A solar tower central receiver with separated boiler and Super-Heater allows better control on the output steam’s temperature. The boiler takes higher solar flux density and works at lower temperature while the Super-Heater takes lower solar flux and works at high temperature to optimize the cost to performance ratio. The solar fluxes of the boiler and super-heater are adjustable through the pointing of the heliostats. The boiler consists of parallel pipes as solar absorber and the Super-Heater consists of helix parallel pipes as solar absorber. The steam drum chamber interconnects boiler and Super-Heater. The absorb pipes and circulation pipes are connected to water chamber, steam drum chamber, and Super-Heater chambers. The water level sensor and temperature sensors provide information regarding the operating status of the receiver.
Figure 4 steam and water flow direction.
METHOD AND APPARATUS OF SOLAR CENTRAL RECEIVER WITH BOILER AND SUPER-HEATER

BACKGROUND OF THE INVENTION

[0001] The present invention broadly relates to a central solar energy receiver and more particularly it relates to a solar energy receiver assembly for receiving radiant energy and generating steam from water. In a particularly preferred embodiment of the invention, it relates to a central solar energy receiver assembly for use in the solar tower power plant.

[0002] The present invention relates to a central solar receiver with separated boiler and steam super heater for solar tower thermal power plant.

[0003] The solar energy flux is not a constant or controllable during the operating hours. The solar flux varies from daytime to evening, from summer to winter, and from good to bad whether, resulting that received energy density on central receiver is not constant, and is depending on the azimuth angles. The central receiver requires special cares before the optimized performance to cost ratio and high reliability to be reached. A high performance solar central receiver must be able to tolerate a large number of thermal shock cycles during its’ lifetime. It should also be able to tolerate the un-even solar flux from different azimuth angle.

[0004] With separated boiler and super-heater architecture, the boiler can be designed to work only below the critical temperature; it can have effective water circulation system to keep the water in side boiler at different locations within a close temperature range to avoid un-wanted stress. The boiler can be build by less exotic material at lower cost.

[0005] Based on thermal dynamics theory, the boiler will absorb over 75% of the solar energy and the Super-Heater will take less than 25%. The super heater is working at higher temperature and the coolant is steam, which is far less effective of cooling than water, but on the other hand, it required taking less energy flux. The thermal shock and thermal stress issues are needed to be paying more attention.

[0006] When the absorber is cooled with mixed water and steam, the maximum energy density is limited as when it is cooled by steam only. With separated boiler and super heater, the boiler can take higher energy density while the super heater takes as steam cooled absorber, the average energy density of the absorber can be easily doubled.

BRIEF SUMMARY OF THE INVENTION

[0007] A solar tower central receiver contains a boiler and a steam super heater. A drum interconnects the boiler and super heater, and is for separating the steam from water. With well-controlled thermal dynamic properties and income solar flux density, the receiver is designed to take much higher energy density, and tolerate more on thermal stresses.

[0008] The boiler is constructed with four major components: the water chamber, the drum for separating water and steam, parallel absorb pipes and circulation pipes. The super heater is constructed by steam chamber, helix parallel absorb pipes and drum which is shared with the boiler.

[0009] The separated boiler and super heater plus the helix parallel super heater absorb allow the receiver to take much higher solar flux density and avoid the thermal stresses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 shows the solar central tower receiver system;

[0011] FIG. 2 shows two parallel pipes of the boiler and a circulation pipe;

[0012] FIG. 3 shows a helix pipe of the super heater;

[0013] FIG. 4 shows the flow of the flow directions of the water and steam;

DETAILED DESCRIPTION OF THE INVENTION

[0014] The central receiver system is illustrated in FIG. 1. A solar tower central receiver assembly contains a boiler 104 and a steam super heater 102. A drum 103 interconnects the boiler and super heater, and is for separating the steam from water. The drum 103 interconnects the boiler and super heater, and is for separating the steam from water. With well-controlled thermal dynamic properties and income solar flux density, the receiver is designed to take much higher energy density, and tolerate more on thermal stresses.

[0015] The boiler assembly as illustrated by FIG. 2 is constructed with four major components: the water chamber 204, the drum for separating water and steam 201, parallel absorb pipes 202 and circulation pipes 203.

[0016] The water chamber 204 is at the bottom of the boiler and drum 201 is at the top of the boiler. The parallel absorb pipes 202 are between the water chamber and drum with one end connected to water chamber 204 and another end connected to drum 201.

