CONCENTRATE SOLAR THERMAL ENERGY ELECTRIC POWER PLANT LOGIC BOILER

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ABSTRACT

A logic boiler that consists of a concentrated solar energy boiler, a thermal storage system, and a traditional fossil fuel boiler is replacement of the traditional fossil fuel boiler in a power plant for solar thermal electric power generation. The thermal storage system or fossil fuel boiler compensates the output steam of the solar energy boiler to provide on demand, reliable and regulated steam for steam turbine. The controls sequences provide results that maximize the output of the solar boiler while provide the regulated and fast responded steam to the turbine. The control sequences also provide an algorithm to store excessive thermal energy from the solar energy boiler into the thermal storage system. The power plant sees the logic boiler as a conventional boiler without knowing the details of working sequences between the solar boiler and fossil fuel boiler or thermal storage.

Power Plant with Logic Boiler
Figure 3. Driver Disable Functions for Redundancy Control.
Figure 4. Reset Level Controller.
CONCENTRATE SOLAR THERMAL
ENERGY ELECTRIC POWER PLANT LOGIC
BOILER

BACKGROUND OF THE INVENTION

[0001] Field of the Invention
[0002] The present invention relates to a logic boiler constructed from a concentrated solar thermal energy boiler and a fossil fuel boiler or a thermal storage system for generating steam in a solar energy electric power plant.

[0003] Description of Prior Art
[0004] The concentrated solar thermal energy boiler provides clean and fuel burning free steam.

[0005] The solar energy is not controllable. It is different from daytime to evening; it is different from summer to winter, and it different from good weather to bad weather. The uncontrollable solar energy results that steam from the solar boiler is also not controllable, and does not meet the stable and controllable requirements of both large steam turbine and power grid.

[0006] The steam turbines, especially large steam turbines require stable and controllable steam input, otherwise, the lifetime of the turbine may be reduced or unexpected operating situations may be occurred.

[0007] Additional to un-predictable solar flux, the concentrated solar thermal energy boiler is also a complex device, it may contains thousands components and controlled by sophisticated computer programs.

[0008] For the fossil fuel boiler, when the steam is on a demand for more, the controller can increase the fuel supply to raise the output. For the concentrated solar energy boiler, the solar energy supply is not controllable.

[0009] Since the steam from the solar boiler is fuel burning free, so the power plant control system should set the solar boiler is maximum mode to gain the maximum energy solar energy collections, unless in emergency situations. The excessive energy from solar boiler can be saved in the thermal storage system if the storage system is installed. Otherwise, the solar energy collection areas will be reduces to match the steam demands from the turbine and power generator.

[0010] The steam-based power plants are based on much matured technologies. In addition, the power grid has developed a protocol to interface with the steam based power plant. For a large-scale solar thermal energy power plant, it is very important not only to provide solar electric power, it is also very important to provide high quality electric to the grid. For the best interest of the grid, the power plant should be able to send operating information as well as receiving the commands from the grid. Since the energy source of the concentrated solar energy electric power plant is not controllable, therefore, a second energy source or buffer must add to the power plant to provide the required flexibility.

[0011] From the power plant power of view, the logic boiler is identical to a high performance fossil fuel boiler. The logic boiler provide a set of current running parameters and predicted parameters to the power plant controller while receiving the commands from the power plant controllers.

BRIEF SUMMARY OF THE INVENTION

[0012] A logic boiler for steam-based power plant consists a master controller, a concentrated solar energy boiler and a fossil fuel boiler or thermal storage system. The logic boiler is a replacement for the boiler of a conventional steam based power plant, and provides a stable and controllable steam to the turbine for electricity generations.

[0013] FIG. 1 shows the schematics of a power plant with a logic boiler. Both fossil fuel boiler and thermal storage are included in the schematics. In practice, only one of them is required, either fossil fuel boiler or thermal storage.

[0014] The high-pressure water feeds into the solar boiler in the central receiving tower, the fossil fuel boiler, and the thermal storage. The output steam from three boiler and mixed at steam mixer. The output of the steam mixer is then feed to steam turbine.

