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METHOD AND APPARATUS FOR STARTING A STEAM POWER PLANT

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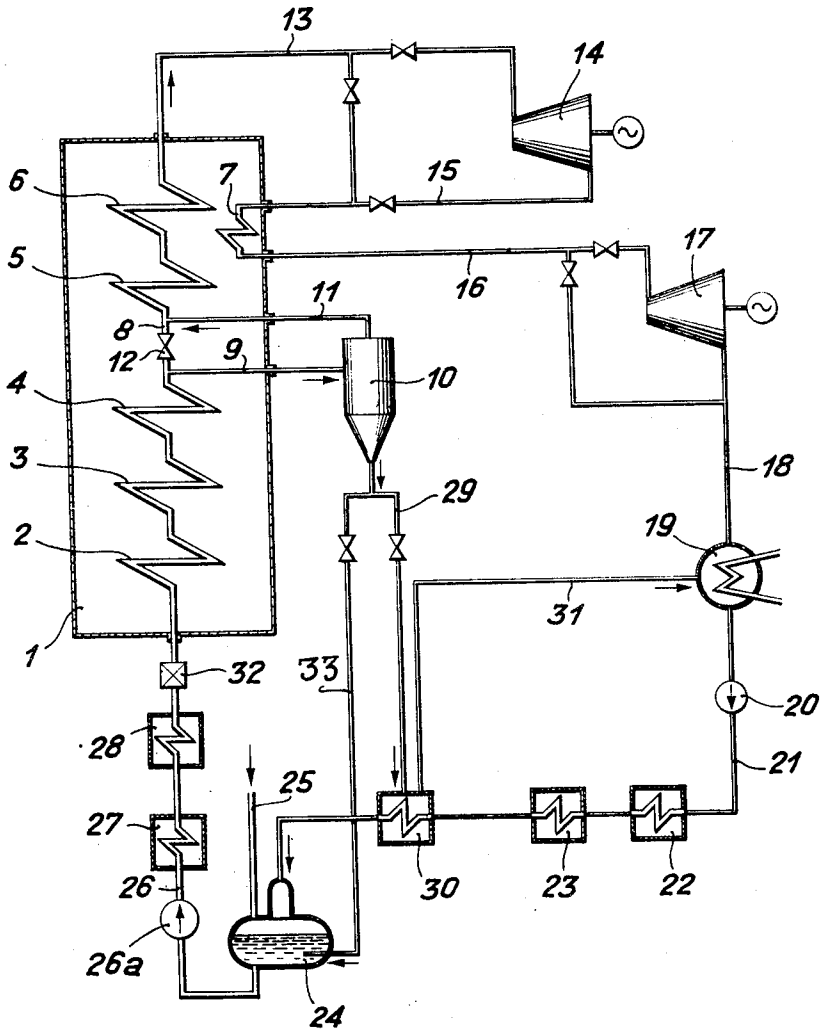

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METHOD AND APPARATUS FOR STARTING A STEAM POWER PLANT

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The present invention relates to a method and means for starting a steam power plant, more particularly to a steam power plant including a forced flow steam generator whose feedwater is preheated by steam from a source other than said steam generator, during the initial starting period of the plant.

When starting a steam power plant including a steam turbine it is desired to operate the turbine a soon as possible after starting the steam generator and it may be of advantage to start the turbine with steam of a much lower pressure than the normal operating pressure. In order to reduce the time between starting the steam generator and starting the turbine it is conventional to supply steam from a source other than the steam generator to a feedwater reservoir for preheating the feedwater for the steam generator before starting the steam generator and during the initial starting period thereof. This causes a rise of the pressure in the feedwater reservoir.

Due to expansion of the heated water in the tubular heating surfaces of the steam generator a mixture of steam and water is formed therein and it has been proposed to conduct the operating medium, before its flow through the final heating sections, through a separator for separating the steam from the water. The flow rate of operating medium through the steam generator before and immediately after starting heating of the steam generator may be considerably greater than the flow rate of the live steam required at that time.

The steam separated in the separator is conducted through the final sections of the heating surfaces of the steam generator and the steam leaving the steam generator is used for heating the pipe leading to the turbine and for heating the turbine. Since the pressure in the separator is lower than in the feedwater reservoir, the water separated in the separator cannot be discharged into the reservoir and it has been proposed to pump this water into the reservoir or into the feed pipe between the reservoir and the steam generator. This requires at least one pump in addition to the condensate pump and to the feed pump.

