zone in which the AE parameter has a maximum value. When the operator inputs the date and time, the sensor number, and the Y axis adjustment in the area R31, the date

and time and the sensor number of a target graph can be displayed or changed in the area R32, and Y axis scaling of specific sensor data can be adjusted. In this manner, the operator can easily and quickly analyze sensor data.

[0137]

5 An explanatory text 80 related to “bursting” is displayed in a space between the area R30 and the area R31 of the display screen DP3. The explanatory text 80 on the display screen DP3 may indicate contents of an abnormality in more detail than the explanatory text 70 on the previous display screen DP2. For example, the explanatory text 80 may display contents such as a tendency of data of a specific AE sensor that is a basis of an abnormality display indicating the occurrence of a bursting, an analysis on the data, a countermeasure, and the like. As described above, since the explanatory text 80 related to an abnormality display is displayed on the display screen DP3 showing data of a sensor which is a basis of the abnormality display, the operator can easily grasp a current state of the plant 1, an action to be taken subsequently, and the like, from a more detailed viewpoint than that on the display screen DP2.

[0138]

The display screen DP3 can be displayed by the display unit 30f at the same time as the display screen DP2. As a result, the operator can simultaneously grasp the bursting details and the sensor data that is a basis of the bursting details.

[0139]

20 According to the display screens DP2 and DP3, the image information indicating a position of a tube in the entire plant 1 and a position of an AE sensor provided in the tube can be displayed in the area R21 of the display screen DP2, and the AE sensor (for example, the sensor (1)) corresponding to the tube in which a bursting occurs can be displayed in a prescribed mode (for example, blinking or coloring). In addition, the determination information used when a state of the tube is determined according to a predetermined algorithm can be displayed in time series in the area R22 of the display screen DP2. Therefore, the operator who visually recognizes the display screen DP2 of the system 30 can grasp the position of the tube and the position of the AE sensor in the entire plant 1, and in addition, the operator can grasp the state of the tube determined or detected by different methods (both using an AE sensor and according to an algorithm). That is, since the operator can efficiently grasp important information necessary for monitoring the tube by, for example, visually recognizing a single screen (the display screen DP2), the operator can make a comprehensive determination. For example, (i) when the occurrence of a bursting is detected and determined using both the AE sensor (the

area R21) and the algorithm (the area R22), the operator determines that there is a high possibility that a bursting occurs in a specific tube in the plant 1, and selects an AE sensor that detected the occurrence of the bursting in the area R21, thereby confirming a time history of a sound pressure level of the AE sensor in the area R32 of the third screen DP3 (FIG. 8) and specifying in which time zone the bursting occurs. (ii) When the occurrence of a bursting is detected using the AE sensor (the area R21) and the occurrence of a bursting is not determined using the algorithm (the area R22), the operator determines that there is a possibility that a bursting occurs in a tube in the plant 1, and selects an AE sensor that detected the occurrence of the bursting in the area R21, thereby confirming a time history of a sound pressure level of the AE sensor in the area R32 of the third screen DP3 (FIG. 8) and confirming the determination information (the abnormality degree and the reliability degree) in the area R22, so that the operator can determine the certainty of the bursting. (iii) When the occurrence of a bursting is not detected using the AE sensor (the area R21) and the occurrence of a bursting is determined using the algorithm (the area R22), the operator can determine that there is a possibility that a bursting occurs in a tube in the plant 1, and can determine the certainty of the bursting based on the determination information in the area R22 (the abnormality degree and the reliability degree, and the two types of parameters α and β having respective correlations with the abnormality degree and the reliability). Therefore, the system 30 can contribute to a stable operation of the plant 1.

[0140]

In the system 30, both the detection result of the state of the tube detected by the AE sensor and the determination result of the state of the tube determined based on the predetermined algorithm can be displayed in the same format (a bar chart format) in the area R23 of the display screen DP2. Therefore, the operator can visually recognize and grasp tube state determination (detection) results obtained using different methods in the same format, and can make a comprehensive determination.