[0015] The inputs and outputs of all components of the logic boiler are equipped with sensors that measuring the water level, temperature, pressure, and flow speed of the water and steam. All information is send to logic boiler controller. The boiler controller reads information from sensors and drives the valves until pre-set running parameters are met. The boiler controller is a computer based with redundancy in the case of the failure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 shows a schematic diagram of a power plant with a logic boiler in accordance with the principles of the inventions;

[0017] FIG. 2 shows a the relationship between power plant control master, the boiler master computers, the boiler networks, the solar tower boiler controllers, the fossil fuel boiler controllers, the thermal storages, and the logic level controllers;

[0018] FIG. 3 shows a schematic diagram of the driver disable functions for boiler controller redundancy controls;

[0019] FIG. 4 shows a schematic diagram of the reset logic of logic boiler controllers;

[0020] FIG. 5 shows a schematic diagram of the steam mixer;

[0021] FIG. 6 shows a schematic diagram of a power plant with a logic boiler that supports reheat of steam in accordance with the principles of the inventions.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The logic boiler consists of the solar boiler, the fossil fuel boiler and thermal storage as shown in FIG. 1. The high-pressure water from the steam condenser is pumped by 102 P1 and then feed into boilers. The water levels in the boilers are monitored by sensors and controlled by logic boiler controller through 114 V3, 113 V4, and 112 V5.

[0023] The values 114 V3, 113 V4, and 112 V5 are linear valves with redundancy that they can response to the command from the boiler controller to control the water flow rate, resulting control the water levels in the boilers.

[0024] The outputs of the boilers are connected steam mixer through valves 110 V9, and 108 V7. 110 V9, 108 V7, and 107 V8 are on and off valves with redundancy for boilers to be online or offline from the system.

[0025] The values 108 V7 and 115 V2 are thermal charge values with redundancy. They are will be "on" when the thermal storage is on charge mode, and will be "off" when the thermal storage is on discharge mode.
The mixer mixes the steam from the boilers following the commands of the boiler controller. The detail structure of the mixer is illustrated by Fig. 5. 504 S1, 505 S2, 506 S3, 514 S4, and 517 S5 are sensors for temperature, pressure and flow rate. 508 V1, 510 V1.2, 512 V1.3, and 516 V1.4 are linear values with redundancy and controlled by the boiler controller. Buffer is a steam storage unit for stabilizing the steam and better mixing.

[0028] Fig. 2 shows the structure of the schematic diagram of the logic boiler controller. The power plant feed or receiving information to or from the boiler master computers. The 202 boiler master computer 1 and 203 boiler computer 2 are redundant to each other. The boiler master computers are communicating with modules in logic boilers through two redundant networks, 204 boiler net1 and 205 boiler net2.

[0029] Within the logic boiler controller, there are four models; they are 206 and 207 solar tower boiler controller, 208 and 209 fossil fuel boiler controller, 210 and 211 thermal storage controller, and 212 and 213 logic level controller.

[0030] The 206 and 207 solar tower boiler controller controls concentrate mirrors and detail operation of the receivers.

[0031] The 208 and 209 fossil fuel boiler controls the traditional fossil fuel boiler.

[0032] The 210 and 211 thermal storage controller controls the thermal storage.

[0033] The 212 and 213 logic level controller controls the detail operation of the logic boiler. It controls all values 214000 to 214nm through and read all sensors 215000 to 215 nm. They are microprocessor based with redundancy.

[0034] Each sensor (215000 to 215 nm) contains three sub-sensor and they are redundant to each other. Each sub-sensor has two independent outputs and connected to two redundant microprocessors. The active microprocessor will receive three independent readings from each sensor. Only two readings in agreement will be used, and the third reading has to be within the critical range, otherwise the alarm will be triggered.

[0035] The controller drivers (214000 to 214 mmm) are designed to support redundancy. Fig. 3 shows the schematic diagram of the disable function of the driver. Each value is connected with two separated wires from two separate drivers of the logic level controllers. When a driver output monitored by the sensors is not in agreement with the intent states, this driver will be disabled by it's redundant microprocessor through "high" state signal and buffer 304 B2. By doing this, it will cut off the connection of current driver and will allow the redundant driver to take over the control of the value.

