

DESCRIPTION

Title of Invention

DISPLAY DEVICE, CONTROL DEVICE, CONTROL METHOD, AND
COMPUTER PROGRAM

Technical Field

[0001]

The present invention relates to a display device, a control device, a control method, and a computer program for displaying an index related to operation of a plant.

Background Art

[0002]

In the related art, a sensor has been provided in a plant to monitor an operating status of the plant through a measurement value of the sensor. For example, PTL 1 discloses displaying information related to an object from a sensor in a case where the object on a display screen is selected, so that an operator can intuitively identify a target to be detected or a detection result of a sensor. In addition, PTL 2 discloses displaying a plurality of warning messages within a warning monitoring screen and displaying information about a graph of a corresponding warning

message in a case where an operator presses a graph display on a display screen.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Publication No.
1992-308895

[PTL 2] Japanese Unexamined Patent Publication No.
2016-115195

Summary of Invention

Technical Problem

[0004]

In the configurations of the related art, while it is possible to monitor data of the sensor installed in the plant, it is difficult to check an operation ratio related to operation of the plant in a predetermined period in the past.

[0005]

An exemplary object of an aspect of the present invention is to provide a display device, a control device, a control method, and a computer program that can show an operation ratio related to operation of a plant to an operator.

Solution to Problem

[0006]

In order to solve the problem, a display device of an aspect of the present invention is a display device that displays an index related to operation of a plant, in which an operation ratio related to the operation of the plant is displayed as the index in a selected period.

[0007]

According to the aspect, the operation ratio related to the operation of the plant can be shown to an operator.

[0008]

A control device of another aspect of the present invention is a control device that controls a display device that displays an index related to operation of a plant, the control device including an acquisition unit that acquires process data of the plant, a calculation unit that calculates an operation ratio related to the operation of the plant as the index related to the operation of the plant based on the acquired process data, and a display control unit that displays the calculated operation ratio on the display device.

[0009]

According to the aspect, the operation ratio related to the operation of the plant calculated based on the

acquired process data of the plant can be shown to the operator.

[0010]

A control method of another aspect of the present invention is a control method of controlling a display device that displays an index related to operation of a plant, the control method including an acquisition step of acquiring process data of the plant, a calculation step of calculating an operation ratio related to the operation of the plant as the index related to the operation of the plant based on the acquired process data, and a display step of displaying the calculated operation ratio on the display device.

[0011]

According to the aspect, the operation ratio related to the operation of the plant calculated based on the acquired process data of the plant can be shown to the operator.

[0012]

A computer program of another aspect of the present invention causes a computer to execute an acquisition step of acquiring process data of a plant, a calculation step of calculating an operation ratio related to operation of the plant as an index related to the operation of the plant based on the acquired process data, and a display step of

displaying the calculated operation ratio on a display device.

[0013]

According to the aspect, the operation ratio related to the operation of the plant calculated based on the acquired process data of the plant can be shown to the operator.

[0014]

Arbitrary combinations of the above components, and substitution of the components and expressions of the present invention with each other among a method, a device, a system, a computer program, a data structure, a recording medium, and the like are also valid as an aspect of the present invention.

Advantageous Effects of Invention

[0015]

According to the present invention, the operation ratio related to the operation of the plant can be shown to the operator.

Brief Description of Drawings

[0016]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant according to the present embodiment.

Fig. 2 is a diagram illustrating functional blocks of a system according to the present embodiment.

Fig. 3 is a diagram illustrating a physical configuration of the system according to the present embodiment.

Fig. 4 is a diagram illustrating transitions among various display screens according to the present embodiment.

Fig. 5 is a diagram illustrating an example of an operation ratio display screen according to the present embodiment.

Fig. 6 is a diagram illustrating an example of a region for adding a planned stoppage period according to the present embodiment.

Fig. 7 is a flowchart illustrating an example of operation processing related to display of an operation ratio according to the present embodiment.

Fig. 8 is a diagram illustrating an example of a dashboard display screen according to the present embodiment.

Fig. 9 is a flowchart illustrating an example of operation processing related to display of an efficiency according to the present embodiment.

Description of Embodiments

[0017]

Hereinafter, the present invention will be described through an embodiment of the invention with reference to the drawings. It should be noted that the following embodiment does not limit the invention according to the claims. In addition, not all combinations of features described in the embodiment are essential to the solution of the invention. The same or equivalent components, members, and processing illustrated in each drawing will be designated by the same reference signs, and description will not be repeated as appropriate.

[0018]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant according to the present embodiment. First, a configuration of a plant 1 targeted by the present embodiment will be described using Fig. 1. For example, the plant 1 is a power generation plant (incineration plant) including a circulating fluidized bed boiler (circulating fluidized bed type), and includes a boiler that generates vapor by combusting fuel while

circulating a circulation material such as silica sand that is fluidized at a high temperature. As the fuel of the plant 1, not only fossil fuel such as coal but also, for example, non-fossil fuel (woody biomass, waste tires, waste plastic, sludge, or the like) can be used. The vapor generated in the plant 1 is used for driving a turbine 100. The plant targeted by the present embodiment is not limited to a power generation plant or an incineration plant including a boiler and may be a plant such as a chemical plant or a wastewater treatment plant in which process data can be acquired.