[0017] Water feed into water chamber 204, heated up when it is flowing through the absorb pipes 202 by the income solar photons reflected from the heliostats. When the water reached the vaporization temperature, some bobbles will be formed and mixed with water. Because the mixed water and bobbles has lower mass density, they will flow up into the drum 201. In the drum 201, the steam and water will be separated that steam will be at higher half and water at the lower half. The steam will flow out through the output pipes on the top of the drum 201. The water at lower half of the drum will be then circulating through the circulation pipes 203 with one end connected at the bottom of the drum 201 and another end connected to the water chamber 204.

[0018] As the steam flow out from the output pipes, the water level will be reduced in the drum 201; the fresh new water will be feed into water chamber 204 and to force the water level at drum 201 to be at a constant level.

[0019] The super heater is illustrated by FIG. 3. Where the steam and water separation drum 303 (which is also called 201 in FIG. 2) is located at the bottom of the super heater, and the steam chamber 301 is at the top of the super heater. The absorber is made of helix parallel pipes 302 with one end connected to the drum 303 and another end connected to the steam chamber 301.

[0020] The helix parallel pipes 302 has the best performance on tolerate the thermal stresses. It is free for expansion. In addition, the coolant inside of the pipe provides better thermal exchange than straight pipes because of centrifuge force and higher density of the cooler coolant creating turbulence flow.
The output the super heater has uniform temperature because the absorber can tolerate the solar flux variation at different azimuth angles.

The steam come out the steam and water separation drum of the boiler will be send to super heater and heated to the working temperature.

The two end sides of a parallel absorb pipe of the boiler are shift from neighbor pipes for easy repair accesses.

The up side end of the parallel absorb pipe of the boiler is connected to out-side of the drum and the up side of a circulation pipe is connected to the bottom side of the drum to issue the water circulation.

Sensors with fault tolerances monitors on the water level are inside of the drum.

The boiler and the super heater share the same steam and water separation drum. One end of the boiler absorb pipes are connected at the bottom half of the drum, and the top end of the super heater absorb pipes are connected to the top half of the drum.

FIG. 4 shows the steam and water flow directions.

There are two redundant mechanical emergency release valves installed on the steam chamber at the top of the receiver. They provide emergency pressure release.

Multiple sensors are installed at various locations of the receiver to monitor the working temperature.

What is claimed is:

1. A solar tower central receiver is designed to accept high concentrated solar energy to generate high temperature and high-pressure steam for a steam turbine, consists a boiler and a Super-Heater module, that Super-Heater is positioned above the boiler. Three or more water level sensors are installed on the drum chamber to monitoring the water level of the chamber. The temperature sensors and pressure sensors are installed on the receiver for monitoring the temperature and pressure of the receiver.

(a) The central receiver consists of boiler and super-heater;

(b) The super-heater is made by helix solar radiation absorb pipes;

(c) The size of the receiver and running protocols of the heliostat field is designed to make the solar intensities on boiler and super-heater controllable;

2. A boiler as set forth in claim 1 wherein said boiler consists of a water chamber at the bottom of the boiler, a drum at the top of the boiler, and straight parallel solar absorb pipes between bottom chamber and drum, and water circulation pipes that connects between drum and bottom chamber. The sensors installed on the drum and chambers provide information to keep the boiler running under water critical parameters.

3. A steam super-heater as set forth in claim 1 wherein said steam Super-Heater consists of a steam chamber at top of the module and a drum at bottom of the device, where the drum is shared with the boiler, and helix parallel solar absorb pipes between drum and top chambers with the connection to the water and steam separation chamber at top of the chamber. The sensors installed on the module provide information to keep the module running within the safe range. Two redundant emergency mechanical steam release valves are installed on the top of the steam chamber to keep system pressure and temperature within safe range.

4. The size of the modules as set forth in claim 1 wherein the size is optimized between the sizes of the spots from the longest distant away heliostats from the geo-optic limitations, wind turbulences, the thermal losses and the cost of the manufacturing. The geo-optic limitation is 0.8% of the distance, the wind influences is about 1 sigma of the standard deviations.

5. The method of the operating the central receiver as set forth in claim 1 wherein the method consists using the smaller spot from the closer heliostat to adjust energy intensity ratio between two modules.

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