Description

Method of and arrangement for deaerating a condensate

The invention relates to a method of deaerating a condensate in a water/steam cycle of a combined-cycle gas turbine plant. Furthermore, it relates to an arrangement for carrying out the method.

In a combined-cycle gas turbine plant, the heat contained in the exhaust gas from the gas turbine is utilized for generating steam for the steam turbine. In the process, the steam expanded in the steam turbine is condensed in a water/steam cycle, and the feedwater accumulating as a result is evaporated in a waste-heat boiler through which the hot exhaust gas from the gas turbine flows. In order to avoid corrosion in the water/steam cycle, the gas released in the condensate, in particular oxygen, is normally removed by thermal deaeration. To this end, a deaeration means is normally provided in a feedwater tank connected downstream of the condenser of the steam turbine, the condensate, which flows to the feedwater and is slightly undercooled at a temperature of 8 to 15 K, being heated up to boiling point in the feedwater tank by a heating medium.

In a method of heating and deaerating the condensate collected in the feedwater tank, which method is disclosed by the publication "Handbuch der Energie", vol. 7, 1984, pages 100 to 107, steam is used as heating medium, which for this purpose is additionally generated in a low-pressure evaporator in the waste-heat boiler. As shown in European Patent Application 0 515 911, steam in the form of tapped steam from a low-pressure part of the steam turbine may alternatively be used as heating medium. In both cases, however, this heating steam is lost for driving the steam turbine, so that the efficiency of the plant is limited.

The object of the invention is therefore to specify a method of deaerating a condensate in a water/steam cycle of a combined-cycle gas turbine plant, in which method adequate deaeration of the condensate is guaranteed at a simultaneously high efficiency of the plant through especially high energy utilization of the waste heat from the gas turbine. This is to be achieved with simple means in an arrangement suitable for carrying out the method.

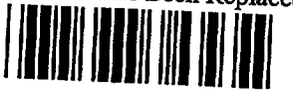
With regard to the method, this object is achieved according to the invention in that a partial flow of the preheated condensate or a partial flow of the preheated feedwater is used as heating medium.

The invention in this case is based on the idea of obtaining the heating medium for the deaeration in the feedwater tank as far as possible from the low-pressure temperature range of the gas-turbine exhaust gases while avoiding the extraction of steam from the water/steam cycle in order to thereby achieve especially high utilization of the exhaust-gas heat and thus a high efficiency of the waste-heat boiler.

Here, the partial flow may be passed directly into the feedwater tank. However, the partial flow is preferably expanded before it is passed into the feedwater tank. In this case, both steam arising during the expansion of the partial flow and water arising in the process are fed to the feedwater tank.

To set the feedwater temperature in the feedwater tank, cold condensate may be admixed to the preheated condensate. The preheat temperature of the condensate before it enters the feedwater tank is preferably set by at least some of the preheated condensate being circulated, in which case preheated condensate is admixed to the cold condensate.

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In addition to the deaeration function, the feedwater tank also performs the function of an intermediate reservoir, its filling level for setting the feedwater flow fed to the water/steam cycle being monitored with the aid of the condensate level arising in the feedwater tank. In order to achieve especially effective deaeration of the condensate, the heating medium is preferably passed into the feedwater tank below the condensate level. The gases released by the heating of the condensate then emerge at the surface of the condensate level so that the vapour venting of the released gases takes place in the feedwater tank.

With regard to the arrangement for carrying out the method, comprising a waste-heat steam generator having a condensate preheater connected in a water/steam cycle, the said object is achieved according to the invention in that a low-pressure economizer is connected downstream of the condensate preheater via the feedwater tank , the condensate preheater having on the outlet side an outflow line leading into the feedwater tank. Alternatively, the low-pressure economizer has on the outlet side an outflow line leading into the feedwater tank.

The introduction of the heating medium, i.e. of the preheated condensate or the preheated feedwater, into the feedwater tank may be effected in different ways. One possibility is for the hot and pressurized water or condensate coming out of the condensate preheater to be passed via a suitable pipe system having a nozzle pipe directly into the feedwater tank so that the water/steam mixture expands there in the nozzle pipe.

In an alternative configuration, the expansion is effected in an expansion tank which is connected in the outflow line. Here, the expansion tank is expediently

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connected to the feedwater tank on both the steam side and the water side.