[0019]

The plant 1 is configured to combust the fuel in a furnace 2, separate the circulation material from exhaust gas via a cyclone 3 that functions as a solid-gas separation device, and return the separated circulation material to the furnace 2 to be circulated. The separated circulation material is sent back to a lower part of the furnace 2 via a circulation material recovery pipe 4 connected to a part below the cyclone 3. A lower part of the circulation material recovery pipe 4 and the lower part of the furnace 2 are connected through a loop seal part 4a in which a flow path is narrowed. Accordingly, the lower part of the circulation material recovery pipe 4 is in a state where a predetermined amount of the circulation

material is stored. The exhaust gas in which the circulation material is removed by the cyclone 3 is supplied to a rear flue 5 via an exhaust gas flow path 3a.

[0020]

The boiler includes the furnace 2 for combusting the fuel and a heat exchanger for generating water vapor or the like using heat obtained by combustion. A fuel feed port 2a through which the fuel is supplied is provided in a middle part of the furnace 2. A gas outlet 2b through which combustion gas is exhausted is provided in an upper part of the furnace 2. The fuel that is supplied to the furnace 2 from a fuel supply device, not illustrated, is supplied to the inside of the furnace 2 through the fuel feed port 2a. In addition, a furnace wall pipe 6 for heating boiler feedwater is provided in a furnace wall of the furnace 2. The boiler feedwater that flows through the furnace wall pipe 6 is heated by combustion in the furnace 2.

[0021]

In the furnace 2, a solid matter including the fuel supplied from the fuel feed port 2a is fluidized by air for combustion and fluidization introduced from an air supply line 2c in the lower part, and the fuel is combusted at, for example, approximately 800°C to 900°C while being fluidized. The combustion gas generated in the furnace 2 is introduced into the cyclone 3 with the circulation

material. The cyclone 3 separates the circulation material and gas from each other based on a centrifugal effect, returns the separated circulation material to the furnace 2 through the circulation material recovery pipe 4, and sends the combustion gas in which the circulation material is removed to the rear flue 5 from the exhaust gas flow path 3a.

[0022]

In the furnace 2, a part of the circulation material called an in-furnace bed material remains in a bottom part. The bed material may include a bed material having a coarse particle size not suitable for circulation and fluidization or an exhaust impurity. These bed materials not suitable as the circulation material may cause a fluidization failure. Thus, in order to suppress such a fluidization failure, the in-furnace bed material is continuously or intermittently exhausted to the outside from an exhaust port 2d in the bottom part in the furnace 2. Metal or an unsuitable material having a coarse large particle size or the like is removed from the exhausted bed material on a circulation line, not illustrated. Then, the bed material is either supplied to the furnace 2 again or discarded. The circulation material of the furnace 2 circulates in a circulation system configured with the furnace 2, the cyclone 3, and the circulation material recovery pipe 4.

[0023]

The rear flue 5 has a flow path through which the gas exhausted from the cyclone 3 flows to a rear stage. The rear flue 5 includes, as an exhaust heat collection unit that collects heat of the exhaust gas, a superheater 10 that generates superheated vapor, and a coal economizer 12 that preheats the boiler feedwater. The exhaust gas flowing through the rear flue 5 is cooled by exchanging heat with the vapor or the boiler feedwater flowing through the superheater 10 and the coal economizer 12. In addition, a steam drum 8 in which the boiler feedwater that has passed through the coal economizer 12 is stored is provided. The steam drum 8 is also connected to the furnace wall pipe 6.

[0024]

The coal economizer 12 preheats the boiler feedwater by transferring the heat of the exhaust gas to the boiler feedwater. The coal economizer 12 is connected to a pump 7 by a pipe 21 and is connected to the steam drum 8 by a pipe 22. The boiler feedwater that is supplied to the coal economizer 12 from the pump 7 via the pipe 21 and that is preheated by the coal economizer 12 is supplied to the steam drum 8 via the pipe 22.

[0025]

A downcast pipe 8a and the furnace wall pipe 6 are connected to the steam drum 8. The boiler feedwater in the

steam drum 8 moves down through the downcast pipe 8a to be introduced into the furnace wall pipe 6 on a lower part side of the furnace 2 and then, flows toward the steam drum 8. The boiler feedwater in the furnace wall pipe 6 is heated by combustion heat generated in the furnace 2 and evaporates into vapor in the steam drum 8.

[0026]

A saturated vapor pipe 8b through which the vapor inside the steam drum 8 is exhausted is connected to the steam drum 8. The saturated vapor pipe 8b connects the steam drum 8 to the superheater 10. The vapor in the steam drum 8 is supplied to the superheater 10 via the saturated vapor pipe 8b. The superheater 10 generates the superheated vapor by superheating the vapor using the heat of the exhaust gas. The superheated vapor is supplied to the turbine 100 outside the plant 1 through a pipe 10a and is used for power generation.

[0027]

A pressure and a temperature of the vapor exhausted from the turbine 100 are lower than a pressure and a temperature of the vapor exhausted from the superheater 10. The pressure and the temperature of the vapor supplied to the turbine 100 are not particularly limited and are approximately 10 to 17 MPa and approximately 530°C to 570°C, respectively. The pressure and the temperature of

the vapor exhausted from the turbine 100 are approximately 3 to 5 MPa and approximately 350°C to 400°C, respectively.

[0028]

A condenser 102 is provided downstream of the turbine 100. The vapor exhausted from the turbine 100 is supplied to the condenser 102 to be condensed into saturated water in the condenser 102 and then, is supplied to the pump 7. A generator that converts kinetic energy obtained by rotation of the turbine 100 into electrical energy is connected to the turbine 100.

[0029]

A pump 7a supplies makeup water in order to constantly maintain a water level of the condenser 102. In Fig. 1, a makeup water flow rate u_1 (an example of "process data") supplied by the pump 7a is illustrated.

