

Description

Gas- and steam-turbine plant and method of cooling the coolant of the gas turbine of such a plant

5 The invention relates to a gas- and steam-turbine plant having a waste-heat steam generator which is connected downstream of a gas turbine on the flue-gas side and whose heating areas are connected in the water/steam circuit of a steam turbine. It also relates
10 to a method of cooling the coolant of the gas turbine of such a gas- and steam-turbine plant.

 In a gas- and steam-turbine plant, the heat contained in the expanded working medium (flue gas) from the gas turbine is utilized in order to generate steam
15 for the steam turbine. The heat transfer is effected in a waste-heat steam generator, which is connected downstream of the gas turbine on the flue-gas side and in which heating areas in the form of tubes or tube banks are arranged. The latter in turn are connected in
20 the water/steam circuit of the steam turbine. The water/steam circuit normally comprises several, for example two, pressure stages, each pressure stage having a preheating heating area and an evaporator heating area.

25 In an evaporator circuit designated as natural circulation, partial evaporation of the conducted working medium takes place in the evaporator, circulation of the working medium being ensured by pressure differences which develop during the
30 evaporation process and/or by the geodetic arrangement of evaporator and steam drum. Alternatively, the evaporator circuit may also be a forced circulation, in which the circulation of the working medium is ensured by a circulating pump, the working medium likewise being
35 at least partly evaporated in the evaporator. In the cases of both the natural circulation and the forced circulation, the water/steam mixture is fed from the evaporator

to a steam drum connected in the evaporator circuit. Water and steam are separated in the steam drum, the water being fed again from the steam drum to the evaporator.

5 Alternatively, in an evaporator circuit designed as a once-through steam generator, complete evaporation of the working medium may also be provided in one pass through the evaporator with subsequent partial superheating. In this case, the passage of the working
10 medium through the evaporator is likewise ensured by pumps.

Irrespective of whether the natural-circulation, the forced-circulation or the once-through principle is used in the steam-turbine plant, an especially high
15 temperature of the flue gas at the inlet to the gas turbine of, for example, 1000 to 1200°C is aimed at in order to increase the performance of the gas turbine and thus achieve as high an efficiency of such a gas- and steam-turbine plant as possible. However, such a high
20 turbine inlet temperature involves material problems, in particular with regard to the heat resistance of the turbine blades.

An increase in the turbine inlet temperature may be permitted when the turbine blades are cooled to such
25 an extent that they are always at a temperature which is below the admissible material temperature. To this end, it is known from EP-B 0 379 880 to branch off a partial flow of compressed air flowing off from a compressor allocated to the gas turbine and to feed this partial
30 flow as coolant to the gas turbine. The air which serves as coolant is cooled before entry into the gas turbine. In the process, the heat extracted from the cooling air during the cooling is utilized as heat of evaporation and is used to drive the steam turbine. A flash
35 evaporator

having a circulating pump and a flash vessel is used as the evaporator system. In this case, water is removed from the steam drum of the evaporator circuit, and this water is heated up by heat exchange with the cooling air
5 serving as coolant for the gas turbine and is then evaporated by flashing in the flash vessel. The steam which is thus produced is fed to the steam turbine.

Such an apparatus for cooling the cooling air of a gas turbine is designed for a certain temperature
10 difference between the water removed from the steam drum and the cooling air. In this case, the operation of the entire waste-heat steam generator is necessary for reliable cooling of the gas turbine. Such a gas- and steam-turbine plant can therefore only be used in a
15 flexible manner to a limited extent.

The object of the invention is therefore to specify a gas- and steam-turbine plant of the abovementioned type in which reliable cooling of the gas turbine is ensured even under various operating
20 conditions. In addition, a method of cooling the coolant of a gas turbine of a gas- and steam-turbine plant, which method is especially suitable for various operating conditions, is to be specified.

For a gas- and steam-turbine plant of the
25 abovementioned type, this object is achieved according to the invention by a heat exchanger provided for cooling the coolant of the gas turbine being connected on the secondary side in a separate water/steam circuit connected to the water/steam circuit of the steam
30 turbine in such a way that it can be shut off.