It is also known to return the water separated in the separator directly or through a pressure-reducing device into the turbine condenser. This involves loss of heat from the water to the condenser coolant.

It is an object of the invention to provide a method of and means for operating a steam power plant having a forced flow steam generator and a turbine receiving steam therefrom whereby the time needed for warming up and starting the plant is shortened and heat which is wasted by conventional plants during these operations, is saved.

An object of the invention is to provide a method and means which afford recovery of the heat contained in the water separated from the operating medium circulating through a forced flow steam generator during the starting period. The method and means according to the invention avoid the shortcomings of conventional systems and avoid the provision of additional pumps which increase first cost and operating expenses.

According to the invention hot water separated in a separator from the operating medium flowing through a forced flow steam generator, before and during the initial starting period of the steam generator, is conducted in a feedwater heater in heat exchange relation to the feedwater flowing from a turbine condenser to a feedwater reservoir and from the latter into the steam generator. After transferring most of its heat content to the feedwater the water is conducted to the condenser. In this way very little heat is wasted by transfer to the condenser coolant.

When, after the initial starting period, the pressure in the water separator is higher than that in the feedwater reservoir the water separated in the separator may be conducted directly into the feedwater reservoir and no water is passed through the feedwater heater into the condenser.

In plants wherein feedwater heaters are provided for heating feedwater by means of steam tapped from the turbine during normal operation of the plant one of these feedwater heaters may be used for heating the feedwater by means of hot water separated from the operating medium flowing through the steam generator during starting of the plant and no additional feedwater heater need be provided for carrying out the method according to the invention.

In a preferred arrangement of the plant according to the invention the water separator is connected to the outlet of one of a plurality of tubular heating sections arranged in the steam generator in series relation with respect to the flow of the operating medium through the steam generator. The steam space of the separator is connected to the inlet of the subsequent heating section for delivering steam thereinto for further heating the steam. The outlet of the section wherefrom operating medium is conducted into the separator and the inlet for the subsequent heating section whereinto the separated steam is conducted are interconnected by a valved conduit affording by-passing a controlled amount of operating medium around the separator. This avoids provision of a separator which is so large as to pass all operating medium during full load operation at a reasonable pressure drop in the separator and a water separator can be provided which is just large enough to cope with the requirements of the starting operation of the plant. During normal operation only a portion or no operating medium may be passed through the separator and a portion or all of the operating medium is by-passed around the separator.

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 an embodiment thereof when read in connection with the accompanying drawing, the one figure of which is a diagrammatic illustration of a plant according to the invention.

Referring more particularly to the drawing, numeral 1 designates a steam generator having tubular heating surfaces including an economizer 2, and evaporator 3, a preliminary superheater 4, and a final superheater comprising two sections 5 and 6; no heating means for the steam generator are shown. The sections 2, 3, 4, 5 and 6 are arranged in series relation with respect to the flow of the operating medium therethrough. A reheater 7 is arranged within the steam generator 1. A conduit 8 is provided connecting the preliminary superheater 4 and the first section 5 of the final superheater. A pipe 9 is connected to the conduit 8 at the outlet of the preliminary superheater 4 for conducting operating medium to a water separator 10. The steam space of the latter is connected by means of a pipe 11 to the conduit 8 at the inlet of the superheater section 5. A valve 12 is interposed in the conduit 8 between the connections of

the pipes 9 and 11. The final superheater section 6 is connected to a high pressure turbine 14 by means of a pipe 13. The operating medium expanded in the turbine 14 flows through a pipe 15 to the reheater 7 and therefrom through a pipe 16 to a low pressure turbine 17. After expansion of the operating medium in the low pressure turbine 17 the operating medium is conducted through a pipe 18 into a condenser 19. The condensate is pumped by a pump 20 through a conduit 21 wherein low pressure preheaters 22 and 23 are arranged in series relation, to a feedwater reservoir 24.

When starting the steam generator from cold, foreign steam of a pressure of about 5 to 10 atmospheres is supplied into the feedwater reservoir 24 through a conduit 25. Feedwater is pumped from the reservoir 24 by means of a feed pump 26*a* through a conduit 26 wherein high pressure preheaters 27 and 28 are interposed, and through a feedwater control valve 32 into the economizer 2.

