

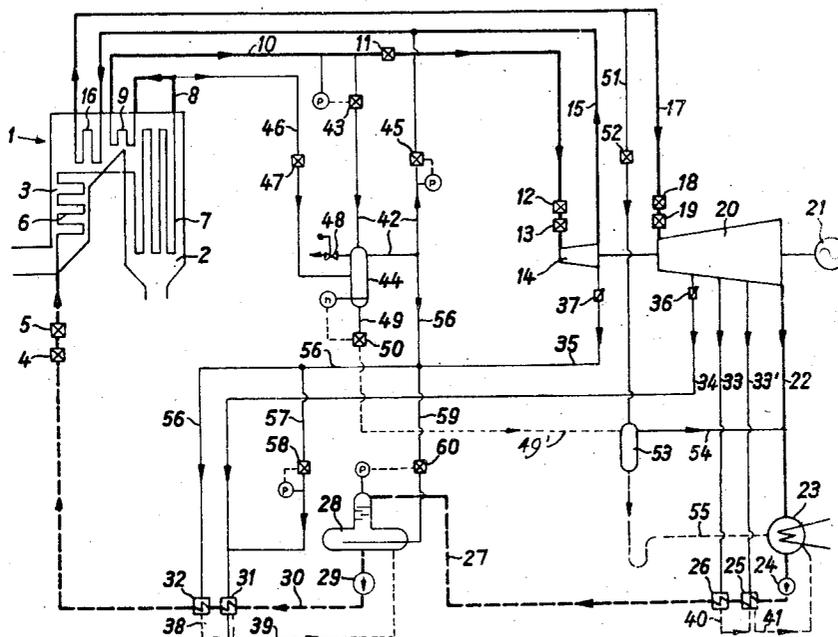
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STEAM POWER PLANT HAVING A FORCED FLOW STEAM GENERATOR

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STEAM POWER PLANT HAVING A FORCED
FLOW STEAM GENERATOR

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The present invention relates to a steam power plant having a forced flow steam generator, a steam turbine comprising at least two parts between which a resuperheater is arranged, a conduit bypassing the high pressure part of the steam turbine and being closed by means of a bypass valve during normal operation, and steam heated feed water preheaters.

The object of the invention resides in the provision of means in a steam power plant of the type described above which means facilitate starting of the plant.

According to the invention a water separator is arranged in the bypass conduit and a throttling means is interposed in the bypass conduit downstream of the bypass valve, a conduit being connected to the bypass conduit between the water separator and the throttling means for conducting heating steam to at least a part of the feed water preheaters.

Since, when starting the plant, the operating medium does not have the normal operating characteristics, it is passed through bypass conduits around the individual parts of the turbine. In order to sufficiently cool the resuperheaters it has been proposed to arrange a water separator in the conduit bypassing the high pressure part of the turbine downstream of the bypass valve and to take the steam from the steam chamber of the separator for cooling the resuperheater, because, due to blow-down difficulties, no feed water can be used for this purpose.

No feed water preheating can take place during starting of the plant. In order to abbreviate the time needed for warming up the plant and in order to utilize the heat transferred in the steam generator to the working medium during the starting period, it has been proposed to use the working medium heated in the steam generator instead of bleeder steam for heating the feed water preheaters whereby the operating medium is taken from an intermediate section or at the outlet of the steam generator. This operating medium is a mixture of steam and water. Therefore, a feed water preheating operation which is equivalent to that effected by condensation of bleeder steam, can be obtained only, if the water removal devices are made much larger than usual. Such structural changes are in most cases objectionable because the feed water preheaters are most of the time heated by bleeder steam. In the previously proposed arrangements a pressure reducing valve must be inserted in the conduit connecting the steam generator with the feed water heaters and a safety valve must be provided at least on the feed water heater operating at the relatively highest pressure of all feed water heaters so that the heating sides of the feed water heaters are not exposed to the high pressure prevailing in the tube system of the steam generator.

The aforesaid undesired structural changes are avoided in a plant according to the invention. If the operating medium which is used for preheating feed water is taken from the bypass conduit downstream of the water separator, steam only will flow to the feed water pre-

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heaters. A throttling device is still necessary and must be inserted in the bypass conduit downstream of the water separator and of the connection of the heating steam conduit for maintaining the desired pressure in the water separator and in the feed water heaters. The throttling device is preferably in the form of a conventional automatic valve which is responsive to the pressure upstream of the valve. In this way it is easily possible to maintain a steam pressure in the water separator which corresponds to the pressure in the highest pressure bleeder stage of the turbine. Because the condensation temperature of steam of this pressure corresponds to the upper temperature limit of the feed water preheating operation, the arrangement according to the invention affords the same preheating of the feed water as during normal full load operation of the plant. The water separator is usually provided with a safety valve so that the heating steam conduit can be directly connected with the feed water heater which operates at the highest heating steam pressure and no reducing valve and safety valve need be provided in the heating steam conduit.

