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TITLE OF THE INVENTION

A POWER PLANT OPERATION CONTROL SYSTEM AND A
POWER PLANT MAINTAINING AND MANAGING METHOD

5 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an operation
control system and a maintaining and managing method
for power generating facilities fit for
10 maintenance/management services of a power network
group consisting of a plurality of power supplying
facilities.

Related Background Art

Technologies on management of power generating
15 facilities have been disclosed in Japanese Non-
examined Patent Publications No. 10-301621 (1998), No.
11-3113 (1999), No. 7-152984 (1995), and No. 5-284252
(1993).

However, these technologies are all related to
20 processing in the inside of a power generating
facility such as instructions of operations, provision
of work information, and so on and do not include
centralized control and management of a plurality of
power generating facilities.

25 Real time diagnoses of a plurality of power

generating facilities such as facility failure
diagnosis, supervision for failure symptoms, facility
diagnosis by evaluation of performance using a
database have been requested between said power
5 generating facilities and an operation control system.

SUMMARY OF THE INVENTION

An object of the present invention is to provide
an operation control system and a maintaining and
10 managing method for power generating facilities fit
for maintenance/management services of a power network
group consisting of a plurality of power supplying
facilities.

The present invention is characterized by an
15 operation control system for controlling a plurality
of power generating facilities, comprising

means for gradually weighting the levels of
failures of said power generating facilities according
to operating status information of each of said power
20 generating facilities and

means for outputting preset information
corresponding to each weighted failure level.

Or the present invention is characterized by a
method of maintaining and managing a plurality of
25 power supplying facilities which supply power to

arbitrary power systems, comprising a step of
selecting a repairing period and procedure for a
failure which occurred in at least one of said power
supplying facilities from repairing periods and
5 procedures which are predetermined according to levels
of failures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a power generation facility network
10 to which the present invention is applied.

FIG. 2 is an explanatory illustration of a general
supervision/diagnosis system which is an embodiment of
the present invention.

FIG. 3 is an explanatory illustration of a general
15 supervision/diagnosis system and a repairing
supporting function.

FIG. 4 is an explanatory illustration of an
optimum scheduling supporting function and a system
stabilization supporting function

20 FIG. 5 is an explanatory illustration of a status
forecasting function.

FIG. 6 is a schematic diagram of a power
generation plant management system which shows a
positional embodiment of the operating method of the
25 present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows a power supplying system comprising a plurality of power generating facilities which include
5 a distributed power supply group which is an embodiment of the present invention. Below will be explained the present invention using the application to an arbitrary gas turbine combined power generating facility as an example.

10 Referring to FIG. 1, the system comprises a general supervision/diagnosis system 1 for managing a power supply system and a piece of control equipment 2 which supplies process quality information of a selected power generating facility to the diagnosing
15 system 1.

One of the power generating facilities is linked to a power system through a power regulator which regulates the voltage and power fluctuation of power generated by a generator 10 and a transformer 15 which
20 regulates power from the power regulator 14 into a voltage for the power system 16.

One of said power generating facilities consists of a compressor 3 which compresses air, a compressor inlet guide vane 11 which regulates the rate of an air
25 flow fed to the compressor 3, a fuel source regulating

valve 22 which regulates the rate of a fuel source sent from a fuel base 23, a diffusion fuel regulating valve 12 and a pre-mixed fuel regulating valve 13 which regulate the flow rates of fuel from the fuel source regulating valve 22 for diffusion and pre-mixing, a burner 4 which mixes and burns fuel sent from the diffusion fuel regulating valve 12 and the pre-mixed fuel regulating valve 13 and a compressed air from the compressor 3 and generates high-temperature combustion gas, a turbine 5 which recovers power from the combustion gas fed from the burner 4, a heat exchanging boiler 6 which recovers heat from the exhaust gas output from the turbine 5 and generates superheated steam, a steam pipe 7 which transfers superheated steam from the heat exchanging boiler 6 to a steam turbine 8, and a rotary shaft 9 which transfers a turning effort of the compressor 3, the turbine 5, and the steam turbine 8 to the generator 10.

Further, this system comprises another power generating facility 17 which is linked to the power system 16 in the same power network, a non-utility power generator or IPP facility 18 which is a distributed power supply, a distributed power supply system 19 which is a local network connecting a power generating facility 18, a circuit breaker 20 which

makes or breaks the connection between the power system 16 and the distributed power supply system 19, and a leased or satellite communication line 21 which transfers control signals from the general
5 supervision/diagnosis system 1 to the fuel base 23, another power generating facility 17, a distributed power facility 18, and so on. Here, the leased or satellite communication line 21 used as a telecommunication means in this embodiment can be
10 substituted by another communication means such as Internet.