[0030]

The process data (data related to operation of the plant 1) handled in the present embodiment may be arbitrary data related to the plant 1. For example, the process data may be data (an example of the "process data") obtained by measuring a state of the plant 1 via a sensor and, more specifically, may include a measurement value such as a temperature, a pressure, and a flow rate of the plant 1. In Fig. 1, a boiler feedwater flow rate u_2 (an example of the "process data") supplied to the coal economizer 12 from the

pump 7 is illustrated. Furthermore, in Fig. 1, a boiler outlet vapor flow rate u_3 (an example of the "process data") supplied to the turbine 100 from the superheater 10 is illustrated, and a saturated vapor flow rate u_4 supplied to the superheater 10 from the steam drum 8 is illustrated. The makeup water flow rate u_1 may be controlled in accordance with the saturated vapor flow rate u_4 . In addition, the boiler feedwater flow rate u_2 may be controlled in accordance with adjustment while both of the boiler outlet vapor flow rate u_3 (or a superheated vapor flow rate) and a liquid surface level of the steam drum 8 are monitored.

[0031]

In a case where a hole has occurred in a pipe system constituting the plant 1, the makeup water flow rate u_1 rises, or a difference in flow rate between the boiler feedwater flow rate u_2 and the boiler outlet vapor flow rate u_3 is increased. A distributed control system (DCS) 20 receives the process data of the plant 1 such as the makeup water flow rate u_1 , the boiler feedwater flow rate u_2 , the boiler outlet vapor flow rate u_3 , and the saturated vapor flow rate u_4 from the plant 1 to identify an operating status including operation ratios of the boiler and the turbine 100 constituting the plant 1 and to monitor whether or not abnormality has occurred in the plant 1.

[0032]

While the makeup water flow rate u_1 , the boiler feedwater flow rate u_2 , the boiler outlet vapor flow rate u_3 , and the saturated vapor flow rate u_4 are illustrated as the process data, the process data related to the plant 1 may be other data. The process data related to the plant 1 may be other data such as a temperature and a pressure or data calculated based on a plurality of pieces of the process data, or may be data that is acquired from the sensor or the like and that is not obtained by calculation processing.

[0033]

Next, a system 30 according to the present embodiment will be described using Fig. 2 and Fig. 3. Fig. 2 is a diagram illustrating functional blocks of the system 30 according to the present embodiment. Fig. 3 is a diagram illustrating a physical configuration of the system 30 according to the present embodiment.

[0034]

The DCS 20 is a distributed control system for controlling the plant 1 and, as illustrated in Fig. 2, acquires the process data from the sensor or the like provided in the plant 1 and supplies a control signal for controlling the plant 1 based on the process data to the plant 1.

[0035]

The system 30 includes a control unit 31 and a display device 32. The control unit 31 includes, for example, a process data acquisition unit 311, an index calculation unit 312, a reception unit 313, and a display control unit 314.

[0036]

For example, the process data acquisition unit 311 acquires the process data from the DCS 20. The process data acquisition unit 311 sequentially acquires the process data from the DCS 20 while the plant 1 is in operation.

[0037]

The index calculation unit 312 calculates various indexes related to the operation of the plant 1 based on the process data. The indexes calculated by the index calculation unit 312 may be arbitrary indexes as long as the indexes are related to the operation of the plant 1. For example, the indexes may include an operation ratio related to the operation of the plant 1 and an efficiency related to the operation of the plant 1.

[0038]

For example, the index calculation unit 312 calculates the operation ratio related to the operation of the plant 1 at an arbitrary timing (daily, weekly, monthly, or the like) set in advance. Here, the operation ratio related to

the operation of the plant 1 may include not only the operation ratio of the entire plant 1 but also operation ratios of various components included in the plant 1. Specifically, for example, the operation ratio related to the operation of the plant 1 may include a boiler operation ratio that is the operation ratio of the boiler included in the plant 1, a turbine operation ratio that is the operation ratio of the turbine included in the plant 1, and a plant operation ratio that is the operation ratio of the entire plant 1.

[0039]

For example, the operation ratio related to the operation of the plant 1 may be calculated as a value obtained by dividing a total of a time in which at least a part of the components of the plant 1 is in operation by an operation ratio calculation period. A "total of a time in which a component as a target is in operation" may be calculated based on an arbitrary efficiency of the component as a target. Specifically, the total may be a value obtained by calculating, over the operation ratio calculation period, a total (an accumulation, an integral, or the like) of a value obtained by multiplying a unit time divided by an arbitrary cycle by an operation efficiency of the component (for example, a load efficiency for the boiler) in the unit time. In addition, for example, the

index calculation unit 312 may calculate the operation ratio based on a count cycle selected on an operation ratio display screen DP1, described later.

[0040]

In addition, the index calculation unit 312 may exclude a planned stoppage period registered by an operator from the operation ratio calculation period in calculating the operation ratio. Here, the planned stoppage period is a period in which a stoppage of the operation of the plant 1 is planned, and may include, for example, a period in which the operation of the plant 1 is stopped for inspection of the plant 1 such as periodic inspection or intermediate inspection. Accordingly, the index calculation unit 312 can calculate both of the operation ratio excluding the planned stoppage period and the operation ratio including the planned stoppage period. The operation ratio excluding the planned stoppage period is calculated based on a planned operation period (a period in which the operation of the plant 1 is planned) that is a period obtained by excluding the planned stoppage period from the operation ratio calculation period, and on an operation period in which the plant 1 is operated. Specifically, the operation ratio excluding the planned stoppage period is calculated as a ratio of the operation period to the planned operation period. The operation ratio including the planned stoppage

period is said to represent a net operation ratio in the period in which the operation of the plant 1 is planned.