The high pressure steam available in the steam chamber of the water separator can also be used for other purposes, for example, for supplying the sealing steam to the stuffing boxes of the turbine and for operating steam jet ejectors for removing the air from the condenser.

Preferably a conduit provided with a flow control means is arranged for connecting an intermediate point of the tube system of the steam generator with the water separator for bypassing at least a part of the superheaters. Two opposed conditions must be met during starting of a forced flow steam generator. Firstly, even at very low fire, a certain amount of operating medium must flow through the portions of the tube system which portions are used for lining the combustion chamber, for avoiding overheating of this part of the tube system. Secondly, as little as possible operating medium should flow through the superheaters in order to obtain, as quickly as possible, the desired temperature of the operating medium leaving the steam generator. Both conditions can be met without difficulty by using the system according to the invention. The operating medium taken from an intermediate point of the tube system is expanded and flows into the water separator. The heat contained in this operating medium is introduced into a relatively high temperature part of the starting circuit so that the steam formed by the expansion can be used for cooling the resuperheaters as well as for heating the feed water preheaters. The operating medium taken from an intermediate point of the tube system of the steam generator can also be used for cooling steam which leaves the outlet of the steam generator and which is already superheated when flowing through the bypass conduit into the water separator.

The above-described heating steam conduit is preferably connected with the last steam heated feed water heater, with respect to the flow of the feed water, and the bleeder steam conduit, which is connected with the highest bleeder steam stage of the turbine and which is provided with a check valve, terminates in the heating steam conduit. Branch conduits individually provided with pressure reducing valves may be connected with the heating steam conduit and with those of the feed water heaters which are upstream of the last feed water heater, with respect to the flow of the feed water. The feed water heaters can thus be heated with bleeder steam during normal operation as well as with steam from the water separator during starting of the plant. The term "feed water heater" used in this specification includes all

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devices in which feed water is heated and includes, for example, surface or indirect feed water heaters as well as mixing or direct feed water heaters.

Though in the present specification the word "water" is used for the liquid phase of the operating medium, and the term "steam" is used for the gas phase of the operating medium, the present invention is not limited to water and steam as the operating medium.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself however and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing the one figure of which is a diagram illustrating a steam power plant according to the invention.

A steam generator 1 having a combustion chamber 2 and a flue 3 is shown schematically. The flow of the operating medium during normal operation is as follows: Water is conducted into an economizer 6 through two valves 4 and 5 which serve for controlling the feed water supply. The water flows from the economizer 6 into a tubular heating section 7 lining the walls of the combustion chamber 2. Thereupon the operating medium flows through a connecting conduit 8 into a superheater 9 and therefrom through a conduit 10 provided with a regulating valve 11 and through valves 12 and 13 into the high pressure part 14 of a turbine. After partial expansion the steam flows back into a resuperheater 16 through a conduit 15 and then into a low pressure part 20 of the turbine through a conduit 17 and valves 18 and 19. The high pressure part 14 and the low pressure part 20 drive an electric generator 21. The exhaust of the low pressure turbine part 20 flows through a conduit 22 into a condenser 23, the condensate being pumped by a pump 24 through feed water heaters 25 and 26 and a conduit 27 into a deaerator 28. The water is pumped from the latter by means of a pump 29 through a conduit 30 in which feed water preheaters 31 and 32 are interposed into the steam generator.

During normal operation the feed water heaters 25 and 26 are heated by steam bled from the turbine into bleeder conduits 33 and 33', respectively, the feed water preheaters 31 and 32 being heated by steam bled from the turbine through conduits 34 and 35, respectively, the latter terminating in heating steam conduit 56 which will be described later. The conduits 34 and 35 are provided with check valves 36 and 37, respectively. The condensate formed in the feed water preheaters 32 and 31 is conducted through conduits 38 and 39 provided with steam traps, not shown, into the deaerator 28, the condensate formed in the feed water heaters 26 and 25 being conducted through conduits 40 and 41, also provided with steam traps, not shown, into the condenser 23. Only four feed water heaters are shown to avoid undue complication of the diagram. In modern steam plants there are quite often ten and more feed water heaters.

When starting the plant, the operating medium is bypassed around the high pressure part 14 and the low pressure part 20 of the turbine. The operating medium flows through a bypass conduit 42 after leaving the superheater 9. The conduit 42 is provided with a bypass valve 43 which responds to the pressure at the outlet of the superheater, a water separator 44, and a throttling means 45 which maintains the pressure in the conduit 42. The throttling means 45 is in the form of a conventional automatic overflow valve which is responsive to the pressure upstream of the valve. The separator 44 serves several purposes. It serves primarily for separating water so that saturated steam is available for cooling the resuperheater 16. This function of the water separator is important because the superheater is usually flooded when starting forced flow steam generators. In plants in which the steam generator is operated at supercritical pressure the

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water separator is indispensable because, when starting the plant, a separation of the steam phase from the liquid phase is only possible after the operating medium is expanded in the bypass valve 43. Operating medium can be conducted from the conduit 8 into the water separator 44 through a conduit 46 provided with a valve 47. Steam liberated by expansion in the valve 47 and in the water separator 44 can also be used for cooling the resuperheater 16 and, at the same time, superheated steam flowing from the superheater 9 into the bypass conduit 42 can be cooled by the operating medium coming from the conduit 8, so that the water separator serves also as steam cooler. The water separator 44 is provided with a safety valve 48, safeguarding all conduits, containers, and the like, communicating with the separator, against excessive pressure. The water separated in the device 44 is removed through a conduit 49 provided with a valve 50 which is responsive to the water level in the separator.