In the normal operation status of this system, the general supervision/diagnosis system 1 usually monitors process quantities sent from said control
15 equipment 2 and provides the operation manager with daily management information required for operation, information about remaining service lives of expendables, etc.

When a failure occurs in this system, the general
20 supervision/diagnosis system 1 provides the operation manager with the level of the failure and information about possible causes of the failure. If the operation manager requires, this system secures the power quality of said power system 16 and provides
25 information on operations to protect the power

generating facility which has the failure.

Further, if a fatal failure which damages a power
generating facility occurs, this system provides
information required to shorten the repairing period
5 and minimizes the operating time of the power
generating facility which has the failure.

Below will be explained functions to materialize
the above operations.

FIG. 2 shows the content of the general
10 supervision/diagnosis system 1 of FIG. 1. The general
supervision/diagnosis system 1 is equipped with an
error supervision/diagnosis function 24 which receives
process supervision information and operation
instruction information from the control equipment 2
15 and diagnoses the operating status of target power
generating facilities and failure level judges 25
which determine the level of the failure according to
information sent from the error supervision/diagnosis
function 24.

20 This embodiment transfers operating status
information from respective power generating
facilities to the error supervision/diagnosis function
24 by a communication means. For easier judgment of
fault levels (or failure levels), information on
25 operating status and secular characteristic changes of

apparatus or information from operators of selected power generating facilities are used as the operating status information from respective power generating facilities. The failure level judges receive
5 information from the error supervision/diagnosis function 24 and give stepwise weights to failures according to the degrees of failures in the power generating facilities. For example, the description of this embodiment assumes there are three failure
10 levels: Fatal fault, Non-fatal fault 1, and Non-fatal fault 2. These weights are given according to time periods and procedures required for repairing or correction. A repairing period and a repairing procedure are assigned to each failure (fault) in
15 advance.

In details, the fault level judge 25 judges whether the failure is fatal or non-fatal. A failure which does not require stopping of a power generating system is judged to be non-fatal.

20 When the fault level judge 25 judges it as a non-fatal failure, the fault level judge 26 judges whether the failure is non-fatal fault 1 or non-fatal fault 2. A failure which may cause device damages when left unrepaired is judged to be non-fatal fault 1. A
25 failure which may cause no device damage when left

unrepaired is judged to be non-fatal fault 2. Failure information judged to be non-fatal fault 2 is sent to the fault level judge 27.

5 This embodiment comprises a status forecasting function 28 which forecasts the status of the power generating facility from information sent from the fault level judges 26 and 27.

10 When the fault level judge 25 judges that the failure is a fatal fault which requires stopping of the power generating facility, the fault level judge 25 sends the failure information to the optimum scheduling supporting function 36. This embodiment is constituted so that information may be transferred from this optimum scheduling supporting function 36 to 15 the pumping-up power facility control function 45, the system stabilization supporting function 46, the fuel base control function 47, and so on.

The status forecasting function 28 processes information as explained below. The information judged 20 to be non-fatal fault 1 is evaluated by the fault level evaluating function 29 whether the failure may propagate into an apparatus damage. The fault level evaluating function 29 sends the information to the recoverability evaluator 30.

25 Similarly, the information judged to be non-fatal

fault 2 is sent to the recoverability evaluator 30.

The recoverability evaluator 30 checks whether the status can be recovered by adjustment of control value settings, that is by changing control values. If it is possible, the information is sent to the control value
5 adjusting function 31. The function 31 performs remote tuning of control value settings and the like and adjusts the control quantities. If it is not possible, information is sent from the recoverability evaluator
10 30 to the fault propagation evaluating function 32.

The fault propagation evaluating function 32 is so constituted to display information about occurrence of a failure and forecasted result of propagation of the failure, to send the information to the repairing
15 supporting function 33, and to provide the operation manager with information about failure causes, repairing procedures, etc.

When a fatal failure which requires stopping of a facility occurs in a power generating facility, this
20 embodiment can immediately inform to the power generating facility or stop the operation of the power generating facility.

The optimum scheduling supporting function 36 processes information as follows. When the information
25 is judged to be fatal by the fault level judge 25, the

automatic plant stopping function 34 stops the power
generating facility which has the failure and
automatically stops. In this case, the automatic plant
stopping function 34 can send process quantities to
5 the repairing supporting function 35 and provide the
operation manager with information about failure
causes, repairing procedures, etc. When a fatal
failure which requires stopping of a facility occurs
in a power generating facility, this embodiment can
10 immediately inform to the power generating facility or
stop the operation of the power generating facility.

