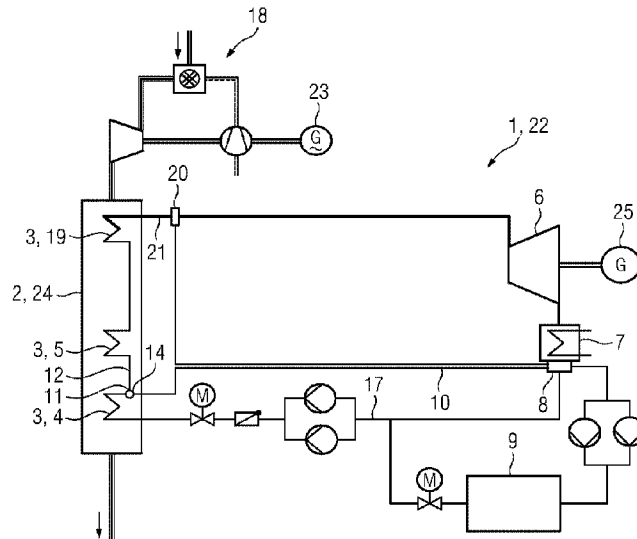




(86) Date de dépôt PCT/PCT Filing Date: 2020/02/17
 (87) Date publication PCT/PCT Publication Date: 2020/11/19
 (45) Date de délivrance/Issue Date: 2023/10/24
 (85) Entrée phase nationale/National Entry: 2021/11/12
 (86) N° demande PCT/PCT Application No.: EP 2020/054074
 (87) N° publication PCT/PCT Publication No.: 2020/229001
 (30) Priorité/Priority: 2019/05/15 (EP19174635.3)

(51) Cl.Int./Int.Cl. *F01K 13/02* (2006.01),
F01K 11/02 (2006.01), *F01K 23/10* (2006.01),
F22B 35/10 (2006.01), *F22B 37/26* (2006.01),
F22D 11/00 (2006.01)
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(54) Titre : CENTRALE ELECTRIQUE ET PROCEDURE DE NETTOYAGE D'EAU POUR UN CYCLE EAU/VAPEUR A PASSAGE UNIQUE D'UNE CENTRALE ELECTRIQUE
 (54) Title: POWER PLANT AND WATER CLEANING METHOD FOR A ONCE-THROUGH WATER/STEAM CYCLE OF A POWER PLANT



(57) **Abrégé/Abstract:**

A power plant with a water-steam-cycle includes a steam generator with a plurality of heating surfaces that carry a fluid and transfer heat to the fluid. The plurality of heating surfaces has an economizer for preheating the fluid and a fluidly connected evaporator for producing steam. A steam turbine receives the steam produced in the steam generator to generate power output. A condenser condenses steam from the steam turbine. The condenser has a hotwell as collection container for condensed steam or water. A polishing plant is arranged fluidly between the hotwell of the condenser and the economizer. A drain line interconnects an outlet of the economizer and the hotwell of the condenser. A fluid line interconnects the outlet of the economizer and the evaporator. The fluid line includes a syphon to hold back water in the economizer.

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ABSTRACT

A power plant with a water-steam-cycle includes a steam generator with a plurality of heating surfaces that carry a fluid and transfer heat to the fluid. The plurality of heating surfaces has an economizer for preheating the fluid and a fluidly connected evaporator for producing steam. A steam turbine receives the steam produced in the steam generator to generate power output. A condenser condenses steam from the steam turbine. The condenser has a hotwell as collection container for condensed steam or water. A polishing plant is arranged fluidly between the hotwell of the condenser and the economizer. A drain line interconnects an outlet of the economizer and the hotwell of the condenser. A fluid line interconnects the outlet of the economizer and the evaporator. The fluid line includes a syphon to hold back water in the economizer.

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POWER PLANT AND WATER CLEANING METHOD FOR A ONCE-THROUGH
WATER/STEAM CYCLE OF A POWER PLANT

5 FIELD OF THE INVENTION

The present invention relates to a power plant and a water cleaning method for a once-through water-steam cycle of a power plant.

10

More specifically, the invention relates to water cleaning during start-up of the power plant.