To set the condensate temperature, a return line is connected in parallel with the condensate preheater. In addition or alternatively, a bypass line may also be connected in parallel with the condensate preheater.

Exemplary embodiments of the invention are explained in more detail with reference to a drawing, in which:

Figure 1 shows in cut-away section a waste-heat steam generator of a combined-cycle gas turbine plant with a circuit for deaeration in the feedwater tank,

Figure 2 shows an embodiment differing from the exemplary embodiment according to Figure 1, having an expansion tank in the condensate run, and

Figure 3 shows a further embodiment differing from the exemplary embodiment according to Figure 1, having an expansion tank in the feedwater run.

Parts corresponding to one another are provided with the same reference numerals in all figures.

The waste-heat steam generator 1 shown in cut-away section in Figure 1 is part of a combined-cycle gas turbine plant 2 for generating electric energy. The hot exhaust gas AG from the gas turbine 2a flows through it and it serves to generate steam, its heating surfaces being connected in a water/steam cycle 3 of a steam turbine 2b.

To this end, the waste-heat steam generator 1 has a condensate preheater 6 which is connected to a condenser 5 via a condensate line 4 and is connected on the outlet side to its inlet via a return line 8 having a circulating pump 10 and a valve 12.

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A bypass line 14 having a valve 16 is connected in parallel with the condensate preheater 6 in order to circumvent it when required. In addition, the condensate preheater 6 is connected on the outlet side to a deaerator 24 via a line 18 in which valves 20 and 22 are connected, which deaerator 24 is part of a feedwater tank 26. A nozzle pipe 30 leads into the feedwater tank 26 below a condensate level 28, which nozzle pipe 30 is connected via a valve 32 in a pipe line 34 to the line 18 and thus to the outlet of the condensate preheater 6.

On the outlet side, the feedwater tank 26 is connected via a feedwater line 36 having a feedwater pump 38 and a valve 40 to a low-pressure preheater or low-pressure economizer 42 which is arranged as heating surface in the waste-heat steam generator 1. The low-pressure economizer 42 is connected via a valve 44 to a low-pressure drum 46 to which a low-pressure evaporator 48 likewise arranged as heating surface in the waste-heat steam generator 1 is connected. On the steam side, the low-pressure drum 46 is connected via a line 50 to a low-pressure superheater 52, the heating surface of which is likewise arranged in the waste-heat steam generator 1.

In addition, the low-pressure economizer 42 is connected on the outlet side, via a line 54 having a pump 56 and a valve 58, to a further economizer heating surface 60 arranged in the waste-heat steam generator 1. On the outlet side, the economizer heating surface 60 is connected in a manner not shown in more detail to further evaporator and superheater heating surfaces which are arranged in the waste-heat steam generator 1 and lead into the steam turbine 2b in the same way as the low-pressure superheater 52. This is indicated by the arrows 62 and 64. In this arrangement, steam at different pressure stages, i.e. low-pressure steam LP, intermediate-pressure steam IP and high-pressure steam HP, is fed to the steam turbine 2b.

During operation of the waste-heat steam generator 1, condensate K from a condenser 64 [sic] connected downstream of the steam turbine is fed to the condensate preheater 6 via the condensate line 4. In the process, the condensate preheater 6 may be completely or partly circumvented via the bypass line 14. The condensate K is heated in the condensate preheater 6 by heat exchange with the hot exhaust gas AG flowing off from the gas turbine 2a and to this end is at least partly circulated via the circulating pump 10 in the return line 18. The heated condensate K' is passed via the line 18 into the feedwater tank 26. In the process, the preheated condensate K' is heated there by means of a partial flow t_1, passed via the line 34, of the preheated condensate K'. To this end, the partial flow t_1 is passed as heating medium HZ directly into the feedwater tank 26 via the valve 32, in the course of which it expands in the nozzle pipe 30. The vapour venting of the released gases therefore takes place only in the feedwater tank 26.

The preheated condensate K' is fed as feedwater S via the feedwater pump 38 to the low-pressure economizer 40 [sic], the feedwater S being further heated there. A partial flow t_2 of the preheated feedwater S is passed into the low-pressure drum 46. This partial flow t_2 is evaporated in the low-pressure evaporator 48, steam separated in the low-pressure drum 46 being superheated in the low-pressure superheater 52 and the superheated low-pressure steam LP being fed to the low-pressure part of the steam turbine 2b.