At almost the same time, information to stop the
power generating facility is sent from said automatic
plant stopping function 34 to the optimum scheduling
15 supporting function 36.

The optimum scheduling supporting function 36
checks, by the operating status judge (in the
identical system) 37, whether the other power
generating facility in the system which contains the
20 power generating facility which has stopped can take
over the load of the faulty power generating facility.
If the load can be taken over by the other power
generating facility, the operation control function
(in the identical system) 38 increases the load of a
25 running power generating facility which does not have

a failure and approximately at the same time, sends a "Change in Total Fuel Amount" signal for the fuel base 23 to said fuel base control function 47. Thus, if at least one of said power supplying facilities (power
5 generating facilities) fails, it is possible to assure the steady power supply of the whole power system comprising a plurality of power generating facilities by selecting a repairing period and procedure for the failure from repairing period periods and procedures
10 which are determined according to levels of failures and by controlling the operation of at least one of power supplying facilities except the faulty power supplying facility. It is also possible to control the power supplying facilities in the other power system,
15 the power supplying facility in the stop status, or the distributed power source facilities.

If the operating status judge (in identical system) 37 judges that the load cannot be taken over by the other power generating facility, the
20 information is sent to the operating status judge (in other power generating facility) 39 which judges whether the load of the faulty power generating facility can be taken over by a power generating facility in the other system. When the load can be
25 taken over by a power generating facility in the other

system, the operation control function (in other system) 40 increases the load of a running power generating facility and at the same time, sends a "Change in Total Fuel Amount" signal for the fuel base
5 23 to said fuel base control function 47.

If the operating status judge (in other power generating facility) 39 judges that the load cannot be taken over by any power generating facility in the other system, the information is sent to the operating
10 status judge (in other power generating facility) 41 which judges whether a power generating facility in the stop status can be started immediately. If the power generating facility in the stop status can be started immediately, the information is sent to the
15 operation control function (other power generating facility) 42 and the power generating facility in the stop status is started. Approximately at the same time, the "Change in Total Fuel Amount" signal for the fuel base 23 is sent to said fuel base control function 47

20 If the operating status judge (in other power generating facility) 41 judges that there is no power generating facility which can be started immediately, the information is sent to the operation status judge (decentralized power supply) 43 which judges whether
25 the load can be taken over by a running or stopping

distributed power source facility. If the load can be taken over by a distributed power source facility, the information is sent to the operation control function (distributed power supply) 44. The operation control
5 function 44 increases the load of the running distributed power source facility or starts a stopping distributed power source facility. Approximately at the same time, the "Change in Total Fuel Amount" signal for the fuel base 23 is sent to said fuel base
10 control function 47.

Information generated by said operation control functions 38, 40, 42, and 44 are sent to said system stabilization supporting function 46.

If the operation status judge (distributed power
15 supply) 43 judges that there is no power generating facility which can be started immediately, the information is sent to the operation control function (pumping-up power station) 45 and the load is taken by a pumping-up power generation.

20 As explained above, as failures of the power generating facilities are respectively given stepwise weights according to the operating status information of each power generating facility in the system, we can exactly grasp the level of a failure which
25 occurred in one power generating facility and its

location. Therefore, operations of a plurality of power generating facilities can be managed collectively, concentrating facilities and increasing the efficiency of management jobs. Particularly, this
5 embodiment is suitable for collectively controlling power generating facilities which are remotely dispersed.

Further, this embodiment is equipped with means for outputting preset information for each weighted
10 failure level. So a proper repairing action can be taken for a power generating facility which has a failure. Therefore, for quick repairing, it is preferential to send said repairing information to the section in charge of the operation of the power
15 generating facility or the operation supporting section and to dispatch service engineers to the facility. Further, as the repairing period and procedure fit for the failure can be obtained just by selection, quick and exact maintenance services can be
20 done on the power supplying facility which has a failure.

Referring FIG. 3, below will be explained the details of the error supervision/diagnosis function 24 and said repairing supporting functions 33 and 35 in
25 FIG. 2. FIG. 3 shows the functional block diagram of

said error supervision/diagnosis function 24 and said repairing supporting functions 33 and 35.

The error supervision/diagnosis function 24 performs as explained below. The error
5 supervision/diagnosis function 24 receives a run command signal 48 from the control equipment 2 and sends to the physical model simulator 50 which contains a set of tuning parameters 51 to eliminate a difference between the result of computation and the
10 result of actual operation.

