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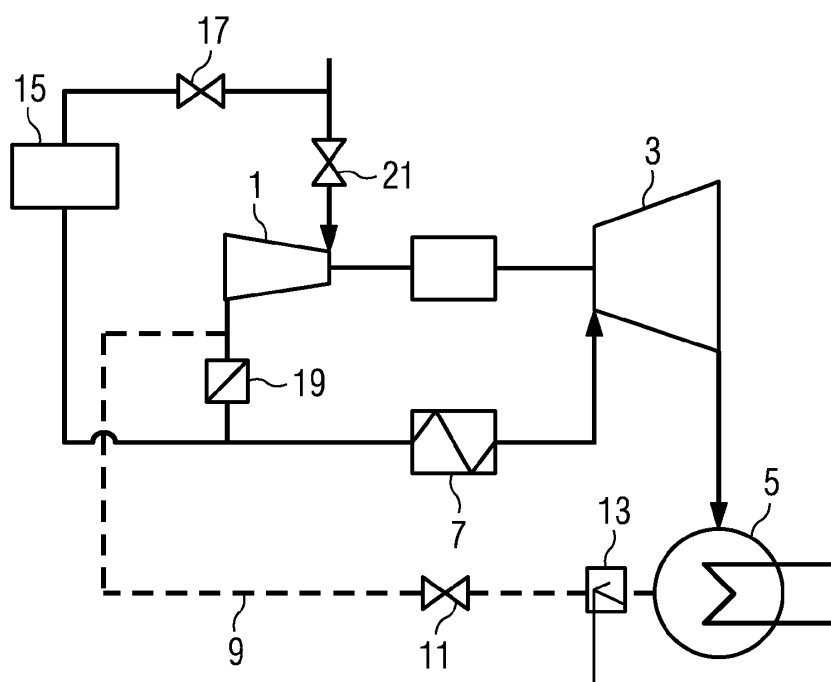
Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Single intermediate pressure operation mode for solar driven steam turbine plants**

(57) The present invention discloses a steam turbine plant using steam generated by a solar fields which comprises a high pressure turbine 1 with an inlet for inputting the steam and an outlet for outputting the steam, a mid or low pressure turbine 3 with an inlet for inputting the steam outputted by the outlet of the high pressure turbine 1 and an outlet for outputting the steam into a condenser 5, a reheater 7 arranged between the high pressure turbine

bine 1 outlet and the mid or low pressure turbine 3 inlet and which is arranged for reheating steam outputted by the high pressure turbine 1 outlet, wherein the high pressure turbine 1 outlet is connected with the condenser 5 via a pipe 9, and wherein a first flow control device 11 which controls the flow of the steam in the pipe 9 and a temperature control device 13 which cools the steam in the pipe 9 are arranged downstream of the high pressure turbine 1 outlet and upstream of the condenser 5.

FIG 1



Description

FIELD OF THE INVENTION

[0001] The present invention relates to steam turbine plants using steam generated by a solar field.

BACKGROUND OF THE INVENTION

[0002] Solar turbines are driven by steam generated from a solar field. These solar turbines are part of steam turbine plants which use steam generated by a solar field. Thereby, the steam generation is totally depended on the amount of sun light received by collectors. That is, the steam generation is totally depended on the power of the sun. For example, if there is cloudy weather, the steam generation decreases along with the sun radiation. When a cloud resides between the sun and the solar field the power of the sun useable by the solar field decreases.

[0003] In prior art steam turbine plants a high pressure turbine is connected to a low pressure turbine or to an intermediate pressure turbine with a reheater arranged between the two turbines. Steam exhausted by the high pressure turbine is inputted, into the reheater where the steam is reheated and this reheated steam is inputted into the low pressure turbine or the intermediate pressure turbine. Normally, the steam turbine has a minimum load, for example a minimum generator output, and if too little steam flow is inputted into the high pressure turbine wherein the steam has a pressure below a predefined minimum pressure value, the steam turbine produces windage heat. If the steam turbine plant is driven below minimum load and with a higher pressure in the reheater the limited amount of steam flowing through the high pressure turbine is not enough to dissipate windage heat, since the reheater is connected to the output of the high pressure turbine, so that the temperature in the exhaust or the outlet of the high pressure turbine rises which might result, in damages of the high pressure turbine.