[0036] Each pair of the redundant computers are controlled through the inter reset logic unit are illustrated in Fig. 4. The reset can be at different levels, such as interrupt, reset, and disable.

[0037] There are three operation modes: solar boiler with thermal storage, solar boiler with fossil fuel boiler; and thermal storage with fossil fuel boiler.

[0038] When the solar boiler works with thermal storage, it contains two operational states: thermal storage charge state and thermal storage discharge state.

During the thermal storage charge state, the excessive thermal energy will send to thermal storage through valve 108 V7. The steam will deposit its energy and be condensed becoming water through 118 the thermal energy exchange with the storage material. The condensed water will be pumped by 117 P2 and send back to boilers.

During the thermal storage discharge state, the steam from the solar boiler is with parameter to maximize the solar receiving efficiency. Since the solar energy is not a stable source, the output of the thermal storage will be adjusted to compensate the steam parameter from solar boiler and the needs of the turbine.

When the solar boiler is working with 119 fossil fuel boiler, the operation is relative simple. The output of the fossil fuel boiler will compensates the variation of the output of the solar boiler and matches the demands of the steam turbine.

When 118 the thermal storage is used to provide steam for the turbine, no need for the fossil fuel boiler to be online. But, on the other hand, with the help of the fossil fuel boiler, the total energy discharge of the thermal storage can be maximized.

Fig. 6 illustrates re-heater system for turbine. The high-pressure output of 604 turbine is re-heated by heat exchange 605. The steam temperature from 607 steam mixer is higher than the required temperature of the turbine. The higher temperature steam deposits partial energy to the lower pressure steam and raise the temperature of the middle pressure steam to boost the efficiency of the thermal cycle.

What is claimed is:

1. A logic boiler is designed to be in replacement of the conventional boiler in a fossil fuel burned steam power plant, is controlled and monitored by valves, redundant sensors and redundant controllers, is taking the commands from the power plant controller and send requested information back to power plant controller, is with redundant circuits for reliabilities, provides stable, on demand, and reliable steam to turbine, provides thermal storage energy charge and discharge functions, consists of a steam mixer, consists of a solar boiler and a thermal storage system, or consists of a solar boiler and a fossil fuel boiler, or a solar boiler and a thermal storage system and a fossil fuel boiler.

2. A logic boiler controller as set forth in claim 1 wherein said controller consists of redundant boiler master computers, redundant boiler local area networks, redundant solar tower boiler controllers, optional redundant fossil fuel boiler controllers, optional redundant thermal storage controllers, and redundant logic level controllers with redundant drivers and redundant sensors.

3. A logic boiler steam mixer as set forth in claim 1 wherein said mixer consists of sensors for monitoring the input steam parameters, controllable valves for adjust input steam flow rate, a buffer for helping to regulate the output steam conditions, a sensor for monitoring the steam parameters in the buffer, a controllable value for adjust the output steam parameters, and a sensor for monitoring the output steam parameters.

4. The redundant circuits as set forth in claim 1 wherein said redundant circuits consist of computer or microprocessor reset level circuits, the sensor redundancy circuits, and the redundant driver circuits.

5. The thermal storage charge and discharge functions as set forth in claim 1 wherein said thermal storage energy
charge and discharge functions are controlled by the logic boiler controller through reroute the steam to thermal storage system and internal working mode of the thermal storage system.

6. The computer or microprocessor reset level circuits as set forth in claim 4 wherein said computer or microprocessor reset level circuits consists of input and output buffers, and reset level decoders, is controlled by the redundant computer or microprocessor. The reset algorithm start with the level 1, if failed, it will go level 2, and then if failed again, it will go next high level.

7. The sensor redundancy circuits as set forth in claim 4 wherein said sensor redundancy circuits consists of at least three set of sensors and two pair of independent read out systems that connect to microprocessor of redundant to each other.