[0041]

In addition, the efficiency related to the operation of the plant 1 may be, for example, an arbitrary efficiency of at least a part of the components of the plant 1. For example, the efficiency related to the operation of the plant 1 may include a boiler efficiency η_b that is an efficiency of the boiler included in the plant 1, a turbine room efficiency η_t that is an efficiency of the turbine included in the plant 1, and a power generation end efficiency η_n that is an efficiency of the entire plant 1.

[0042]

The boiler efficiency η_b (%) may be defined as $\eta_b = (1 - L/(H + Q)) \times 100$. Here, L is a total of a heat loss amount (kJ/kg), H is a heating value of the fuel (kJ/kg), and Q is a total of an input heat amount of other than the fuel (kJ/kg).

[0043]

The turbine room efficiency η_t (%) may be defined as $\eta_t = P_g \times 3.6 / \{Z \times (h_s - h_w)\} \times 100$. Here, P_g is a power generation output (kW), Z is a water and vapor flow rate (kg/h), h_s is vapor enthalpy (kg/h), and h_w is water supply enthalpy (kg/h).

[0044]

The power generation end efficiency η_n (%) may be defined as $\eta_n = \eta_b \times \eta_P/100 \times \eta_t/100$. Here, η_P is a principal pipe transmission efficiency (%).

[0045]

The reception unit 313 receives input of various types of information, instructions, selections, and the like corresponding to operations of the operator. The reception unit 313 receives, for example, an instruction for display screen transition, a designation, an input, or a selection of the planned stoppage period, selections of the operation ratio calculation period and the count cycle, and a selection of display of the indexes related to the operation of the plant 1.

[0046]

The display control unit 314 generates display data based on the acquired process data and on various indexes (the operation ratio, the efficiency, and the like) calculated based on the process data, and displays a display screen based on the display data on the display device 32.

[0047]

The display device 32 displays various display screens including information related to the operation of the plant 1 based on the display data supplied by the display control

unit 314. Various display screens displayed by the display device 32 will be described later.

[0048]

As illustrated in Fig. 3, the system 30 physically includes a central processing unit (CPU) 30a, a random access memory (RAM) 30b, a read only memory (ROM) 30c, a communication unit 30d, an input unit 30e, and a display unit 30f. These configurations are connected to each other to be capable of transmitting and receiving data through a bus. Each functional block of the system 30 illustrated in Fig. 2 is implemented by the physical configurations illustrated in Fig. 3.

[0049]

While a case where the system 30 is configured with one computer will be 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 constituting a different display unit for displaying other information may be provided. In addition, the system 30 may be configured with a tablet terminal. By configuring the system 30 with a tablet terminal, it is possible to carry the system 30. For example, it is possible to use the system 30 while moving around in the plant 1. In addition, the configurations illustrated in Fig. 3 is merely an example. The system 30

may have a configuration other than the configurations or may not have a part of the configurations. In addition, a part of the configurations 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 display device 32 including the display unit 30f and the like may be configured to acquire a control signal generated in the control unit 31 provided at the remote location through a network.

[0050]

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

[0051]

In the storage unit, data can be rewritten in the RAM 30b. For example, the RAM 30b may be configured with a semiconductor storage element such as a DRAM or an SRAM. The RAM 30b may store the program executed by the CPU 30a

and data such as the process data of the plant 1. The program and the data are merely an example, and the RAM 30b may store data other than the program and the data or may not store a part of the program and the data.

[0052]

In the storage unit, data can be read out from the ROM 30c. For example, the ROM 30c may be configured with a semiconductor storage element such as a flash memory or with an HDD. The ROM 30c may store, for example, a computer program for executing various types of processing illustrated 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 and to specifications of components of the plant 1. In addition, the ROM 30c may store, for example, data such as the process data of the plant 1, the indexes (the operation ratio, the efficiency, and the like) related to the operation of the plant 1, and the planned stoppage period.

[0053]

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

[0054]

The input unit 30e receives input of data corresponding to operations performed by the operator and may include, for example, a keyboard and a touch panel.

[0055]

The display unit 30f has a screen on which the calculation result of the CPU 30a is visually displayed, and may be configured with, for example, a liquid crystal display (LCD). The display unit 30f may display the graph and the description of the process data. In addition, the display unit 30f may be provided by connecting a plurality of displays to configure one screen.

[0056]

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

[0057]

Fig. 4 is a diagram illustrating transitions among various display screens according to the present embodiment. As illustrated in Fig. 4, the display device 32 displays a login display screen DP0, the operation ratio display screen DP1, and a dashboard display screen DP2. Arrows between each display screen illustrated in Fig. 4 indicate that each display screen transitions based on instructions from the operator. That is, in the system 30, a transition can be made from the login display screen DP0 to the operation ratio display screen DP1 and to the dashboard display screen DP2 based on an instruction from the operator. In a case where each display screen transitions in the system 30, the previous display screen may be replaced with the subsequent display screen, or the subsequent display screen may be displayed together while the previous display screen is maintained. In addition, the above display screens are merely an example, and the display device 32 may display a display screen other than the display screens.

[0058]

The login display screen DP0 displays information required for the operator to log in to the system 30. The information required for login is, for example, a user ID and a password of the operator. The login display screen DP0 receives input of a user ID and of a password from the

operator. A transition can be made from the login display screen DP0 to the dashboard display screen DP2, the operation ratio display screen DP1, and the like.