A partial flow t_3 of the preheated feedwater S' is brought to a high pressure level by means of the pump 56 and is then further heated in the economizer 60. This partial flow t_3 is likewise evaporated in a manner not shown in more detail and the superheated high-pressure steam HP is fed to the high-pressure part of the steam turbine 2b.

In the exemplary embodiment according to Figure 2, an expansion tank 70 is connected in the outflow line 34. The steam

separated during the expansion of the partial flow t_1 of the preheated condensate K' in the expansion tank 70 is used here as heating medium HZ. The water separated during the expansion of the partial flow t_1 in the expansion tank 70 is fed to the feedwater tank 26 via the line 72.

In the exemplary embodiment according to Figure 3, the low-pressure economizer 40 [sic] is connected on the outlet side to the feedwater tank 26 via an outflow line 74 which has a valve 73 and via which a partial flow t_4 of the preheated feedwater S' is directed. The steam separated during the expansion of the partial flow t_4 of the preheated feedwater S' in the expansion tank 70' is used here as heating medium HZ for heating the condensate K' in the feedwater tank 26. The expansion tank 70' is again connected on the water side to the feedwater tank 26 via a line 72'.

Through the use of either the partial flow t_1 of the preheated condensate K' or the partial flow t_4 of the preheated feedwater S' as heating medium HZ for heating the condensate K' in the feedwater tank 26, heat for the heating medium HZ is extracted from the low-temperature range of the waste-heat steam generator 1 in an especially effective manner without the need for additional preheater or evaporator heating surfaces and/or additional auxiliary units, such as pumps for example.

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Patent Claims

1. Method of deaerating a condensate (K) of a combined-cycle gas turbine plant (2) by heating the condensate in a feedwater tank (26) to which preheated condensate (K') is fed and from which feedwater (S) is extracted for heating surfaces (6, 42, 48, 52, 60) connected in the water/steam cycle (3) of the steam turbine (2b) and heated by the exhaust gas (AG) from the gas turbine (2a), characterized in that a partial flow (t_1) of the preheated condensate (K') or a partial flow (t_4) of preheated feedwater (S') is used as heating medium (HZ) for heating the condensate.

2. Method according to Claim 1, characterized in that the partial flow (t_1, t_4) is expanded before it is passed into the feedwater tank (26).

3. Method according to Claim 2, characterized in that both steam arising during the expansion of the partial flow (t_1, t_4) and water arising in the process are fed to the feedwater tank (26).

4. Method according to one of Claims 1 to 3, characterized in that the heating medium (HZ) is passed into the feedwater tank (26) below the condensate level (28).

5. Method according to one of Claims 1 to 4, characterized in that cold condensate (K) is admixed to the preheated condensate (K').

6. Arrangement for carrying out the method as claimed in one of Claims 1 to 5, comprising a waste-heat steam generator (1) having a condensate preheater (6)

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connected in a water/steam cycle (3) and a low-pressure economizer (42) connected downstream of the condensate preheater (6) via a feedwater tank (26), the condensate preheater (6) having on the outlet side an outflow line (34) leading into the feedwater tank (26).

7. Arrangement for carrying out the method as claimed in one of Claims 1 to 5, comprising a waste-heat steam generator (1) having a condensate preheater (6) connected in a water/steam cycle (3) and a low-pressure economizer (42) connected downstream of the condensate preheater (6) via a feedwater tank (26), the low-pressure economizer (42) having on the outlet side an outflow line (74) leading into the feedwater tank (26).

8. Arrangement according to Claim 6 or 7, characterized by an expansion tank (70, 70') connected in the outflow line (34, 74).

9. Arrangement according to Claim 8, characterized in that the expansion tank (70, 70') is connected on the water side to the feedwater tank (26).

10. Arrangement according to one of Claims 6 to 9, characterized in that a return line (8) is connected in parallel with the condensate preheater (6).

11. Arrangement according to one of Claims 6 to 10, characterized in that a bypass line (14) is connected in parallel with the condensate preheater (6).

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