[0141]

In the system 30, the detection information detected by the specific sensor (for example, the sensor (1)) selected from the AE sensors displayed in the area R21 of the display screen DP2 can be displayed in time series in the area R32 of the display screen DP3 that is transitioned from the display screen DP2 having the area R21 and the like. Therefore, there is an advantage in that the detection information can be enlarged and displayed in the area R32 of the display screen DP3 that is different from the display screen DP2 having the area R21 and the like, and a time history and the like of the detection information can be grasped in detail.

[0142]

As described above, although a transition from the login display function 40 to the abnormality display function 42, a transition from the abnormality display function 42 to the abnormality detailed display function 44, and a transition from the abnormality detailed display function 44 to the sensor data detailed display function 46 have been described as transitions of the functional blocks in FIG. 4 with reference to the flowchart in FIG. 5, transitions of the functional blocks are not limited thereto. Hereinafter, a transition to another functional block shown in FIG. 4 will be described with reference to FIGS. 9 to 14.

[0143]

FIG. 9 shows an example of the display screen DP4 displayed by the abnormality history display function 48. The display screen DP4 is a screen displayed when the operator selects the bursting history display 76 on the display screen DP2. The display screen DP4 includes areas R40 to R43.

[0144]

The area R40 displays information indicating a status of the current screen and a screen transition to the current screen. In FIG. 9, “dashboard > bursting details” is displayed, and it is possible to grasp that the current display screen DP4 is transitioned in the order of the display screen DP1 (the dashboard) and the display screen DP2 (the bursting details).

[0145]

The area R41 receives an input of an occurrence date and time at which it is determined that an abnormality occurs, a type of a determination (the AE method or the logic method), whether a correct or incorrect determination is completed, and a maximum display number. When the operator selects a search display after inputting each item in the area R41, a search result is displayed in the area R43.

[0146]

The area R42 receives an input of a correct or incorrect determination (confirmed alarm, false alarm, alarm failure) and a comment as an actual result of an abnormality. In the area R42, an occurrence date and time and a resolve date and time can be input as alarm failure for the occurrence of an abnormality such as a bursting that cannot be detected by the system

[0147]

A detection result according to settings in the area R41 is displayed in the area R43. Specifically, the area R43 displays a desired search result according to the occurrence date and time or the resolve date and time of the abnormality, a type of the abnormality, the sensor

number of the sensor that detected the abnormality, whether a correct or incorrect determination is completed, and the like. As a result, the operator can easily grasp an occurrence history of the abnormality.

[0148]

FIGS. 10 to 13 show examples of display screens displayed by the guide display function 50. Display screens DP5a to DP5d are screens displayed when an operator selects any one of the items listed in the area R12 on the display screen DP1.

[0149]

FIG. 10 shows a first example of a display screen displayed by the guide display function 50. The display screen DP5a is displayed after transitioning from the display screen DP1 in response to the selection of a warning display in the area R12 of the display screen DP1. The display screen DP5a includes an area R51a and an area R52a. The system 30 can confirm an outline of the state of the plant 1 through a plurality of pieces of process data on the display screen DP1, and can confirm the state of the plant 1 in detail through specific process data on the display screen DP2. When display contents on the display screen DP2 are confirmed and the display screen DP2 transitions to the display screen DP1, it is indicated that a corresponding alarm in the “latest alarm information” has been confirmed. The fact that a corresponding alarm has been confirmed is indicated by, for example, changing a character originally displayed in red to a character in black. When a transition button indicated by “1/10” in a lower portion of the display screen DP5a is pressed, another graph related to the selected alarm is displayed.

[0150]

In the case of the present example, the area R51a includes a first graph (a scatter diagram) of a “boiler efficiency (a loss method) (%)” and a “boiler load (%)”, and a second graph showing a temporal change of the “boiler efficiency (a loss method) (%)”. A graph of second process data (the boiler load in the present example) related to first process data (the boiler efficiency (a loss method) in the present example) can be displayed in the area R51a. In this manner, it is possible to monitor the state of the plant from various angles by displaying not only a graph of the first process data but also a graph of the related second process data. In the first graph, a threshold for determining whether to issue an alarm may be displayed. In the second graph, a threshold for determining whether to issue an alarm may be displayed, or a time at which a cause of the alarm occurs may be displayed. The number of graphs of the second process data related to the first process data is not limited to one, and two or more graphs may be displayed. In the case of the present example, another graph of the second

process data is displayed by pressing the transition button indicated by “1/10” in the lower portion of the display screen DP5a. The same applies to other display screens shown in FIGS. 11 to 13 which will be described later.