[0059]

The operation ratio display screen DP1 displays the operation ratio related to the operation of the plant 1 in a predetermined period in the past. Here, the operation ratio related to the operation of the plant 1 may include not only the operation ratio of the entire plant 1 but also the operation ratios of various components included in the plant 1. For example, the operation ratio display screen DP1 displays the boiler operation ratio, the turbine operation ratio, and the plant operation ratio included in the selected operation ratio calculation period. In addition, for example, the operation ratio display screen DP1 displays each operation ratio counted based on the selected count cycle. In addition, the planned stoppage period can be added or deleted on the operation ratio display screen DP1. The operation ratio excluding the planned stoppage period registered by the operator and the operation ratio including the planned stoppage period can be displayed on the operation ratio display screen DP1.

[0060]

The dashboard display screen DP2 displays various indexes related to the operation of the plant 1 in real

time. In other words, the dashboard display screen DP2 displays various latest indexes related to the operation of the plant 1 for each predetermined time. For example, the dashboard display screen DP2 displays a trend graph based on various indexes related to the operation of the plant 1. In addition, for example, the dashboard display screen DP2 displays an abnormality display indicating an occurrence or possibility of abnormality that has a possibility of stopping the plant 1, and a warning display indicating an occurrence or possibility of a warning in a case where the process data related to the plant 1 is in a predetermined state. In addition, for example, the dashboard display screen DP2 displays the number and generation times of alarms.

[0061]

Next, an example of the operation ratio display screen DP1 will be described using Fig. 5. The operation ratio display screen DP1 includes regions R10 to R16 and a calculation display 50.

[0062]

For example, the region R10 is displayed in an upper part of the operation ratio display screen DP1. In the region R10, "operation ratio calculation" is displayed as a status of the current screen. By displaying the region R10,

it is possible to easily identify which status of which system the current screen is in.

[0063]

For example, the region R11 is displayed at the upper left of the operation ratio display screen DP1. The region R11 receives input of a period (operation ratio calculation period) in which the operation ratio is calculated or displayed. In the example illustrated in Fig. 5, each of a start time and an end time of the operation ratio calculation period can be input. While both of the start time and the end time are in the form of being designated by a year and a month in the example illustrated in Fig. 5, the present invention is not limited thereto. The start time and the end time may be in the form of being further designated by a date and time. In addition, the region R11 includes a display of a time selectable as the end time of the operation ratio calculation period. In the example illustrated in Fig. 5, "calculable month: to 2020-05" is displayed in the region R11 as the time selectable as the end time of the operation ratio calculation period. This shows that the operation ratio before May 2020 can be calculated or displayed. Accordingly, the operator can input a time before the time shown in the display as the start time or the end time of the operation ratio calculation period.

[0064]

For example, the region R12 is displayed below the region R11 of the operation ratio display screen DP1. The region R12 receives input of the count cycle. Here, the count cycle is a cycle for dividing a period in which counting is performed for calculating one operation ratio. In other words, the operation ratio in units of periods indicated by the count cycle is calculated or displayed. A length of the count cycle is not particularly limited and, in the example illustrated in Fig. 5, includes "MONTH" with which the count cycle is set as a month, and "YEAR" with which the count cycle is set as a year.

[0065]

For example, the region R13 is displayed below the region R12 of the operation ratio display screen DP1. The region R13 includes various displays related to the planned stoppage period. The region R13 may display the planned stoppage period that is already registered. The region R13 includes a latest data update display 51, a planned stoppage addition display 52, and a deletion display 53.

[0066]

In a case where the latest data update display 51 is selected, processing that reflects the latest planned stoppage period is executed in the region R13. For example, the latest planned stoppage period that is registered may

be displayed in the region R13. Accordingly, the operator can identify a period registered as the planned stoppage period. In addition, for example, the index calculation unit 312 may calculate the operation ratio that reflects the latest planned stoppage period, and store the calculated operation ratio in the storage unit such as the ROM 30c.

[0067]

In a case where the planned stoppage addition display 52 is selected, a region R131, for example, for adding the planned stoppage period illustrated in Fig. 6 is displayed. As illustrated in Fig. 6, the region R131 is displayed in the aspect of a pop-up on the operation ratio display screen DP1. In the example illustrated in Fig. 6, each of a start time and an end time of the planned stoppage period can be input. In a case where a display of "add" included in the region R131 is selected, an input period is newly added as the planned stoppage period. In a case where a display of "close" is selected, an operation of adding the planned stoppage period is interrupted, and the display of the region R131 is cleared.

[0068]

Fig. 5 will be referred to again. In a case where the deletion display 53 is selected, for example, a registration of an arbitrary planned stoppage period

selected from the registered planned stoppage period is deleted. For example, by selecting a period to be deleted from the registered planned stoppage period displayed by selecting the latest data update display 51 and then by selecting the deletion display 53, the operator can delete the registration of the planned stoppage period with respect to the selected period.

[0069]

In a case where the calculation display 50 is selected, for example, the operation ratio related to the operation of the plant 1 is displayed on the right side of the regions R10 to 13 of the operation ratio display screen DP1. In the example illustrated in Fig. 5, various operation ratios in February, March, and April 2020 which are the operation ratio calculation period are displayed in the aspect of a bar graph in each of three regions R14 to 16. For example, the boiler operation ratio is displayed in the region R14, and the plant operation ratio is displayed in each of the regions R15 and R16. The operation ratio including the planned stoppage period is displayed in the region R15, and the operation ratio excluding the planned stoppage period (the operation ratio as the ratio of the operation period to the planned operation period) is displayed in the region R16. A hatched part provided in an upper part of each bar graph indicates a ratio of a period

in which the component as a target is not in operation. The number of display regions of the operation ratio included in the operation ratio display screen DP1 is not particularly limited and may be three as illustrated in Fig. 5 or may be one, two, or four or more. In addition, the display aspect of the operation ratio is not limited to a bar graph and may be an arbitrary aspect such as a line graph, a pie graph, a scatter plot, or a histogram.