15 BACKGROUND OF THE INVENTION

According to the state of the art, in the bottoming cycle of for example a combined cycle power plant the iron content in the water can be too high, especially when the water has been
20 standing still in the heat recovery steam generator for a while. This iron needs to be removed from the water before it is all turned into steam, to avoid damage in equipment downstream of the evaporator part in the heat recovery steam generator.

25

Known combined cycle power plants with a once-through steam generation system typically comprise a separator arranged in the heat recovery steam generator and installed to separate the water fraction (containing the dissolved iron) and to take that

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water fraction out of the steam flow. The separated water fraction is then thrown away or can be further cleaned.

5 A typical disadvantage of such an arrangement is that a separator requires extra connections, piping, and a support structure. This makes the heat recovery steam generator heavier, more complex and more voluminous.

10 It is therefore a goal of the present invention to provide a power plant, which overcomes the above-mentioned disadvantage. A further goal of the invention is to provide a water cleaning method for a power plant with water-steam-cycle.

15 SUMMARY OF THE INVENTION

In accordance with the invention there is provided a power plant with a water-steam-cycle. The power plant comprises a steam generator with a plurality of heating surfaces configured
20 to carry a fluid and to transfer heat to said fluid, the plurality of heating surfaces comprising an economizer for preheating said fluid and an evaporator for producing steam, the evaporator being fluidly connected to the economizer. The power plant further comprises a steam turbine that is
25 configured to receive the steam produced in the steam generator to generate power output; the power plant also comprises a condenser configured to condense steam from the steam turbine, the condenser comprising a hotwell as collection container for condensed steam or water. Finally, the power plant also
30 comprises a polishing plant that is arranged fluidly between

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the hotwell of the condenser and the economizer. A drain line interconnects an outlet of the economizer and the hotwell of the condenser and a fluid line interconnects the outlet of the economizer and the evaporator and the fluid line comprises
5 means to hold back water in the economizer. The invention is characterized in that tubes at the outlet header of the economizer are bent upwards to create a syphon.

In other words, in preparation of the start-up of the power
10 plant, the water contained in the economizer (the rest of the steam generator is empty during stand-still) is pumped through the drain to the hotwell, where it is diluted and the water from there is led at least partly through the polishing plant and cleaned. As soon as the water in the economizer has been
15 replaced by clean water from the hotwell and the polishing plant, the steam generator is ready to start-up. When the water from the hotwell is not of the correct quality, water can be circulated over this drain and led through the polishing plant until it is clean enough for starting the steam generator.

20

A syphon carries out its function passively without any moveable components and its thermal stability is identical to the other tubes in the steam generator. Depending on the syphon's height above the inlet of the economizer, a part of
25 the preheated water may get into evaporator and superheater tubes. This fluid would have to be drained afterwards.

Therefore, it is advantageous, when the cyphon reaches till above the inlet header of the economizer, even more
30 advantageously as high as possible.

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In an embodiment of the power plant according to the invention, at the outlet of the economizer an outlet header for collecting preheated feedwater and for evenly spreading this preheated
5 feedwater over the evaporator tubes is arranged. From this outlet header the drain line to the hotwell and the fluid line to the evaporator branch off.

According to an embodiment a polishing plant is arranged
10 fluidly between the hotwell of the condenser and the economizer and a capacity of the polishing plant in parallel flow to a main condensate line is less than 100% of an amount of water supplied to the economizer at base load.

15 The invention is applicable to all power plants with a water-steam-cycle. It is particularly advantageous when the heat source for the steam generator is a gas turbine.

According to another aspect of the present invention, there is
20 provided a method for starting operation of a power plant with a water-steam-cycle, wherein the power plant comprises a steam generator with a plurality of heating surfaces forming at least an economizer, a steam turbine and a condenser comprising a hotwell, the method comprising: draining water contained in the
25 economizer to the hotwell, where it is diluted, leading water from the hotwell at least in part through a polishing plant in order to clean it, supplying the economizer with water from the hotwell and water from the polishing plant, and starting-up the steam generator as soon as at least a part of the water in the
30 economizer has been replaced by clean water from the hotwell

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and the polishing plant, wherein water getting over syphon tubes at an economizer outlet into evaporator and superheater tubes is drained by a drip leg at a steam generator outlet and led to the hotwell.