SUMMARY OF THE INVENTION

[0004] The above described problem is solved by a steam turbine plant using steam generated by a solar field, wherein the steam turbine plant comprises a high pressure turbine with an inlet for inputting the steam and with an outlet for outputting the steam. The steam turbine plant further comprises a mid or low pressure turbine with an inlet for inputting the steam outputted by the outlet of the high pressure turbine and with an outlet for outputting the steam into a condenser. Furthermore, the steam turbine plant according to the present invention comprises a reheater which is arranged between the high pressure turbine outlet and the mid or low pressure turbine inlet and which is arranged for reheating steam outputted by the high pressure turbine outlet. Furthermore, the high pressure turbine outlet is connected with the condenser via a pipe. A first flow control device controls the flow of

the steam in this pipe and a temperature control device is adapted for cooling the steam in the pipe before inputted into the condenser. The first flow control device and the temperature control device are arranged downstream of the high pressure turbine outlet and upstream of the condenser.

[0005] When it is detected, that a steam pressure of steam inputted into the inlet of the high pressure turbine is below a predefined pressure value, then the first flow control device can control the flow of the steam outputted through the high pressure turbine in such a way, that the steam is at least partially inputted, into the condenser via the pipe. By controlling the steam flow inside the pipe with the first flow control device and by cooling the flow in the pipe with the temperature control device the pressure inside the pipe and therefore the pressure at the outlet of the high pressure turbine can be decreased. Thereby windage losses can be lowered and damages of the high pressure turbine become less likely. Furthermore, all the available heat flow can be used to operate the mid or low pressure turbine. This means that a lower minimum load is allowed, for example a lower generator output is allowed. Consequently, the steam turbine plant according to the present invention can stay on the grid during periods of clouds when the steam production is low. Furthermore, the steam turbine plant according to the present exhibits a short ramp-up time. And the steam turbine plant according to the present invention can increase load and generator output within a short time instead of being shut down when clouds appear.

[0006] The steam turbine plant according to the present invention can furthermore comprise a high pressure bypass which connects the high pressure turbine inlet with the high pressure turbine outlet. Furthermore, the steam turbine plant can comprise a second flow control device which is arranged in the high pressure bypass controlling the flow of the steam in the bypass. This high pressure bypass together with the second flow control device is provided to allow a bypassing of the high pressure turbine. Furthermore, the steam turbine plant according to the present invention can further comprise a check valve which is arranged between the outlet of the high pressure turbine and the reheater wherein the check valve is arranged of the pipe. A corresponding arrangement of the check valve in the steam turbine plants allows that the steam flow appears only downstream of the high pressure turbine, which is the steam flow from the outlet of the high pressure turbine towards the reheater.

[0007] The above described temperature control device can for example be a water injection. Nevertheless the present invention is not limited, thereto that the temperature control device is a water injection. The steam inside the pipe can also be cooled down by another device capable of cooling down the steam in the pipe. Nevertheless the present invention is not limited thereto to have a temperature control device, it all depends on the condenser design.

[0008] A water injection arranged between the outlet

of the high pressure turbine and the condenser allows a fast and reliable cooling down of the steam temperature in the pipe.

[0009] The present invention furthermore discloses a method for operating one of the above described steam turbine plants, wherein when a steam pressure of steam inputted into the inlet of the high pressure turbine is below a predefined pressure value, steam outputted through the high pressure turbine outlet is at least partially inputted into the condenser via the pipe.