[0070]

The operation ratio including the planned stoppage period and the operation ratio excluding the planned stoppage period are displayed on the operation ratio display screen DP1. Furthermore, these operation ratios are parallelly disposed on the operation ratio display screen DP1. Thus, the operator can easily identify an effect of the planned stoppage period on the operation ratio.

[0071]

Next, operation processing related to the display of the operation ratio according to the present embodiment will be described using Fig. 7. Fig. 7 is a flowchart illustrating an example of the operation processing. The content and order of steps illustrated below are merely an example, and the operation processing is not limited thereto.

[0072]

First, during the operation of the plant 1, the process data acquisition unit 311 acquires the process data of the plant 1 from the DCS 20 (S10). The process data acquisition unit 311 may store the process data sequentially supplied from the DCS 20 in the ROM 30c or the like.

[0073]

Then, the index calculation unit 312 calculates the operation ratio based on a condition set in advance at an arbitrary timing set in advance (S11). For example, for each month, the index calculation unit 312 calculates the operation ratio of the plant 1 and/or the operation ratios of various components (the boiler operation ratio, the turbine operation ratio, and the like) included in the plant 1 in the month. In this case, the operation ratio including the planned stoppage period and/or the operation ratio excluding the planned stoppage period may be calculated in a case where the planned stoppage period is registered. The index calculation unit 312 stores the calculated operation ratio in the storage unit such as the ROM 30c.

[0074]

In a case where the operator performs an operation of registering the planned stoppage period, the reception unit 313 receives the registration of the planned stoppage

period (S12). Specifically, the region R131 is displayed by the operator by selecting the planned stoppage addition display 52 in the region R13 of the operation ratio display screen DP1, and the planned stoppage period is registered in the region R131. For example, the reception unit 313 stores the planned stoppage period in the storage unit such as the ROM 30c. In this case, for example, in accordance with a selection of the latest data update display 51 in the region R13 of the operation ratio display screen DP2, the index calculation unit 312 may newly calculate the operation ratio that reflects the latest planned stoppage period, and store the operation ratio in the storage unit such as the ROM 30c.

[0075]

In a case where the operator selects various conditions related to the display of the operation ratio, the reception unit 313 receives the selection (S13). For example, the reception unit 313 receives a selection of the operation ratio calculation period in accordance with an operation of the operator with respect to the region R11 of the operation ratio display screen DP2. In addition, the reception unit 313 receives a selection of the count cycle in accordance with an operation of the operator with respect to the region R12 of the operation ratio display screen DP2. In accordance with these operations, the index

calculation unit 312 may calculate the operation ratio under a new condition and store the operation ratio in the storage unit such as the ROM 30c.

[0076]

In a case where the operator selects the calculation display 50 on the operation ratio display screen DP2, the display control unit 314 displays the operation ratio under various selected conditions (the operation ratio calculation period, the count period, and the like) on the operation ratio display screen DP2 (S14). For example, the display control unit 314 displays the regions R14 to R16 and the like illustrated in Fig. 5 on the operation ratio display screen DP2. In a case where the operation ratio under various selected conditions (the operation ratio calculation period, the count period, and the like) is not stored in the storage unit such as the ROM 30c, the index calculation unit 312 may newly calculate the operation ratio under the conditions and store the operation ratio in the storage unit such as the ROM 30c. The new operation ratio is displayed on the operation ratio display screen DP2 by the display control unit 314. This ends the processing.

[0077]

Next, an example of the dashboard display screen DP2 will be described using Fig. 8. The dashboard display

screen DP2 includes regions R20 to R25 and a calculation display 80.

[0078]

In the region R20, "dashboard" is displayed as a status of the current screen. By displaying the region R20, it is possible to easily identify which status the current screen is in.

[0079]

In the region R21 at the upper left of the dashboard display screen DP2, information indicating an occurrence of abnormality having a possibility of stopping the plant 1 and time information at which the abnormality has occurred are displayed. In Fig. 8, information "burst" is displayed by a text of a large size as an example of the information indicating an occurrence of abnormality having a possibility of stopping the plant 1. Current time information "MM/DD/YYYY hh:mm:ss" is displayed below the information. For example, the current time information is automatically updated for each predetermined time (for example, every minute). Alternatively, a manual update may be performed by an operation of the operator. This information displayed in the region R21 enables the operator of the plant 1 to recognize that a burst that is severe abnormality having a possibility of stopping the plant 1 has currently occurred at hh:mm:ss on MM/DD/YYYY.

As a modification example, the time information immediately below the information "burst" may be a time at which the abnormality has occurred.

[0080]

In the region R22 at the lower left of the dashboard display screen DP2, the warning display indicating an occurrence of a warning in a case where the process data related to the plant is in the predetermined state is displayed as "latest alarm information". The warning display displays the predetermined state of the process data that affects an operation efficiency of the plant 1, for example, a state such as the burst that does not have a possibility of stopping the plant 1 and that decreases the operation efficiency of the plant 1. In the region R22, a generation history of the warning display is displayed in a state where time information indicating a time of generation and information indicating content are arranged in order of the time of generation. For example, at the top of the region R22, time information such as "MM/DD/YYYY hh:mm:ss" and information indicating content of warning such as "alarm A" are displayed in association with each other. This information displayed in the region R22 enables the operator of the plant 1 to recognize that the alarm A is generated at hh:mm:ss on MM/DD/YYYY. The operator of the plant 1 can also recognize a history of the time

information indicating a time of occurrence of the predetermined state of another process data that affects the operation efficiency of the plant 1, and of the information indicating the content.