[0151]

5 The guide display function 50 is configured to display a second graph of the first process data different from the first graph in the area R51a. A first graph (a scatter diagram) of the “boiler efficiency (a loss method) (%)” serving as the first process data and a second graph showing a temporal change of the “boiler efficiency (a loss method) (%)” are shown, and a plurality of types of graphs of the first process data are displayed, so that the state of the plant
10 1 can be monitored from various angles. The guide display function 50 may display three or more graphs related to the first process data.

[0152]

The guide display function 50 is configured to display an explanatory text related to the first process data in the area R52a adjacent to the area R51a on the display screen. In the
15 case of the present example, a guide name is “boiler efficiency”, content is “boiler efficiency (a heat input and output method)”, occurrence date and time is “2019/08/07 10:35:24”, and an article describing a method of capturing an event from a graph and having a title of “1. Monitoring point (how to read graph)” and an article describing a method of optimizing a state of the first process data and having a title of “2. Solution” are described in a solution filed.
20 The method for optimizing the state of the first process data is a method of optimizing a state in which the process data of interest exceeds a threshold and setting the process data within the threshold.

[0153]

“1. Monitoring point (how to read graph)” describes a definition of the boiler
25 efficiency (a loss method) and a calculation formula. With such an explanatory text, it is possible to confirm a method of capturing an event from a graph, and it is easy to understand what kind of event occurs.

[0154]

“2. Solution” lists items to be checked when the boiler efficiency (a loss method) is in
30 a state different from that in a normal state. With such an explanatory text, it is possible to confirm a method of optimizing the state of the first process data, and it is easy to understand what kind of countermeasure is required.

[0155]

FIG. 11 shows a second example of a display screen displayed by the guide display function 50. The display screen DP5b is displayed after transitioning from the display screen DP1 in response to the selection of a warning display in the area R12 of the display screen DP1. The display screen DP5b includes an area R51b and an area R52b.

[0156]

In the case of the present example, the area R51b includes a first graph (a scatter diagram) of an “evaporation factor (-)” and a “boiler load (%)”, and a second graph showing a temporal change of the “boiler efficiency (a loss method) [%-LHV]”. As described above, a graph of second process data (the boiler efficiency (a loss method) in the present example) related to first process data (the evaporation factor in the present example) can be displayed in the area R51b. In this manner, it is possible to monitor the state of the plant from various angles by displaying not only a graph of the first process data but also a graph of the related second process data.

[0157]

The guide display function 50 is configured to display an explanatory text related to the first process data in the area R52b adjacent to the area R51b on the display screen. In the case of the present example, a guide name is “boiler efficiency”, content is “boiler efficiency (a heat input and output method)”, occurrence date and time is “2019/08/07 10:35:24”, and an article describing a method of capturing an event from a graph and having a title of “1. Monitoring point (how to read graph)” and an article describing a method of optimizing a state of the first process data and having a title of “2. Solution” are described in a solution filed.

[0158]

“1. Monitoring point (how to read graph)” describes a definition of the evaporation factor and a calculation formula. With such an explanatory text, it is possible to confirm a method of capturing an event from a graph, and it is easy to understand what kind of event occurs.

[0159]

“2. Solution” lists items to be checked when the evaporation factor is in a state different from that in a normal state. With such an explanatory text, it is possible to confirm a method of optimizing the state of the first process data, and it is easy to understand what kind of countermeasure is required.

[0160]

FIG. 12 shows a third example of a display screen displayed by the guide display function 50. The display screen DP5c is displayed after transitioning from the display screen

DP1 in response to the selection of a warning display in the area R12 of the display screen DP1. The display screen DP5c includes an area R51c and an area R52c.

[0161]

In the case of the present example, the area R51c includes a first graph (a scatter diagram) of a “turbine steam consumption rate (kg/kWh)” and a “power generation amount (MW)”, and a second graph showing a temporal change of the “turbine steam consumption rate (kg/kWh)”. As described above, a graph of second process data (the power generation amount in the present example) related to first process data (the turbine steam consumption rate in the present example) can be displayed in the area R51c. In this manner, it is possible to monitor the state of the plant from various angles by displaying not only a graph of the first process data but also a graph of the related second process data.