The invention is based on the idea that, in the case of a gas- and steam-turbine plant which can be used in an especially flexible manner, the gas turbine should be operable independently of the waste-heat steam
35 generator and thus



also independently of the steam turbine. Even during solo operation of the gas turbine, reliable cooling of its turbine blades should be ensured. To this end, a cooling system which is independent of the water/steam circuit of the steam turbine is provided for cooling the coolant of the gas turbine.

The heat exchanger is preferably designed as an evaporator for the separate water/steam circuit. In this case, during normal operation of the gas- and steam-turbine plant, the steam obtained in the separate water/steam circuit can expediently be fed to the water/steam circuit of the steam turbine.

To separate the steam from the water/steam mixture flowing off from the heat exchanger, a steam drum is expediently connected in the separate water/steam circuit. This steam drum expediently has an integrated condenser.

For an especially favourable recovery of the heat extracted from the coolant of the cooling system, a steam line which can be shut off and via which the steam generated in the separate water/steam circuit can be fed into a steam drum connected in the water/steam circuit of the steam turbine is preferably connected to the steam drum connected in the separate water/steam circuit.

The separate water/steam circuit can expediently be operated by natural circulation for an especially simple type of construction and for an especially low cost in terms of assembly and installation.

So that the heat extracted from the cooling air when it is being cooled is reliably discharged even during solo operation of the gas turbine, the steam drum connected in the separate water/steam circuit is

advantageously connected to a secondary cooling circuit. In this case, the secondary cooling circuit may contain, for example, a cooling tower.

With regard to the method of cooling the coolant
5 of a gas turbine of a gas- and steam-turbine plant, the said object is achieved by the coolant being cooled by heat exchange with a medium carried in a water/steam circuit which is independent of the steam turbine.

The medium carried in the independent
10 water/steam circuit is expediently at least partly evaporated during the heat exchange with the coolant. The independent water/steam circuit is advantageously operated by natural circulation.

The advantages achieved by the invention consist
15 in particular in the fact that reliable cooling of the gas turbine irrespective of the operating state of the steam turbine is ensured by the cooling of the coolant of the gas turbine by heat exchange with a medium carried in a water/steam circuit which is independent of
20 the steam turbine. The gas turbine can therefore be reliably operated even during various operating states of the gas- and steam-turbine plant, in particular even during solo operation. In addition, due to the connection between the separate water/steam circuit and
25 the water/steam circuit of the steam turbine, which connection can be shut off, the heat extracted from the cooling air of the gas turbine when the cooling air is being cooled can be returned into the energy-generation process during normal operation of the gas- and steam-
30 turbine plant. The gas- and steam-turbine plant can therefore be operated especially efficiently during normal operation.

An exemplary embodiment of the invention is explained in more detail below with reference to a
35 drawing, in which the single figure schematically shows

a gas- and steam-turbine plant having a cooling system for cooling the coolant for the gas turbine.

The gas- and steam-turbine plant 1 schematically shown in the figure comprises a gas-turbine plant 2 having a waste-heat steam generator 4 connected downstream on the flue-gas side. The gas-turbine plant 2 comprises a gas turbine 6 having a coupled air compressor 8. Connected upstream of the gas turbine 6 is a combustion chamber 10, which is connected to a fresh-air line 12 of the air compressor 8. A fuel line 14 leads into the combustion chamber 10 of the gas turbine 6. The gas turbine 6 and the air compressor 8 as well as a generator 16 sit on a common shaft 18.

The waste-heat steam generator 4, connected downstream of the gas turbine 6 of the gas-turbine plant 2 on the flue-gas side, has a number of heating areas, which are connected in a water/steam circuit 20 of a steam turbine 21. In this case, the heating areas are a condensate preheater 22, a low-pressure evaporator 24, a low-pressure superheater 26, a high-pressure preheater 28, a high-pressure evaporator 30, and a high-pressure superheater 36 formed from two sections 32, 34.