The physical model simulator 50 calculates normal-operation process quantities which are expected when a facility is operated by said run command signal 48 and outputs the result to the subtractor 52.

15 The process quantity measurement signal 49 sent from the control equipment 2 is sent to the operation log database 56 which has a function to correct and update the normal/abnormal operation data by results of daily operations.

20 The operation log database 56 sends the information of measurement in the current operation status to said subtractor 52. The subtractor 52 sends the resulting difference information to the switch 53.

The switch 53 sends the difference information to
25 the fault diagnosing function 55 while the operation

is normal or to the parameter adjusting function 54 when the difference between the result of computation and the result of actual operation exceeds a preset limit even in the normal operation. If the output of the subtractor 52 exceeds a preset limit, the switch
5 sends the signal to the fault diagnosing function 55. The fault diagnosing function 55 compares the information from said switch 53 by data (normal operation data and abnormal operation data) from the
10 operation log database 56 and checks whether the operation is normal or abnormal. When assuming there may be a failure, the fault diagnosing function 55 outputs a Fault Detected signal 57.

When the switch 53 switches to send a signal from
15 said subtractor 52 to said parameter adjusting function 54, the function 54 outputs a signal which adjusts said tuning parameters 51 so that the difference between the result of computation by said simulator 50 and the normal operation data sent from
20 said operation log database may be zero. An offline identifying function is provided so that said parameter adjustment may be carried out while the plant is not in operation for safety. In this way, this embodiment can perform fault supervision and
25 diagnosis efficiently and accurately.

The repairing supporting functions 33 and 35 perform as explained below. When a plant has a failure, the fault locating function 59 locates a faulty part from the Fault Detected signal 57 and sends the
5 resulting information to the fault cause diagnosing function 60 and to the function 62 for selecting the shortest repairing procedure.

The fault cause diagnosing function 60 selects the most possible failure cause information from the fault
10 factors database 58 which classifies the failure information from the operation log database by locations and causes for management and outputs cause display information 61.

The function 62 for selecting the shortest
15 repairing procedure selects and outputs information of parts and procedures required to repair the failure in a very short time period from the replacement part inventory database 63 having information of the inventory of replacement parts and the repairing
20 procedure database 64 having repairing procedures that were actually carried out. This enables easy, accurate, and quick repairing of a faulty power generating facility.

Next will be explained the optimum scheduling
25 supporting function 36 and the system stabilization

supporting function 46, referring to FIG. 4

Operation information 66 from the control
equipment 2, other facility operation information 67
sent from other power generating facilities 17 and 18
5 in FIG. 1 through information transfer means 21, and
information coming from the statistic model database
68 which simulates the operation characteristics of
the other power generating facilities 17 and 18 are
fed to the operation schedule calculating function 69.
10 The operation schedule calculating function 69
calculates the operation schedules of the target power
generating facilities and sends the result to the
optimizing function 71.

The optimizing function 71 includes an evaluating
15 function 72 and an adjusting function 73. The
evaluating function 72 checks whether the entered
information satisfies conditions by functions that the
operation manager selects by the optimization
evaluating function selecting function 70 and sends
20 the result (information of judgment) to the adjusting
function 73. The adjusting function 73 feeds back a
signal for re-scheduling or partial modification so
that the result of operation by the operation schedule
calculating function 69 may be optimum. The signal
25 which is evaluated to be optimum by the evaluating

function 72 is output to a display unit 74 which displays the result of arithmetic operations. In this way, the operation schedule can be optimized.

Next will be explained the status forecasting
5 function 28. The run command signal 48 from the control equipment 2 is sent to a control system model 75 which contains an installation logic of the control equipment 2.

The control system model 75 contains a set of
10 tuning parameters 76 to eliminate a difference between the result of computation and the result of measurement of actual control operation ends. The control system model 75 calculates a control operation end instruction signal which is expected when the
15 facility is operated according to the operation instruction signal 48 and sends the result to the physical model base dynamic characteristics simulator 77.

The physical model base dynamic characteristics
20 simulator 77 calculates the process status quantity from the control signal and outputs the result to the subtractor 78.

The process quantity measurement signal 49 sent from the control equipment 2 is sent to the subtractor
25 78 through the operation log database 56. The

resulting difference information is sent to the evaluating function 79.

The evaluating function 79 sends a switching signal to the switch 81 and a signal to modify preset
5 control values for control of said control operation ends to the parameter regulating function 80.