[0010] The present invention will now be described by way of example with reference to figure 1 which is a schematic diagram of a steam turbine plant according to the present invention. Steam which is heated and generated by a not shown solar field is inputted into the inlet of a high pressure turbine 1. The high pressure turbine 1 is connected with a mid or low pressure turbine 3. The mid or low pressure turbine 3 can also be an intermediate pressure turbine. The high pressure turbine 1 exhibits an inlet for inputting the steam and exhibits an outlet for outputting the steam. The mid or low pressure turbine 3 exhibits an inlet for inputting the steam outputted by the outlet of the high pressure turbine 1. and an outlet for outputting the steam into a condenser 5. A reheater 7 is arranged between the high pressure turbine 1 outlet and the mid or low pressure turbine 3 inlet and is arranged for reheating steam outputted by the high pressure turbine 1 outlet. Steam which is generated by a solar field is inputted into the inlet of the high pressure turbine 1. The steam drives the high pressure turbine 1. The partially expanded steam is then outputted by the outlet of the high pressure turbine 1 into the reheater 7, where the steam is reheated before it is inputted into the inlet, of the mid or low pressure turbine 3. This reheated steam drives the mid or low pressure turbine 3. The high pressure turbine 1 and the mid or low pressure turbine 3 are connected with a not shown generator for generating electric power.

[0011] When the generation of steam is lowered by the solar field due to for example a cloud disposed between the sun and the solar field, then the high pressure turbine 1 does not operate with its maximum power. The steam pressure inside the reheater is also present at the outlet of the high pressure turbine 1. Due to low steam flow through the high pressure turbine 1 in such a the high pressure turbine 1. exhibits quite a lot of windage losses and the temperature at the outlet of the high pressure turbine 1 rises up which may result in damages of the high pressure turbine 1.

[0012] The reheated steam reheated by the reheater 7 inputted into the inlet of the mid or low pressure turbine 3 is outputted by the outlet of the mid or low pressure turbine 3 into a condenser 5. In the condenser 5 the steam is condensed at low pressure and the resulting fluid is again reheated by for example the solar field so that steam is generated and heated which is again inputted into the inlet of the high pressure turbine 1.

[0013] To reduce the pressure and the temperature of

the steam at the outlet of the high pressure turbine 1 a pipe 9 connects the outlet of the high pressure turbine 1. with the condenser: 5. Furthermore, a first flow control device 11, which controls the flow of the steam in the pipe 9, and a temperature control device 13, which cools the steam in the pipe 9, are arranged downstream of the high pressure turbine 1 outlet and upstream of the condenser 5. When the first flow control device 11 opens part of the pipe 9 then steam outputted through the outlet of the high pressure turbine 1 flows from the outlet of the high pressure turbine 1 into the condenser 5. The steam inside the pipe 9 is cooled down by the temperature control device 13 and the pressure is reduced due to flow connection with the condenser, which maintains a low pressure. Because of the pressure in the pipe 9 is reduced the pressure at the outlet of the high pressure turbine 1 is also reduced. Therefore, in case of a lowered steam pressure at the inlet of the high pressure turbine 1, windage losses are reduced. Furthermore, the probabilities of damages of the high pressure turbine 1 are lowered.

[0014] Figure 1 also shows a high pressure bypass 15 which connects the high pressure turbine 1 inlet with the high pressure turbine 1 outlet. Furthermore, figure 1 shows a second flow control device 17 which is arranged in the high pressure bypass 15 and which controls the flow of the steam in the bypass 15. When the second flow control device 17 is opened, then the inlet of the high pressure turbine 1 and the outlet of the high pressure turbine 1 are bypassed. In this case, the flow which does not enter the high pressure turbine 1, for example because of a at least partly closed flow control device 21, is led to the high pressure bypass 15.