Connected downstream of the steam turbine 21 on the steam side is a condenser 40, which is connected to the condensate preheater 22 via a condensate pump 42 and via a preheater 44 arranged outside the waste-heat steam generator 4 as well as via a condensate feed 46. The condensate preheater 22 is connected on the outlet side to a feedwater tank 52 via a feed line 50, which can be shut off by a control valve 48. Arranged on the feedwater tank 52 on the outlet side is a feed line 54 for the feeding of feedwater into a steam drum 56 connected to the low-pressure evaporator 24. Furthermore, the feedwater tank 52 is connected on the outlet side via a feed line 58 to the high-pressure preheater 28, which in turn is connected on the outlet

side to a steam drum 60 connected to the high-pressure evaporator 30. The feed lines 54, 58 can each be shut off by a control valve 62 and 64 respectively.

The steam drums 56 and 60 are connected via the
5 low-pressure superheater 26 and respectively the high-pressure superheater 36 to a low-pressure part and respectively a high-pressure part of the steam turbine 21, so that a closed water/steam circuit 20 results.

The gas-turbine plant 2 is designed for
10 achieving an especially high efficiency. To this end, the entry of flue gas B into the gas turbine 6 is provided with a temperature of about 1000 to 1200°C during operation of the gas-turbine plant 2. In order to reliably avoid material problems in the process, in
15 particular associated with the heat resistance of the turbine blades of the gas turbine 6, a cooling system 70 is allocated to the gas-turbine plant 2.

In this case, air L originating from the air compressor 8 is provided as coolant for the gas turbine
20 6 and this air L, while bypassing the combustion chamber 10, can be fed directly to the gas turbine 6 via a coolant line 72 branching off from the fresh-air line 12. To cool the air L provided as coolant, the cooling system 70 comprises a heat exchanger 74 connected in the
25 coolant line 72 on the primary side.

The heat exchanger 74 is connected on the secondary side in a separate water/steam circuit 76 which is independent of the water/steam circuit 20 of the steam turbine 21. To this end, the heat exchanger 74
30 is designed as an evaporator for a medium M circulating in the separate water/steam circuit 76 and is connected on the outlet side via a water/steam line 78 to a steam drum 80 having an integrated condenser. The steam drum 80 is connected to the heat exchanger 74 via a
35 condensate line 82.

In this case, the separate water/steam circuit 76 is designed for natural circulation. A circulating pump 86 connected in a bypass loop 84 of the condensate line 82 is provided only for a start-up phase.

5 The separate water/steam circuit 76 is connected to the water/steam circuit 20 of the steam turbine 21 in such a way that it can be shut off. To this end, the steam drum 80 is connected to the steam drum 56, designed as a low-pressure drum, via a steam line 92
10 which can be shut off by a valve 90. On the water side, the steam drum 80 is connected to the feed line 54 via a line 96 which can be shut off by a control valve 94.

 Arranged in the steam drum 80 is a heat exchanger 100, which is connected to a secondary cooling
15 circuit 102. A cooling tower 104 is connected in the secondary cooling circuit 102.

 The gas- and steam-turbine plant 1 is designed in such a way that reliable operation with reliable cooling of the gas turbine 6 is ensured even during
20 various operating states. To this end, the air L provided as coolant for the gas turbine 6 is cooled by heat exchange with the medium M carried in the water/steam circuit 76 which is independent of the steam turbine 21. The medium M at least partly evaporated
25 during the heat exchange with the air L in the heat exchanger 74 is fed to the steam drum 80, where the steam generated is separated from the medium M which has not evaporated. During normal operation of the gas- and steam-turbine plant 1, that is, during joint operation
30 of the gas turbine 6 and the steam turbine 21, the steam D separated in the steam drum 80 is fed via the steam line 92 into the steam drum 56 when valve 90 is opened. The heat extracted from the air L when it is being cooled in the heat exchanger 74

is therefore fed into the water/steam circuit 20 of the steam turbine 21 and is supplied for the generation of energy. The gas- and steam-turbine plant 1 therefore works at an especially high efficiency.

