

Description

Method of and arrangement for cooling a low-pressure turbine section

- 5 The invention relates to a method of cooling the low-pressure turbine section of a steam turbine connected in a water/steam circuit, in which method a coolant flows through the low-pressure turbine section, in particular during idling operation. Furthermore, it is directed towards an arrangement for carrying out the method.
- 10 A turbo set having a heating steam turbine is in many cases designed in such a way that, when heat is extracted from an intermediate-pressure turbine section, the low-pressure turbine section or each low-pressure turbine section receives no substantial steam supply and
- 15 therefore works in idling operation. However, this leads to increased heating of the blading in the low-pressure turbine section of the heating steam turbine, in particular in the case of full heat extraction and shut-off low-pressure turbine section.
- 20 To avoid inadmissible warming-up effects through ventilation losses in the blading, it is known from German Offenlegungsschrift DE 41 29 518 A1 to feed cooling steam and/or condensate to the low-pressure turbine section via a tap provided on the turbine.
- 25 However, this involves a relatively large heat loss, since the heat contained in the cooling steam together with the lost heat resulting essentially from the ventilation is dissipated via the condenser connected downstream of the steam turbines and is therefore not
- 30 available for heating purposes. Since an appropriately large quantity of the cooling steam for reducing a temperature rise, resulting from the ventilation, in the blading has to be selected, the heat losses are relatively high.

The object of the invention is therefore to specify especially effective cooling of the low-pressure turbine section, in particular in idling and/or low-load operation. This is to be achieved with especially simple means in an arrangement suitable for carrying out the method.

With regard to the method, the said object is achieved according to the invention in that condensate which is bled from a condenser connected downstream of the steam turbine is used as coolant, the coolant being fed back to the water/steam circuit after flowing through the low-pressure turbine section, after at least a partial flow of the coolant has emitted the heat absorbed during the cooling to the water/steam circuit and in the process has cooled down itself.

The invention is here based on the idea that a suitable coolant for cooling the low-pressure turbine section during idling or low-load operation has as a further property in addition to its effective cooling property the ability to recover as large a portion as possible of the lost heat caused by ventilation of the turbine final stages. To this end, the coolant is to have an appropriately low temperature. Since the condenser is in operation to maintain a necessary vacuum even during idling of the low-pressure turbine section, the use of condensate as coolant is therefore especially suitable, especially as it also has a suitable temperature.

The coolant is expediently directed in a closed cooling loop. In this case, the coolant is expediently passed through passages in the guide blade, or in each guide blade, of the low-pressure turbine section. Alternatively, the coolant may also be passed through passages inside the casing of the low-pressure turbine section, i.e. along outer or inner contours of the inner casing.

The partial flow of the warmed-up or heated-up coolant, after cooling-down is effected, is expediently fed to the condenser on its outflow side, while the other partial flow is fed directly to the condenser on its inflow side.

If the warmed-up coolant is fed to the water/steam circuit, this is effected at a suitable point with regard to its pressure and temperature and by controlling the final temperature of the warmed-up coolant. In an especially suitable control of the final temperature of the coolant, the coolant flow fed to the low-pressure turbine section is set.

With regard to the arrangement for cooling the low-pressure turbine section of a steam turbine connected in a water/steam circuit and having a condenser connected downstream, in which arrangement the low-pressure turbine section is connected to a coolant line connected to the outflow side of the condenser, the said object is achieved according to the invention in that a heat exchanger is connected on the primary side in the coolant line in the direction of flow behind the low-pressure turbine section, the secondary side of which heat exchanger is connected in the water/steam circuit.

By means of this heat exchanger or cooler, the heat contained in the warmed-up coolant can be extracted for recovery in an especially suitable manner and emitted to the water/steam circuit at such a suitable point where a low condensate pressure prevails, e.g. downstream of a first low-pressure preheater.