[0162]

The guide display function 50 is configured to display a second graph of the first process data different from the first graph in the area R51c. A first graph (a scatter diagram) of the “turbine steam consumption rate (kg/kWh)” serving as the first process data and a second graph showing a temporal change of the “turbine steam consumption rate (kg/kWh)” are shown, and a plurality of types of graphs of the first process data are displayed, so that the state of the plant 1 can be monitored from various angles.

[0163]

The guide display function 50 is configured to display an explanatory text related to the first process data in the area R52c adjacent to the area R51c on the display screen. In the case of the present example, a guide name is “boiler efficiency”, content is “boiler efficiency (a heat input and output method)”, occurrence date and time is “2019/08/07 10:35:24”, and an article describing a method of capturing an event from a graph and having a title of “1. Monitoring point (how to read graph)” and an article describing a method of optimizing a state of the first process data and having a title of “2. Solution” are described in a solution filed.

[0164]

“1. Monitoring point (how to read graph)” describes a definition of the steam consumption rate and a calculation formula. With such an explanatory text, it is possible to confirm a method of capturing an event from a graph, and it is easy to understand what kind of event occurs.

[0165]

“2. Solution” lists items to be checked when the steam consumption rate is in a state different from that in a normal state. With such an explanatory text, it is possible to confirm

a method of optimizing the state of the first process data, and it is easy to understand what kind of countermeasure is required.

[0166]

FIG. 13 shows a fourth example of a display screen displayed by the guide display function 50. The display screen DP5d is displayed after transitioning from the display screen DP1 in response to the selection of a warning display in the area R12 of the display screen DP1. The display screen DP5d includes an area R51d and an area R52d.

[0167]

In the case of the present example, the area R51d includes a first graph (a scatter diagram) of a “steam consumption rate (fuel-supply based) (kg/kWh)” and a “power generation amount (MW)”, and a second graph showing a temporal change of the “steam consumption rate (fuel-supply based) (kg/kWh)”. As described above, a graph of second process data (the power generation amount in the present example) related to first process data (the steam consumption rate (fuel-supply based) in the present example) can be displayed in the area R51d. In this manner, it is possible to monitor the state of the plant from various angles by displaying not only a graph of the first process data but also a graph of the related second process data.

[0168]

The guide display function 50 is configured to display a second graph of the first process data different from the first graph in the area R51d. A first graph (a scatter diagram) of the “steam consumption rate (fuel-supply based)” serving as the first process data and a second graph showing a temporal change of the “steam consumption rate (fuel-supply based) (kg/kWh)” are shown, and a plurality of types of graphs of the first process data are displayed, so that the state of the plant 1 can be monitored from various angles.

[0169]

The guide display function 50 is configured to display an explanatory text related to the first process data in the area R52d adjacent to the area R51d on the display screen. In the case of the present example, a guide name is “boiler efficiency”, content is “boiler efficiency (a heat input and output method)”, occurrence date and time is “2019/08/07 10:35:24”, and an article describing a method of capturing an event from a graph and having a title of “1. Monitoring point (how to read graph)” and an article describing a method of optimizing a state of the first process data and having a title of “2. Solution” are described in a solution filed.

[0170]

“1. Monitoring point (how to read graph)” describes a definition of the heat consumption rate and a calculation formula. With such an explanatory text, it is possible to

confirm a method of capturing an event from a graph, and it is easy to understand what kind of event occurs.

[0171]

“2. Solution” lists items to be checked when the heat consumption rate is in a state different from that in a normal state. With such an explanatory text, it is possible to confirm a method of optimizing the state of the first process data, and it is easy to understand what kind of countermeasure is required.

[0172]

The areas R50a to R50d shown in FIGS. 9 to 13 display information indicating a status of the current screen and a screen transition to the current screen. Specifically, “dashboard > guide display” is displayed in the areas R50a to R50d, and it is possible to grasp that the current display screen is transitioned from the display screen DP1 (the dashboard).