5

The advantages of this method largely correspond to the above-mentioned advantages of the power plant.

10 Preferably, water is continuously drained from the economizer, led at least partly through the polishing plant and supplied to the economizer in case water from the hotwell and the polishing plant is not of a required quality, until it is clean enough for starting the steam generator.

15 It is appropriate that water contained in the economizer is drained by pumping boiler feedwater into the economizer and where applicable by opening a drain at an economizer outlet header.

20 Expediently, the circulation of water is maintained until an iron level is low enough.

An important advantage of the power plant according to the present invention is the implementation of a mechanical
25 arrangement such that only the economizer contains water at standstill, and that an intermediate loop can be formed to circulate the water over the polishing plant until it is clean.

This leads to a very compact design of the bundle, and no
30 separator and connecting piping is needed anymore. This saves a

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lot of weight and volume, resulting in a lighter and more compact steam generator. This can amount to 20% weight saving, which especially for offshore applications is very important.

5 Furthermore, the size of the polishing plant can be kept small. Another way to clean up the water that is used, is to install a polishing plant of 100% capacity, and all the water is led through this polishing plant. While filling the steam generator, just prior to start-up, it is with clean water. With
10 this new system the steam generator doesn't need to be drained and refilled, and the polishing plant can be kept at its regular size of about 50%.

Keeping always water in (a part of) the bundle drastically
15 reduces temperature excursions and thus thermal shocks, while in some other designs a gas turbine is started while the heating surfaces are empty, creating severe thermal stresses when filling the heating surfaces. Therefore, the new design is much better suited for fast starting and flexible operation
20 because of this avoidance of thermal stresses.

Especially for offshore applications significant savings are made in weight and space, making the use of e.g. a combined cycle power plant more attractive, or use this as a steam tail
25 for existing simple cycle operating gas turbines (where adding weight on an existing platform or ship is strictly limited).

BRIEF DESCRIPTION OF THE DRAWINGS

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Embodiments of the invention are now described, by way of example only, with reference to the accompanying drawings, of which:

5 Figure 1 shows a power plant; and

Figure 2 shows a heat recovery steam generator bundle of the inventive power plant.

10 The illustration in the drawings is in schematic form. It is noted that in different figures, similar or identical elements may be provided with the same reference signs.

15 DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates a schematic diagram of a power plant 1 according to the invention. As illustrated in the exemplary embodiment of Figure 1 the power plant 1 may be a combined
20 cycle power plant 22, including a gas turbine 18. The gas turbine 18 generates power output from combustion of a fuel gas and air mixture. In the embodiment of Figure 1 the gas turbine 18 is connected to a first generator 23. The gas turbine 18 produces exhaust gas at an exit of the gas turbine 18.

25

According to the embodiment of figure 1 a combined cycle power plant 22 includes a steam generator 2, or more specifically a heat recovery steam generator 24, which is located downstream of the gas turbine 18. The heat recovery steam generator 24
30 receives the exhaust gas from the gas turbine 18. The heat

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recovery steam generator 24 comprises a plurality of heating surfaces 3. A heat recovery steam generator 24 usually includes multiple pressure steam systems. In the illustrated example embodiment of Figure 1, for the sake of simplicity, the heating surfaces of the heat recovery steam generator 24 belong to only one pressure system and comprise a superheater 19, an evaporator 5 and an economizer 4. The exhaust gas flows across the heating surfaces 3 to produce steam by extracting energy from the exhaust gas.

10

According to the embodiment of in Figure 1, a combined cycle power plant 22 also includes a steam turbine 6 that is configured to receive the steam produced in the heat recovery steam generator 24 to generate power output.

15

The combined cycle power plant 22 illustrated in Figure 1 is in a multi-shaft configuration. The steam turbine 6 is connected to a second generator 25. The invention is of course also applicable to a single shaft configuration.