In this case, the coolant line is expediently connected to the condensate collecting tank or hot well provided directly below the condenser. If the warmed-up coolant is fed back into the water/steam circuit at a suitable point, the coolant line is expediently

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

connected to the pressure side of a condensate pump connected in the water/steam circuit. Alternatively or in addition, a circulating pump may be connected in the coolant line. The inclusion of a circulating pump is especially expedient if the coolant is directed in a separate cooling loop with the coolant line directly connected to the hot well of the condenser.

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

Fig. 1 shows a functional diagram for cooling the guide blades of a low-pressure turbine section by means of condensate bled behind a condensate pump, and Fig. 2 shows an alternative functional diagram having a cooling loop directed via a condenser hot well.

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

Figure 1 schematically shows merely the final stage of a steam turbine 1 having a double-flow low-pressure turbine section 2 and a condenser 4, arranged below the latter, and its collecting tank or hot well 6 for condensate K. The hot well 6 is connected in a water/steam circuit 12 (only shown in part) of the steam turbine 1 via a condensate line 8 having a condensate pump 10. The condensate line 8 leads via a first preheater 14 and a second preheater 16 into a feedwater tank 18 likewise connected in the water/steam circuit 12.

During operation of the steam turbine 1, condensate K flows out of the hot well 6 of the condenser 4 via the condensate line 8 and the condensate pump 10 as well as via the preheaters 14 and 16 into the feedwater tank 18, where it is collected and normally de-aerated. From there, it is fed as feedwater S (in

a manner not shown in more detail) into evaporator and superheater heating areas, connected in the water/steam circuit 12, for generating steam for the steam turbine 1. The steam is expanded in the steam turbine 1 to perform work and is then passed into the condenser 4, where it condenses. The condensate 4 is collected in the hot well 6.

A partial flow t_1 of the condensate K from the hot well 6 of the condenser 4 is fed to the low-pressure turbine section 2 via a coolant line 22 connected on the pressure side of the condensate pump 10 to the condensate line 8. The quantity of condensate or coolant K' directed per unit of time via the coolant line 22, i.e. the coolant flow, is set in the process. In the exemplary embodiment, the coolant K' flows through guide blades 24 of the low-pressure turbine section 2, of which only two are shown. To this end, passages are provided inside the guide blades 24 in a manner not shown in more detail, which passages are interlinked in a cooling loop. Alternatively or in addition, the coolant K' may also flow through passages which are provided inside the inner casing 26 of the low-pressure turbine section 2 and which may be outer or inner contours of the inner casing 26. This is indicated by the arrows 28.

A valve 30 for setting the quantity of coolant K' fed to the low-pressure turbine section 2 per unit of time, i.e. for setting the condensate partial flow t_1 , is connected in the coolant line 22 on the inflow side. The coolant line 22 is directed via the second preheater 16 on the outflow side, i.e. in the direction of flow of the coolant K' behind the low-pressure turbine section 2, and leads into the feedwater tank 18. Between the low-pressure turbine section 2 and the second preheater 16, a non-return valve 32 is connected in the coolant line 22.

When flowing through the guide blades 24 and/or the inner casing 26, the partial flow t_1 of the coolant K'

directed via the coolant line 22 absorbs the heat, arising through ventilation during idling or low-load operation, from the low-pressure turbine section 2 and emits this heat in the second preheater 16 to the condensate K flowing to the feedwater tank 18. The coolant K' cooled down as a result is mixed in the feedwater tank 18 with the condensate K fed directly to the latter.

To set the final temperature T_K' of the coolant K' warmed-up or heated up as a result of the cooling of the low-pressure turbine section 2, the coolant flow is varied by means of the valve 30. To this end, a temperature sensor 34 measures the current final temperature T_K' of the warmed-up coolant K' on the outflow side of the low-pressure turbine section 2 connected in the coolant line 22 inside the cooling loop. A controlled quantity determined with reference to the measured final temperature T_K' and a predeterminable desired temperature is transmitted by a controller module 36 via a signal line 38 to the controllable valve 30 for setting the coolant flow t_1 .