5 The loss of medium M which occurs in the separate water/steam circuit 76 due to the feeding of the steam D into the water/steam circuit 20 of the steam turbine 21 is compensated for by feeding feedwater into the steam drum 80 via the line 96 when control valve 94
10 is opened as required. Reliable and lasting operation of the separate water/steam circuit 76 is therefore ensured.

 However, the gas- and steam-turbine plant 1 can also be operated with reliable cooling of the gas
15 turbine 6 during solo operation of the gas-turbine plant 2, that is, during operation of the gas turbine 6 when the steam turbine 21 is shut down. To this end, the valve 90 and the control valve 94 are closed during solo operation of the gas-turbine plant 2, so that the
20 separate water/steam circuit 76 is completely cut off from the water/steam circuit 20 of the steam turbine 21. The cooling of the gas turbine 6 is therefore also ensured during complete shutdown of the steam turbine 21 and the components allocated to its water/steam circuit
25 20. In this operating state, the heat extracted from the air L when it is being cooled is given off to the ambient via the secondary cooling circuit 102. At the same time, the steam which is generated in the heat exchanger 74 is condensed in the steam drum 80 at its
30 integrated condenser.

 In order to enable the temperature level of the medium M circulating in the separate water/steam circuit 76 to be adapted to varying requirements during the cooling of the air L, a further connecting line 106 is
35 provided between the water/steam circuit 20 of the steam turbine 21 and the separate water/steam circuit 76. As viewed in the direction of flow of the medium, the connecting line 106

branches off downstream of the condenser 40 from the water/steam circuit 20 of the steam turbine 21 and leads out in an injector 108 connected in the condensate line 82. Cold condensate can be injected as and when required
5 into the separate water/steam circuit 76 via the injector 108. In this case, by injection of the cold condensate, the temperature of the medium M circulating in the separate water/steam circuit 76 can be varied and adapted to specific requirements during the heat
10 exchange with the air L.



Patent Claims

1. Gas- and steam-turbine plant (1) having a waste-heat steam generator (4) which is connected downstream of a gas turbine (6) on the flue-gas side and whose heating areas are connected in the water/steam circuit (20) of a steam turbine (21), a heat exchanger (74) provided for cooling the coolant of the gas turbine (6) being connected on the secondary side in a separate water/steam circuit (76) connected to the water/steam circuit (20) of the steam turbine (21) in such a way that it can be shut off.
2. Gas- and steam-turbine plant (1) according to Claim 1, in which the heat exchanger (74) is designed as an evaporator for the separate water/steam circuit (76).
3. Gas- and steam-turbine plant (1) according to Claim 1 or 2, in the separate water/steam circuit (76) of which a steam drum (80) is connected.
4. Gas- and steam-turbine plant (1) according to Claim 3, in which the steam drum (80) connected in the separate water/steam circuit (76) has an integrated condenser.
5. Gas- and steam-turbine plant (1) according to one of Claims 1 to 4, in which steam generated in the separate water/steam circuit (76), via a steam line (92) which can be shut off, can be fed into a steam drum (56, 60) connected in the water/steam circuit (20) of the steam turbine (21).
6. Gas- and steam-turbine plant (1) according to one of Claims 1 to 5, the separate water/steam circuit (76) of which can be operated by natural circulation.
7. Gas- and steam-turbine plant (1) according to one of Claims 3 to 6, the steam drum (80) connected in the separate water/steam circuit



(76) being connected to a secondary cooling circuit (102).

8. Method of cooling the coolant of a gas turbine (6) of a gas- and steam-turbine plant (1), in which the
5 coolant is cooled by heat exchange with a medium (M) carried in a water/steam circuit (76) which is independent of the steam turbine (21).

9. Method according to Claim 8, in which the medium (M) carried in the independent water/steam circuit (76)
10 is at least partly evaporated during the heat exchange with the coolant.

10. Method according to Claim 8 or 9, in which the independent water/steam circuit (76) is operated by natural circulation.