[0015] Figure 1 also shows a check valve 19 which is arranged between the outlet of the high pressure turbine 1 and the reheater 7 wherein the check valve 19 is arranged downstream of the pipe 9. The check valve 19 allows a flow of the steam outputted by the outlet of high pressure turbine 1 towards the reheater 7 and avoids a steam flow from the reheater 7 back to the inlet of the high pressure turbine 1.

[0016] The temperature control device 13 shown in figure 1 can for example be a water injection. This water injection 13 cools down the steam inside the pipe 9 very effectively, so that the temperature of the steam inside the pipe 9 is reduced within a short time. The pressure inside the pipe 9 is reduced because of the connection to the condenser 5.

[0017] With the steam turbine plant according to the present invention the high pressure turbine 1 can stay on the grid even during the time when clouds darken the sun because the steam pressure at the outlet of the high pressure turbine 1 is lowered by introducing the steam into the pipe 9 into the condenser 5, whereby the steam pressure inside the pipe and therefore at the outlet of the high pressure turbine 1 is lowered. Therefore, all available heat flow may go through the mid or low pressure turbine 3 which is adapted for a lower steam pressure

compared with the steam pressure necessary for the high pressure turbine 1.

REFERENCE NUMERAL LIST

[0018]

- 1 High pressure turbine
- 3 Mid or high pressure turbine
- 5 Condenser
- 7 Reheater
- 9 Pipe
- 11 First flow control device
- 13 Temperature control device
- 15 High pressure bypass
- 17 Second flow control device
- 19 Check valve
- 21 Third flow control device

Claims

1. Steam turbine plant using steam generated by a solar field, comprising:

a high pressure turbine (1) with an inlet for inputting the steam and an outlet for outputting the steam;
 a mid or low pressure turbine (3) with an inlet for inputting the steam outputted by the outlet of the high pressure turbine (1) and an outlet for outputting the steam into a condenser (5);
 a reheater (7) arranged between the high pressure turbine (1) outlet and the mid or low pressure turbine (3) inlet and being arranged for reheating steam outputted by the high pressure turbine (1) outlet;
 wherein the high pressure turbine (1) outlet is connected with the condenser (5) via a pipe (9), and
 wherein a first flow control device (11) controlling the flow of the steam in the pipe (9) and a temperature control device (13) cooling the steam in the pipe (9) are arranged downstream of the high pressure turbine (1) outlet upstream of the condenser (5).

2. The steam turbine plant according to claim 1, further

comprising:

a high pressure bypass (15) connecting the high pressure turbine (1) inlet with the high pressure turbine (1) outlet; and
 a second flow control device (17) arranged in the high pressure bypass (15) controlling the flow of the steam in the bypass (15).

3. The steam turbine plant according to any of the preceding claims, further comprising:

a. check valve (19) arranged between the outlet of the high pressure turbine (1) and the reheater (7) wherein the check valve (19) is arranged downstream of the pipe (9).

4. The steam turbine plant according to any of the preceding claims, wherein the temperature control device (13) is a water injection.

5. Method for operating a steam turbine plant according to any of the preceding claims, wherein when a steam pressure of steam inputted into the inlet of the high pressure turbine (1) is below a predefined pressure value, steam outputted through the high pressure turbine (1) outlet is at least partially inputted into the condenser (5) via the pipe (9).

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Amended claims in accordance with Rule 137(2) EPC.

1. Steam turbine plant using steam generated by a solar field, comprising:

a high pressure turbine (1) with an inlet for inputting the steam and an outlet for outputting the steam;
 a mid or low pressure turbine (3) with an inlet for inputting the steam outputted by the outlet of the high pressure turbine (1) and an outlet for outputting the steam into a condenser (5);
 a reheater (7) arranged between the high pressure turbine (1) outlet and the mid or low pressure turbine (3) inlet and being arranged for reheating steam outputted by the high pressure turbine (1) outlet;

characterized in that the high pressure turbine (1) outlet is connected with the condenser (5) upstream of the reheater (7) via a pipe (9), and wherein a first flow control device (11) controlling the flow of the steam in the pipe (9) and a temperature control device (13) cooling the steam in the pipe (9) are arranged downstream of the high pressure turbine (1) outlet upstream of the condenser (5).