[0173]

Since the guide display function 50 shown in FIGS. 9 to 13 displays the graph of the first process data in a first area of the display screen and displays an explanatory text related to the first process data in an adjacent second area, it is easy for an operator to understand what kind of event occurs and it is easy for an operator to understand what kind of countermeasure is required.

[0174]

The explanatory text displayed by the guide display function 50 may include an image, a legend graph, and the like in addition to character information, a mathematical expression, and the like. Further, the explanatory text displayed by the guide display function 50 may have a function of displaying a time at which a warning of the same process occurred in the past. By adding these pieces of information, it is possible to further enhance understanding for an operator.

[0175]

The graph of the first process data displayed in the first area of the display screen can show 12 hours before and after an occurrence time of a warning in time series. As a result, it is possible to easily grasp a change in the process data before and after the occurrence time.

[0176]

In particular, in a plant, when there are a large number of events and parameters to be monitored and a change occurs in the state of the plant, it is required to efficiently and quickly notify an operator of the change. In this regard, the guide display function 50 of the system 30 according to the present embodiment displays not only a graph of the first process data but

also a graph of the related second process data, so that it is possible to efficiently grasp the change in the state of the plant, and the guide display function 50 displays the explanatory text, so that it is possible to confirm a method of optimizing the state of the plant, and it is possible to quickly grasp what kind of countermeasure is required.

5 [0177]

FIG. 14 shows an example of a display screen DP6 displayed by the evaluation item display function 52. The display screen DP6 is a screen displayed when an operator selects the evaluation item display 60 on the display screen DP1. The display screen DP6 includes areas R60 and R61.

10 [0178]

The area R60 displays information indicating a status of the current screen and a screen transition to the current screen. Specifically, “dashboard > evaluation item list” is displayed in the area R60, and it is possible to grasp that the current display screen is transitioned from the display screen DP1 (the dashboard).

15 [0179]

Evaluation items for evaluating the state of the plant 1 are displayed in the area R61. Specifically, an ID, a major classification, a middle classification, a minor classification, and an evaluation item name of an evaluation item are displayed in the area R61. Accordingly, even in a situation in which there is no abnormality display or alarm display, it is possible to grasp an evaluation item for the system 30 to evaluate the state of the plant 1. When any one of the evaluation items displayed in the area R61 is selected by an operator, the guide display function 50 may transition the display screen to the display screens DP5a to DP5d as shown in FIGS. 9 to 13. In this case, for example, a graph of the most recent 24 hours from a current time may be displayed as a graph of process data displayed by the guide display function 50.

20 [0180]

As described above, according to the present embodiment, when an abnormality occurs in the plant 1, since a state of the plant 1 that should be grasped by an operator can be displayed in a stepwise and sequential manner, the state of the plant can be easily shown to the operator. In particular, in a plant, when there are a large number of events and parameters to be monitored and a change occurs in the state of the plant, it is required to efficiently and quickly notify an operator of the change. According to the system and the method in the present embodiment, it is possible to confirm a method of optimizing the state of the plant, and it is possible to quickly grasp what kind of countermeasure is required.

25 [0181]

Aspects described through the embodiment of the present invention can be appropriately combined, modified, or improved depending on usage, and the present invention is not limited to matters described in the above-described embodiment. It is apparent from the description of the claims that such combinations, modifications, or improvements are also included in the technical scope of the present invention.

REFERENCE SIGNS LIST

[0182]

1...Plant, 30...System, 42...Abnormality display function, 44...Abnormality detailed display function

46...Sensor data detailed display function, 48...Abnormality history display function, 50...Guide display function

52...Evaluation item display function

CLAIMS

1. A system for displaying a state of a plant, comprising:

5 a first display function including displaying an abnormality display indicating an occurrence of an abnormality having a possibility of stopping the plant and prompting an operator to confirm the abnormality;

10 a second display function including displaying image information indicating a position of a tube in an entire plant and a position of a sensor provided in the tube and indicating an abnormal state of the tube detected by the sensor in a prescribed mode when the abnormality display is selected by the operator in the first display function; and

a third display function including displaying data of the sensor as a basis of the abnormal state indicated in the prescribed mode.

15 2. The system according to claim 1, wherein at least one of the first display function, the second display function, and the third display function further displays an explanatory text related to the abnormality.