20

According to the embodiment, a condenser 7 is located at an exit of the steam turbine 6 and is configured to condense steam from the steam turbine 6, the condenser 7 comprising a hotwell 8 as collection container for condensed steam or water.

25

The power plant 1 of Figure 1 also shows a main condensate line 17 interconnecting hotwell 8 and economizer 4. In parallel to the condensate line 17 a polishing plant 9 is arranged fluidly between the hotwell 8 of the condenser 7 and the economizer 4.

30 The polishing plant 9 removes impurities, that could cause

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damage to the steam generator 2 or the steam turbine, from the condensate.

Condenser 7 (+ polishing plant 9), steam generator 2 and steam
5 turbine 6 form a water-steam cycle.

Figure 2 shows a more detailed view of the steam generator 2 for economizer 4 and evaporator 5, where a drain line 10 interconnects an outlet header 14 arranged at an outlet 11 of the economizer 4 and the hotwell 8 of the condenser 7 and where
10 a fluid line 12 interconnects the outlet 11 of the economizer 4 and the evaporator 5. According to the invention the fluid line 12 comprises means 13 to hold back water in the economizer 4 during standstill. The means 13 to hold back water is a syphon
15 15 that reaches above an inlet header 16 of the economizer 4. In case water is getting over the syphon 15 at the economizer outlet 11 into evaporator 5 and superheater 19 tubes, it is drained by a drip leg 20 at a heat recovery steam generator outlet 21 and led to the hotwell 8.

20

Although the present invention has been described in detail with reference to an embodiment, it is to be understood that the present invention is not limited by the disclosed example, and that numerous additional modifications and variations could
25 be made thereto by a person skilled in the art without departing from the scope of the invention.

CLAIMS:

1. A power plant with a water-steam-cycle comprising:
a steam generator with a plurality of heating surfaces configured to carry a fluid and to transfer heat to said fluid, the plurality of heating surfaces comprising an economizer for preheating said fluid and an evaporator for producing steam, the evaporator being fluidly connected to the economizer,
a steam turbine that is configured to receive the steam produced in the steam generator to generate power output;
a condenser configured to condense steam from the steam turbine, the condenser comprising a hotwell as collection container for condensed steam or water,
a polishing plant that is arranged fluidly between the hotwell of the condenser and the economizer,
wherein a drain line interconnects an outlet of the economizer and the hotwell of the condenser and wherein a fluid line interconnects the outlet of the economizer and the evaporator, wherein the fluid line comprises means to hold back water in the economizer, wherein the means to hold back water is a syphon.
2. The power plant according to claim 1, wherein the syphon reaches above an inlet header of the economizer.
3. The power plant according to claim 1 or claim 2, wherein at the outlet of the economizer an outlet header for collecting preheated feedwater is arranged and from which the drain line and the fluid line branch off.
4. The power plant according to any one of claims 1 to 3, wherein a capacity of the polishing plant in parallel flow to a

main condensate line is less than 100% of an amount of water supplied to the economizer at base load.

5. The power plant according to any one of claims 1 to 4, wherein a heat source for the steam generator is a gas turbine.

6. A method for starting operation of a power plant with a water-steam-cycle, wherein the power plant comprises a steam generator with a plurality of heating surfaces forming at least an economizer, a steam turbine and a condenser comprising a hotwell, the method comprising:

draining water contained in the economizer to the hotwell, where it is diluted,

leading water from the hotwell at least in part through a polishing plant in order to clean the water,

supplying the economizer with water from the hotwell and water from the polishing plant, and

starting-up the steam generator as soon as at least a part of the water in the economizer has been replaced by clean water from the hotwell and the polishing plant,

wherein water getting over syphon tubes at an economizer outlet into evaporator and superheater tubes is drained by a drip leg at a steam generator outlet and led to the hotwell.

7. The method according to claim 6, wherein water is continuously drained from the economizer, led through the polishing plant and supplied to the economizer in case water from the hotwell and the polishing plant is not of a required quality, until it is clean enough for starting the steam generator.

8. The method according to any one of claims 6 or 7, wherein water contained in the economizer is drained by pumping boiler feedwater from the hotwell and the polishing plant into the economizer and, where applicable, by opening a drain at an economizer outlet header.