At this time, the operating medium passing through the sections 2, 3 and 4 of the tubular heating system of the steam generator is a mixture of steam and water. The water is separated from the steam in the separator 10 and the steam is conducted through the pipe 11 into the superheater section 5. The water separated in the separator 10 is conducted through a valved pipe 29 into a heat exchanger 30 which is interposed in the pipe 21 between the low pressure heat exchanger 23 and the feedwater reservoir 24. After transferring heat to the feedwater flowing through the heat exchanger 30 the water from the separator 10 is conducted through a pipe 31 into the condenser 19.

The feedwater heater 30 need not be an additional feedwater heater, but may be one of the conventional feedwater heaters which are heated by steam tapped from the turbine 17.

A valved pipe 33 interconnects the separator 10 and the feedwater reservoir 24 for conducting the water from the separator directly into the reservoir 24 when, after the initial starting period, the pressure in the separator is higher than in the reservoir.

If desired, the pipe 31 may terminate in an auxiliary condenser, not shown.

I claim:

1. A method of starting a steam power plant including a forced flow steam generator and a turbine receiving steam therefrom, comprising, in combination:

heating the feedwater of said steam generator by means of steam from a source other than said steam generator,

conducting the heated feedwater as operating medium through the steam generator,

separating water from operating medium flowing through and before leaving the steam generator,

conducting steam remaining after separation of the water through a portion of the steam generator, and

conducting seperated water in heat exhange relation with the feedwater before the feedwater is heated by steam from a source other than the steam generator.

2. A method of starting a steam power plant including a forced flow steam generator and a turbine receiving steam therefrom, comprising, in combination:

heating the feedwater of said steam generator by steam from a source other than said steam generator,

conducting the heated feedwater as operating medium through the steam generator,

conducting a portion of the operating medium flowing through the steam generator through a separator and separating water from the operating medium,

conducting steam remaining after separation of the water through a portion of said steam generator, and

conducting separated water in heat exchange relation with the feedwater before the feedwater is heated by steam from a source other than the steam generator.

3. A method of starting a steam power plant including a forced flow steam generator, a steam turbine receiving steam from said steam generator, and a condenser receiving exhaust steam from said turbine, comprising, in combination:

heating the feedwater of said steam generator by means of steam from a source other than said steam generator,

conducting the heated feedwater as operating medium through the steam generator,

separating water from operating medium flowing through and before leaving the steam generator,

conducting steam remaining after separation of the water through a portion of the steam generator,

conducting separated water in indirect heat exchange relation wtih the feedwater before the feedwater is heated by steam from a source other than the steam generator, and

conducting water which has been conducted in heat exchange relation with the feedwater into said condenser.

4. In a steam power plant having a forced flow steam generator, a steam turbine receiving steam from said generator, and a condenser receiving exhaust steam from said turbine, the combination of:

feedwater conduit means connecting said condenser to said steam generator for supplying feedwater to the latter,

a feedwater reservoir interposed in said feedwater conduit means,

a feedwater heater interposed in said feedwater conduit means upstream of said reservoir,

steam supply means connected to said reservoir for supplying heating steam thereto from a source other than said steam generator, for heating the feedwater in said reservoir during starting of the plant,

said steam generator including a heating tube system for conducting operating medium therethrough and heating the operating medium therein, and

a water separator interposed in said tube system for separating water from the operating medium and returning the remaining steam to said tube system for further heating the steam,

said water separator being connected to said feedwater heater for supplying water separated in said separator as a heating agent to said feedwater heater for heating the feedwater therein.

5. In a steam power plant as defined in claim 4 and wherein said heating tube system includes a plurality of heating sections arranged in series relation with respect to the flow of the operating medium therethrough, said separator being connected to the outlet of one said sections for receiving operating medium therefrom and to the inlet of the subsequent section for delivering steam thereinto, a valved conduit interconnecting said sections to which said separator is connected and by-passing said separator for passing a controlled portion of operating medium around said separator.

6. In a steam power plant as defined in claim 4 a valved conduit connected to said separator and to said reservoir for conducting water separated in said separator into said reservoir.

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