In the exemplary embodiment according to Figure 2, the cooling of the low-pressure turbine section 2 is effected in an especially simple manner by condensate K being delivered as coolant K' to the guide blades 24 of the low-pressure turbine section 2 from the hot well 6 of the condenser 4 via a circulating pump 40 connected in a coolant line 22'. A partial flow t_2 of the coolant K' heated itself during the cooling, via a partial-flow line 42 which is connected on the outflow side to the coolant line 22' and in which a valve 44 is connected, is directed via the tubing of the condenser 4. In the process, the heated coolant K' emits its heat to the cooling water W flowing through the condenser 4. The quantity of coolant K' bled from the hot well 6 per unit of time is in turn set by means of the valve 30' connected in the coolant line 22'. The valve 30' is in turn controlled by the controller module 36 as a function of the final temperature T_K' , measured by means of the temperature-measuring

sensor 34, of the heated coolant K'.

5 The remaining partial flow t_3 of the heated coolant K', which partial flow t_3 can be set by means of valves 48 and 50, is in turn directed via a heat exchanger or preheater 16', in the course of which it emits its heat at a suitable point to the water/steam circuit 12 of the steam turbine 1. In the exemplary embodiment according to Figure 2, the coolant K' is therefore directed in a separate cooling circuit 52
10 connected directly via the condenser 4.

To avoid erosion on the turbine blading, the guide blades 24 may also be heated with steam via their cooling passages, which steam should for this purpose be bled from a turbine tap in a manner known per se (not
15 shown in more detail here).



Patent Claims

1. Method of cooling the low-pressure turbine section of a steam turbine (1) connected [lacuna] a water/steam circuit (12), in which method a coolant (K') flows through the low-pressure turbine section (2), in particular during idling operation, condensate (K) bled from a condenser (4) connected downstream of the steam turbine (1) being used as coolant (K'), and at least one partial flow (t_1 , t_3) of the coolant (K'), after flowing through the low-pressure turbine section (2), first of all being cooled down by emitting heat to the water/steam circuit (12) and then being fed back to the water/steam circuit (12).
2. Method according to Claim 1, characterized in that the coolant (K') flows through a guide blade (24) or each guide blade (24) of the low-pressure turbine section (2).
3. Method according to Claim 1 or 2, characterized in that the coolant (K') flows through passages provided inside the inner casing (26) of the low-pressure turbine section (2).
4. Method according to one of Claims 1 to 3, characterized in that the coolant (K') is directed in a separate cooling circuit (52), it being fed back into the condenser (4) after flowing through the low-pressure turbine section (2).
5. Method according to one of Claims 1 to 4, characterized in that the coolant flow (t_1) is set in order to control the final temperature (T_K') of the warmed-up coolant (K').
6. Arrangement for cooling the low-pressure turbine section of a steam turbine (1) connected in a water/steam circuit (12)

THIS SHEET HAS BEEN
REPLACED



and having a condenser (4) connected downstream, the low-pressure turbine section (2) being connected to a coolant line (22, 22') for condensate (K'), which coolant line (22, 22') is connected to the outflow side of the condenser (4), and a heat exchanger (16, 16') being connected on the primary side in the coolant line (22, 22') in the direction of flow behind the low-pressure turbine section (2), the secondary side of which heat exchanger (16, 16'), to transfer heat contained in the condensate (K'), is connected in the water/steam circuit (12).

7. Arrangement according to Claim 6, characterized in that the coolant line (22, 22') is connected to the hot well (6) of the condenser (4).

8. Arrangement according to Claim 6 or 7, characterized in that the coolant line (22) is connected to the pressure side of a condensate pump (10) connected in the water/steam circuit (12).

9. Arrangement according to Claim 6 or 7, characterized in that a circulating pump (40) is connected in the coolant line (22').

10. Arrangement according to one of Claims 6 to 9, characterized by means for controlling the final temperature (T_K') of the coolant (K') heated during the cooling.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED



* C L M S *