9. The method according to any one of claims 6 to 8, wherein circulation of water is maintained until an iron level is low enough.

FIG 1

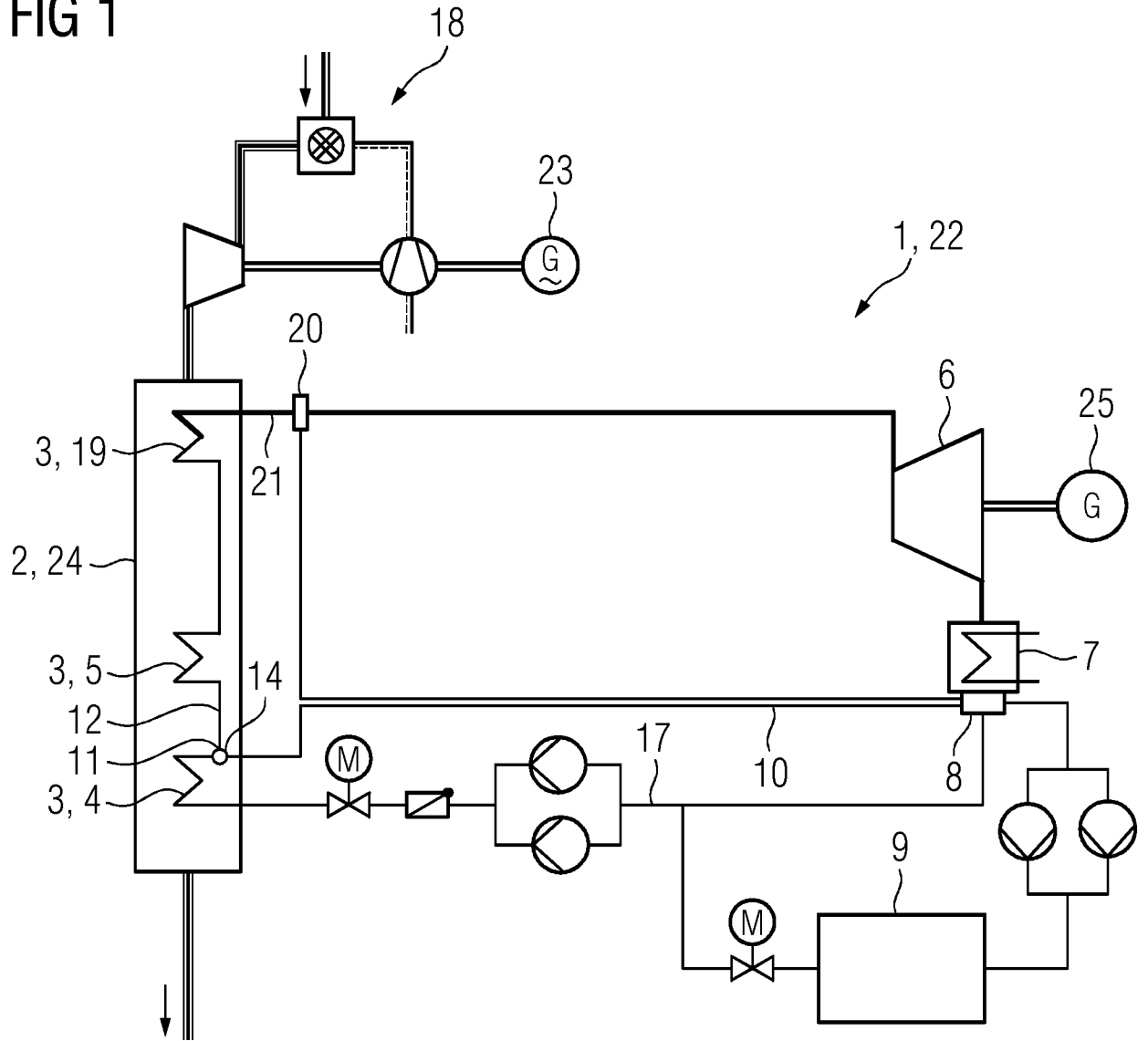


FIG 2