2. The steam turbine plant according to claim 1, further comprising:

a high pressure bypass (15) connecting the high pressure turbine (1) inlet with the high pressure turbine (1) outlet; and a second flow control device (17) arranged in the high pressure bypass (15) controlling the flow of the steam in the bypass (15).

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3. The steam turbine plant according to any of the preceding claims, further comprising:

a check valve (19) arranged between the outlet of the high pressure turbine (1) and the reheater (7) wherein the check valve (19) is arranged downstream of the pipe (9).

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4. The steam turbine plant according to any of the preceding claims, wherein the temperature control device (13) is a water injection.

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5. Method for operating a steam turbine plant according to any of the preceding claims, wherein when a steam pressure of steam inputted into the inlet of the high pressure turbine (1) is below a predefined pressure value, steam outputted through the high pressure turbine (1) outlet is at least partially inputted into the condenser (5) via the pipe (9).

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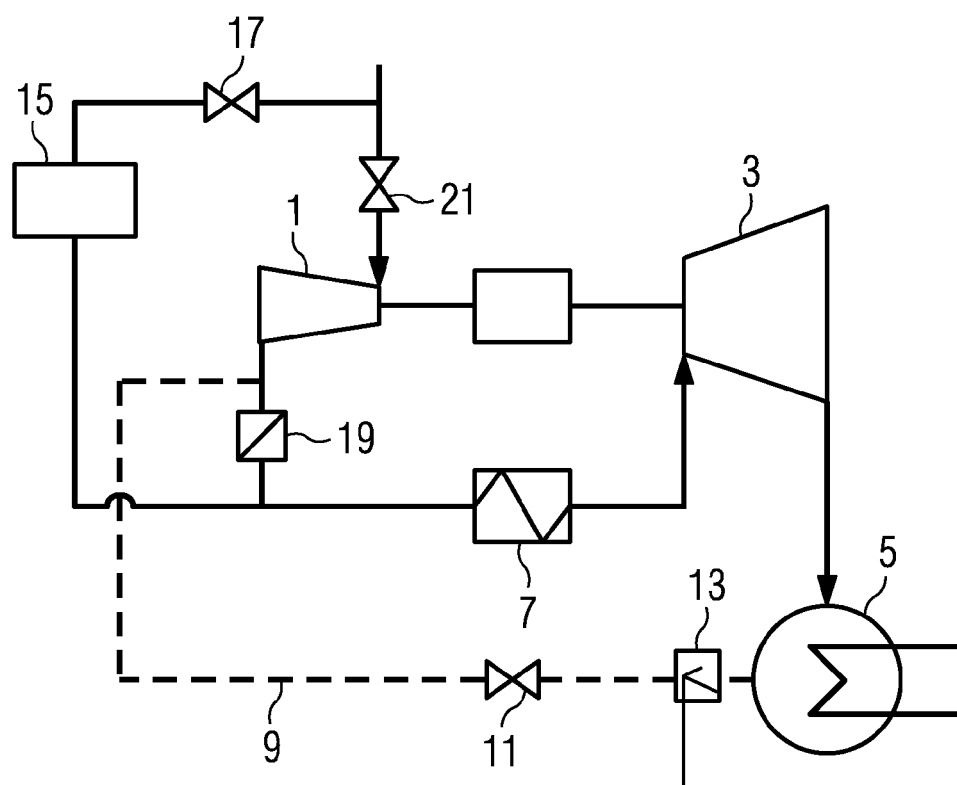
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FIG 1





EUROPEAN SEARCH REPORT

 Application Number
 EP 10 17 6181

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search Munich		Date of completion of the search 20 September 2011	Examiner Zerf, Georges
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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