3. The system according to claim 1 or 2,

20 wherein the second display function further displays an abnormality confirmation display for determining that the abnormality has been confirmed by the operator, and

wherein when the abnormality confirmation display is selected by the operator in the second display function, the first display function displays the abnormality display in a different mode.

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

wherein the second display function further displays determination information that is used when the state of the tube is determined based on process data related to the plant, and

30 wherein the first display function displays the abnormality display based on a result of the abnormal state of the tube detected by the sensor in the second display function and the determination information.

5. The system according to any one of claims 1 to 4,

wherein the second display function displays an abnormality history display for prompting the operator to confirm a history of the abnormality display, and

wherein the system further comprises a fourth display function including displaying the history of the abnormality display when the abnormality history display is selected by the operator in the second display function.

5 6. The system according to claim 5, wherein the fourth display function further displays an area for receiving an input of a correct or incorrect determination of the abnormality display to the operator.

10 7. The system according to any one of claims 1 to 6,
 wherein the first display function further displays a warning display indicating an occurrence of a warning when process data related to the plant is in a predetermined state, and
 wherein the system further comprises a fifth display function including displaying a graph of process data corresponding to the warning display and an explanatory text of the process data corresponding to the warning display in a manner of being adjacent to each other
 15 when the warning display is selected by the operator in the first display function.

8. The system according to any one of claims 1 to 7, wherein the first display function includes:
 displaying, in a first area of a display screen of the plant, the occurrence of the
 20 abnormality having the possibility of stopping the plant; and
 displaying, in a second area of the display screen, an occurrence history of an abnormality that affects an operation efficiency of the plant.

9. The system according to any one of claims 1 to 7, wherein the second display function includes:
 25 displaying, in a first area of a display screen of the plant, the image information indicating the position of the tube in the entire plant and the position of the sensor provided in the tube and display, in the first area, the abnormal state of the tube detected by the sensor in the prescribed mode; and

30 displaying, in a second area of the display screen, the determination information that is used when the state of the tube is determined based on operation data of the plant.

10. The system according to claim 7, wherein the fifth display function includes:

displaying, in a first area of a display screen of the plant, a graph of first process data corresponding to the warning display and a graph of second process data related to the first process data; and

displaying, in a second area of the display screen which is adjacent to the first area,
5 the explanatory text of the process data corresponding to the warning display.

11. The system according to any one of claims 1 to 7,
wherein the first display function displays an evaluation item display for prompting
the operator to confirm an evaluation item for evaluating the state of the plant, and

10 wherein the system further comprises a sixth display function including displaying the
evaluation item when the evaluation item display is selected by the operator in the first display
function.

12. A method of displaying a state of a plant, comprising:

15 displaying an abnormality display indicating an occurrence of an abnormality having
a possibility of stopping the plant and prompting an operator to confirm the abnormality;

receiving a selection of the abnormality display from the operator;

20 displaying image information that indicates a position of a tube in an entire plant and
a position of a sensor provided in the tube and indicating an abnormal state of the tube detected
by the sensor in a prescribed mode when the abnormality display is selected by the operator;

receiving a selection of the display in the prescribed mode from the operator; and

displaying data of the sensor as a basis of the abnormal state indicated in the prescribed
mode when the display of the abnormal state of the tube is selected by the operator.

25 13. A device comprising a display screen for displaying a state of a plant, the device being
configured to:

display, in a first area of the display screen, an occurrence of an abnormality having a
possibility of stopping the plant; and

30 display, in a second area of the display screen, an occurrence history of an abnormality
affecting an operation efficiency of the plant.

14. The device according to claim 13,

wherein the occurrence history of the abnormality displayed in the second area is
displayed in a mode in which time information indicating an occurrence time of the abnormality

and information indicating contents of the abnormality are arranged in an order of the occurrence time.

15. The device according to claim 13,

wherein the plant includes a plurality of sensors, and

wherein the occurrence history of the abnormality displayed in the second area is displayed in a mode in which the number of times that data obtained by the sensors indicates an abnormal value is arranged for each of the sensors.

16. The device according to claim 14,

wherein the plant comprises a plurality of sensors, and

wherein the occurrence history of the abnormality displayed in the second area includes an occurrence history of an abnormality determined to occur based on data obtained from at least two of the sensors and an occurrence history of an abnormality determined to occur based on data obtained from a single one of the sensors.