The steam leaving the resuperheater 16 is conducted through a second bypass conduit 51 provided with a bypass valve 52 around the low pressure turbine part 20 into a second water separator and steam cooler 53 into which the water separated in the first separator 44 may be conducted through a pipe 49'. The steam separated in the device 53 is conducted through a pipe line 54 into the condenser 23, the water separated in the device 53 being conducted into the condenser through a pipe line 55.

An essential novelty of the plant according to the invention resides in the provision of a heating steam conduit 56 which is connected to the bypass conduit 42 between the separator 44 and the valve 45 and terminates in the feed water heater 32. Since the bleeder steam conduit 35 terminates in the conduit 56, at least a portion of the latter carries steam for heating the feed water heater during starting as well as during normal operation of the plant. A pipe line 57 is connected with the heating steam conduit 56 and provided with a valve 58 for conducting steam into the feed water heater 31. A conduit 59 provided with a valve 60 connects the conduit 56 with the deaerator or degasifier 28. The valves 58 and 60 are opened only when the pressure downstream of the valves is below a predetermined value so that the conduits 57 and 59 are blocked during normal operation of the plant and are open only during starting of the plant. The check valves 36 and 37 are closed only during starting of the plant and are open during normal operation. Therefore, at normal operation, either feed water heater is provided with heating steam through an individual conduit. During starting of the plant a single heating steam conduit is in operation which supplies steam through branch conduits to the deaerator or degasifier 28 and to the feed water heaters 31 and 32 which are the last ones through which the feed water flows before entering the steam generator.

The heating conduits 56, 57 and 59 can also be used with advantage during low load operation of the plant when the pressure at the bleeder points of the turbine is so low that insufficient heating steam is available for the feed water heaters.

The arrangement according to the invention can be used in combination with a plurality of resuperheaters and with more than two turbine parts operating at different pressures. The drawing is diagrammatic and it does not make any difference, as far as the invention is concerned, if instead of one superheater section 9 a plurality of superheater sections are used. In modern steam generators operating at high steam temperatures and pressures at least a part of the superheater heating surface is located in the combustion chamber. In this case the connecting conduit 8 may be arranged at the outlet of the last superheater section which is used for lining the combustion chamber wall. The heating steam conduit 56 need not necessarily be connected with the bypass conduit 42. It may be connected with the steam chamber of the separator 44. Likewise, the branch conduits 57 and 59

may be connected with the steam chamber of the separator or with a conduit which is the equivalent of the conduit 56.

What is claimed is:

1. A steam power plant including a turbine, a forced flow steam generator connected with said turbine for supplying steam to said turbine, said turbine having at least two parts operating at different steam pressures, a steam resuperheater interposed for steam flow between said parts and being combined with said steam generator to be heated therewith, a bypass conduit arranged to bypass steam around the high pressure part of said turbine and into said resuperheater, a bypass valve and a water separator interposed in series relation in said bypass conduit, the bypass valve being closed during normal operation of the plant, a plurality of feed water heaters receiving bleeder steam from said turbine, an automatic valve interposed in said bypass conduit downstream of said bypass valve and of said separator and being responsive to the pressure in said bypass conduit upstream of said automatic valve, and a heating steam conduit connected with said bypass conduit between said water separator and said automatic valve and connected with at least a part of said feed water heaters for supplying heating steam thereto.

2. A steam power plant including a turbine, a forced flow steam generator connected with said turbine for supplying steam to said turbine, said turbine having at least two parts operating at different steam pressures, a steam resuperheater interposed for steam flow between said parts and being combined with said steam generator to be

heated therewith, a bypass conduit arranged to bypass steam around the high pressure part of said turbine and into said resuperheater, a bypass valve and a water separator interposed in series relation in said bypass conduit, the bypass valve being closed during normal operation of the plant, a plurality of feed water heaters receiving bleeder steam from said turbine, an automatic valve interposed in said bypass conduit downstream of said bypass valve and of said separator and being responsive to the pressure in said bypass conduit upstream of said automatic valve, a heating steam conduit connected with said bypass conduit between said water separator and said automatic valve and connected with at least a part of said feed water heaters for supplying heating steam thereto, said steam generator having a tube system including a superheater, and a conduit interconnecting said tube system and said bypass conduit for bypassing steam around at least a portion of said superheater.

3. A steam power plant according to claim 2 in which a valve is interposed in the conduit connecting the tube system of the steam generator with the bypass conduit.

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