[0081]

A region R23 is provided in a space between the region R21 and the region R22 at the center on the left side of the dashboard display screen DP2. In the region R23, a plurality of components constituting the plant 1 are displayed as information "by device or component". In addition, a component having a possibility of generating a warning that affects the operation efficiency is displayed in a different aspect from other components.

[0082]

Specifically, "plant", "boiler", "turbine", "generator", and "auxiliary device" are displayed as the components of the plant 1. Here, "boiler" corresponds to parts such as the furnace 2 constituting the boiler. In addition, "turbine" corresponds to parts such as the turbine 100 constituting the turbine. In addition, "auxiliary device" corresponds to parts such as the pump 7 and the pump 7a that do not correspond to main parts such as the boiler. In addition, a part such as "generator" that constitutes the plant 1 and that has a strong possibility of generating a warning may be set as a component as

appropriate. In addition, it is configured to specify the process data that causes the warning affecting the operation efficiency and based on this, display a component (for example, "boiler" and "generator") that is currently generating a warning with, for example, a background color of red, display a component (for example, "plant" and "turbine") that is not generating a warning with, for example, a background color of green, and display a component (for example, "auxiliary device") for which evaluation items are not set in gray. Furthermore, it may be configured to easily specify a component that causes a warning affecting the operation efficiency, by displaying an alarm of a continuing warning in red in the region R22 and by displaying a component corresponding to the alarm with a background color of red in the region R23.

[0083]

In the region R25 at the lower right of the dashboard display screen DP2, a generation history of abnormality is displayed in the aspect of arranging the number of times the data acquired by the sensor indicates an abnormal value for each sensor. Specifically, a Pareto chart in which the number of times abnormality is determined by the DCS 20 is counted within a predetermined time, for example, the past 24 hours, for each sensor in a descending order is shown as information "DCS alarm count". In Fig. 8, "alarm 1", "alarm

2", and the like 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. In addition, 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.

[0084]

In the region R24 at the upper right of the dashboard display screen DP2, the indexes such as the efficiency related to the operation of the plant 1 are displayed in real time. Here, displaying the indexes in real time may be displaying the indexes such as the efficiency related to the operation of the plant 1 in the predetermined period before a predetermined time elapses from the predetermined period. A length of the predetermined time is not particularly limited and, for example, may be in units of seconds such as 1 second, 5 seconds, 10 seconds, or 30 seconds or in units of minutes such as 1 minute or 2 minutes. It is preferable that the length of the predetermined period is as short as possible because a real-time property of information displayed on the dashboard display screen DP2 is improved. The length of the

predetermined time may be arbitrarily settable by the operator or the like.

[0085]

For example, one or a plurality of trend graphs having a vertical axis denoting indexes important for stable operation of the plant 1 and a horizontal axis denoting time are displayed in the region R24. In Fig. 8, for example, trend graphs of Index 1 and Index 2 are displayed in a superimposed manner in an upper part, and trend graphs of Index 3 and Index 4 are displayed in a superimposed manner in a lower part. Time at the rightmost end of the trend graphs is the latest time at which the indexes are calculated. It should be noted that at hh:mm:ss on MM/DD/YYYY which is the current time, the predetermined time has not elapsed yet from the latest time at the rightmost end.

[0086]

As described above, while Index 1 and Index 2 are displayed in a superimposed manner in the upper part of the region R24, for example, Index 1 may be the boiler efficiency, and Index 2 may be the power generation end efficiency. The boiler efficiency (Index 1) and the power generation end efficiency (Index 2) are displayed on a superimposed vertical axis. Accordingly, it is possible to easily identify a correlation between the boiler efficiency

and the power generation end efficiency. Particularly, it is possible to visually and intuitively identify to which degree the boiler efficiency of the boiler that is an important component of the plant 1 is affecting the power generation end efficiency that is the efficiency of the entire plant 1. The indexes displayed in the region R24 are not particularly limited as long as the indexes are related to the operation of the plant 1, and can be arbitrarily selected by the operator.

[0087]

Next, operation processing related to the display of the efficiency according to the present embodiment will be described using Fig. 9. Fig. 9 is a flowchart illustrating an example of the operation processing. The content and order of steps illustrated below are merely an example, and the present invention is not limited thereto. Hereinafter, it will be assumed that the plant 1 is in operation, and that the process data acquisition unit 311 is sequentially acquiring the process data of the plant 1 through the DCS 20.

[0088]

The index calculation unit 312 determines whether or not the predetermined time has elapsed (S20). Here, the length of the predetermined time is not particularly limited and, for example, may be in units of seconds such

as 1 second, 5 seconds, 10 seconds, or 30 seconds or in units of minutes such as 1 minute or 2 minutes. It is preferable that the length of the predetermined period is as short as possible because the real-time property of the information displayed on the dashboard display screen DP2 is improved. The length of the predetermined time may be arbitrarily settable by the operator or the like. The index calculation unit 312 repeats step S20 until it is determined that the predetermined time has elapsed.