17. The device according to any one of claims 13 to 16,

wherein the plant is composed of a plurality of components, and

wherein the device is configured to display, in a fourth area of the display screen, at least one of the components having a possibility of causing an abnormality affecting the operation efficiency in a mode different from other components.

18. The device according to any one of claims 13 to 17,

wherein the device is configured to display, in a fifth area of the display screen, information indicating the operation efficiency of the plant.

19. A system comprising:

a device having a display screen for displaying a state of a plant; and

a control device configured to control the device,

wherein the device is configured to:

display, in a first area of the display screen, an occurrence of an abnormality having a possibility of stopping the plant; and

display, in a second area of the display screen, an occurrence history of an abnormality affecting an operation efficiency of the plant.

20. A device comprising a screen for displaying a state of a plant, the device being configured to:

display, in a first area of the screen, image information indicating a position of a tube in an entire plant and a position of a sensor provided in the tube and display a state of the tube detected by the sensor in the first area in a prescribed mode; and

display, in a second area of the screen, determination information that is used when the state of the tube is determined based on operation data of the plant.

21. The device according to claim 20, wherein the device is configured to display the determination information in time series in the second area.

22. The device according to claim 21, wherein the determination information includes a value obtained by calculating an abnormality degree of the tube based on the operation data and a value obtained by calculating a reliability degree of the state of the tube based on the operation data.

23. The device according to claim 21 or 22, wherein the determination information includes feature amount data affecting the determination of the state of the tube.

24. The device according to any one of claims 20 to 23, wherein the device is configured to display, in a third area of the screen, both of a detection result of the state of the tube detected by the sensor and a determination result of the state of the tube based on the operation data of the plant in time series and in the same format.

25. The device according to claim 24, wherein a time axis in the second area and a time axis in the third area are displayed in conjunction with each other.

26. The device according to any one of claims 20 to 25, wherein when a specific sensor is selected from sensors displayed in the first area, the device is configured to display detection information detected by the specific sensor in time series in a fourth area.

27. The device according to claim 26, wherein the device is configured to display the detection information in the fourth area of a screen that is different from the screen.

28. A system comprising:

a display device having a screen for displaying a state of a plant; and
a control device configured to control the display device,

wherein the display device is configured to:

display, in a first area of the screen, image information indicating a position of a tube in an entire plant and a position of a sensor provided in the tube and display a state of the tube detected by the sensor in the first area in a prescribed mode; and

display, in a second area of the screen, determination information that is used when the state of the tube is determined based on operation data of the plant.

29. A device comprising a display screen for displaying a state of a plant, the device being configured to:

display, in a first area of the display screen, a graph of first process data related to the plant; and

display, in a second area of the display screen which is adjacent to the first area, an explanatory text related to the first process data.

30. The device according to claim 29, wherein the device is configured to display, in the first area, a graph of second process data related to the first process data.

31. The device according to claim 29 or 30, wherein the device is configured to display, in the first area, another graph of the first process data which is different from the graph of the first process data.

32. The device according to any one of claims 29 to 31,
wherein the device is configured to:

display, on the display screen, a first screen displaying a warning when at least one of a plurality of pieces of process data is in an abnormal state; and

display a second screen on the display screen by transitioning the display screen from the first screen to the second screen in response to a selection of the warning, and wherein the second screen includes the first area and the second area.

33. The device according to claim 32, wherein the device is configured to:

display the warning in a third area of the first screen; and
display, in a fourth area that is adjacent to the third area, a graph of representative one
or a plurality of pieces of process data related to the plant.

5 34. The device according to any one of claims 29 to 33, wherein the explanatory text
includes a sentence describing a method of capturing an event from the graph.

35. The device according to any one of claims 29 to 34, wherein the explanatory text
includes a sentence describing a method of optimizing a state of the first process data.

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36. A system comprising:
a device having a display screen for displaying a state of a plant; and
a control device configured to control the device,
wherein the device is configured to:

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display, in a first area of the display screen, a graph of first process data
related to the plant; and

display, in a second area of the display screen which is adjacent to the first
area, an explanatory text related to the first process data.