The parameter regulating function 80 outputs a signal to adjust tuning parameters 76 so that the subtractor 78 outputs 0. This signal is fed to the
10 switch 81 and fed back as a signal for tuning the control setting by a switching signal sent from the evaluating function 79 when a failure occurs. An offline identifying function is provided so that said parameter adjustment may be carried out while the
15 plant is not in operation for safety. In this way, this embodiment can forecast the status efficiently and accurately.

Below will be explained a method of operating a plant to which the present invention is applied,
20 referring to FIG. 6.

Information from a power generation control panel 83 which controls and monitors the operating status of a power generation plant is coded and transmitted to the general control center 85 which contains functions
25 explained in FIG. 1 to FIG. 5 through a communication

line 90 which is a communication means. The coded information can protect the power generation control equipment 83 and the general control center 85 from violating interference from the outside.

5 The communication line 90 has a firewall function 89 and 91 to protect the system against violating accesses on each end of the line. The coded information can protect the power generation control equipment 83 and the general control center 85 from
10 violating interference from the outside.

 Further, the general control center 85 has an intranet 93 for communication which connects a database of apparatus drawing and specification data 94, a database of performance and life cycle
15 evaluation diagnosis data 95, a database of auxiliary parts data, and a database of common data 97 for designing and manufacturing sections so that the engineers in the general control center 85 may share the data. In other words, the engineers can use
20 apparatus drawing and specification data 94, performance and life cycle evaluation diagnosis data 95, auxiliary parts data 96, and common data 97 for designing and manufacturing sections through the general control center 85. This provides an excellent
25 facility maintenance/management service.

Operators and maintenance engineers 88 of the power generation plant 84, the general control center 85, and the service shop 86 which manages replacement parts are interconnected directly communication lines
5 92. This provides an excellent facility maintenance/management service.

For example, when the power generation plant 84 has a failure, the power generation control panel 83 or the operator or maintenance engineer 88 of the
10 plant 84 sends information to the general control center 85.

The general control center 85 sends plant recovery information obtained by functions in FIG. 1 to FIG. 5 to said power generation control panel 83, to said
15 operators and maintenance engineers 88, and to repairing instructors 87 who are dispatched upon request from said general control center 85. Said information is also sent to the service shop 86.

In this way, this embodiment can monitor a
20 plurality of remote power generation facilities and provide information for operators to control the operating status of the facilities if the facility has a possibility of failure. Further when one of the facilities fails, this embodiment can immediately
25 support recovery of the facility. The security

function when added to the communication means can prevent external interference by third parties.

5 This embodiment is very effective for a power supplying system comprising a plurality of power generating facilities linked to a power system and distributed power source facilities such as non-utility power generator, IPP, and fuel cells.

10 The present invention can provide an operation control system and a maintaining and managing method for power generating facilities fit for maintenance/management services of a power network group consisting of a plurality of power supplying facilities.

WHAT IS CLAIMED IS:

1. An operation control system for controlling a plurality of power generating facilities, comprising
means for gradually weighting the levels of
5 failures of said power generating facilities according to operating status information of each of said power generating facilities and
means for outputting preset information
corresponding to each weighted failure level.
- 10 2. An operation control system for collectively controlling a plurality of power generating facilities which are dispersed remotely or for supporting to control said distributed power generating facilities, comprising
15 means for transferring information on operating status and secular characteristic changes of apparatus from said power generating facilities or information from operators of selected power generating facilities,
means for processing and diagnosing information
20 transferred by said transferring means,
means for weighting the level of a failure of a power generating facility which has a failure according to the information sent from said processing and diagnosing means, and
25 means for selecting related repairing information

from repairing information prepared for each of said failure weights and transmitting thereof to the related operation section and the operation supporting section of said power plant.

5 3. An operation control system in accordance with Claim 2, further comprising means for transmitting said repairing information to a location which requires repairing or to a repairing personnel when said power generating facility has a failure to be
10 repaired.

 4. An operation control system for power generating facilities comprising a control facility which maintains and controls a plurality of power supplying facilities, wherein said control facility
15 selects from repairing period periods and procedures required to repair failures which occur in said plurality of power supplying facilities and performs maintenance and management of power supplying facilities which have failures.

20 5. A method of maintaining and managing a plurality of power supplying facilities which supply power to arbitrary power systems, comprising the steps of

 selecting some possible causes for a failure which
25 occurred in at least one of said power supplying

facilities in the order of highest possibility to
lowest possibility and information of a phenomenon
which may extend or propagate if the failure is left
unpaired, and

presenting the selected item information.

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