[0089]

In a case where it is determined that the predetermined period has elapsed (S20; Yes), the index calculation unit 312 calculates various efficiencies and other indexes related to the operation of the plant 1 based on the process data acquired through the DCS 20 by the process data acquisition unit 311. Particularly, the index calculation unit 312 calculates the efficiencies and other indexes that are set in advance to be displayed on the dashboard display screen DP2. For example, the efficiencies related to the operation of the plant 1 calculated by the index calculation unit 312 may include at least any of the boiler efficiency η_b that is the efficiency of the boiler included in the plant 1, the turbine room efficiency η_t that is the efficiency of the turbine included in the plant 1,

and the power generation end efficiency η_n that is the efficiency of the entire plant 1.

[0090]

Next, the display control unit 314 updates the display of the dashboard display screen DP2 based on the efficiencies and other indexes calculated by the index calculation unit 312 (S22). In the example illustrated in Fig. 8, for example, time axes (horizontal axes) of various trend graphs in the region R24 are updated to the latest time representation, and then the efficiencies and other indexes calculated by the index calculation unit 312 are additionally displayed in the trend graphs. Then, the processing returns to step S20, and then steps S20 to S22 are repeated. Accordingly, the operator can check the efficiencies and other indexes related to the operation of the plant 1 in real time.

[0091]

As described above, according to the present embodiment, in a case where abnormality has occurred in the plant 1, the state of the plant 1 to be identified by the operator can be displayed in a stepwise and sequential manner. Thus, it is possible to comprehensively show the state of the plant to the operator. Particularly, there are a significantly large number of events or parameters to be monitored in the plant, and it is required to efficiently

and quickly notify the operator of a change in the state of the plant in a case where the change occurs. A method for adjusting the state of the plant can be checked using the system and the method according to the present embodiment, and it is possible to quickly identify what kind of countermeasure is required.

[0092]

Aspects described through the above embodiment can be appropriately combined, changed, or improved to be used in accordance with their application. The present invention is not limited to the disclosure of the embodiment. It is apparent from the disclosure of the claims that such combined, changed, or improved embodiments may also fall within the technical scope of the present invention.

Reference Signs List

[0093]

- 1 Plant
- 2 Furnace
 - 2a Fuel feed port
 - 2b Gas outlet
 - 2c Air supply line
 - 2d Exhaust port
- 3 Cyclone
 - 3a Exhaust gas flow path

- 4 Circulation material recovery pipe
 - 4a Loop seal part
- 5 Rear flue
- 6 Furnace wall pipe
- 7 Pump
 - 7a Pump
- 8 Steam drum
 - 8a Downcast pipe
 - 8b Saturated vapor pipe
- 10 Superheater
 - 10a Pipe
- 12 Coal economizer
- 21 Pipe
- 22 Pipe
- 30 System
 - 30a CPU
 - 30d Communication unit
 - 30e Input unit
 - 30f Display unit
- 31 Control unit
- 32 Display device
- 100 Turbine
- 102 Condenser
- 311 Process data acquisition unit
- 312 Index calculation unit

313 Reception unit

314 Display control unit

CLAIMS

1. A display device that displays an index related to operation of a plant,

wherein an operation ratio related to the operation of the plant is displayed as the index in a selected period.

2. The display device according to claim 1,

wherein the operation ratio is an operation ratio counted for each selected cycle.

3. The display device according to claim 1 or 2,

wherein the operation ratio is calculated based on an operation period in which the plant is in operation and on a planned operation period in which the operation of the plant is planned.

4. The display device according to any one of claims 1 to 3,

wherein the operation ratio includes at least any of a boiler operation ratio that is an operation ratio of a boiler included in the plant, a turbine operation ratio that is an operation ratio of a turbine included in the plant, and a plant operation ratio that is an operation ratio of the entire plant.

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

wherein the display device further displays an efficiency related to the operation of the plant in real time as the index related to the operation of the plant.

6. The display device according to claim 5,

wherein the display device displays the efficiency in a predetermined period before a predetermined time elapses from the predetermined period.

7. The display device according to claim 5 or 6,

wherein the efficiency includes at least any of a boiler efficiency that is an efficiency of a boiler included in the plant, a turbine room efficiency that is an efficiency of a turbine included in the plant, and a power generation end efficiency that is an efficiency of the entire plant.

8. The display device according to any one of claims 5 to 7,

wherein the display device displays a plurality of the efficiencies.

9. The display device according to claim 8,
wherein the display device displays the plurality of
the efficiencies on a superimposed axis.

10. A control device that controls a display device
that displays an index related to operation of a plant, the
control device comprising:

an acquisition unit that acquires process data of the
plant;

a calculation unit that calculates an operation ratio
related to the operation of the plant as the index related
to the operation of the plant based on the acquired process
data; and

a display control unit that displays the calculated
operation ratio on the display device.

11. The control device according to claim 10, further
comprising:

a reception unit that receives a selection of a
period,

wherein the display control unit displays the
operation ratio in the selected period on the display
device.

12. A control method of controlling a display device that displays an index related to operation of a plant, the control method comprising:

an acquisition step of acquiring process data of the plant;

a calculation step of calculating an operation ratio related to the operation of the plant as the index related to the operation of the plant based on the acquired process data; and

a display step of displaying the calculated operation ratio on the display device.

13. The control method according to claim 12, further comprising:

a reception step of receiving a selection of a period, wherein in the display step, the operation ratio in the selected period is displayed on the display device.

14. A computer program causing a computer to execute:

an acquisition step of acquiring process data of a plant;

a calculation step of calculating an operation ratio related to operation of the plant as an index related to the operation of the plant based on the acquired process data; and

a display step of displaying the calculated operation ratio on a display device.