

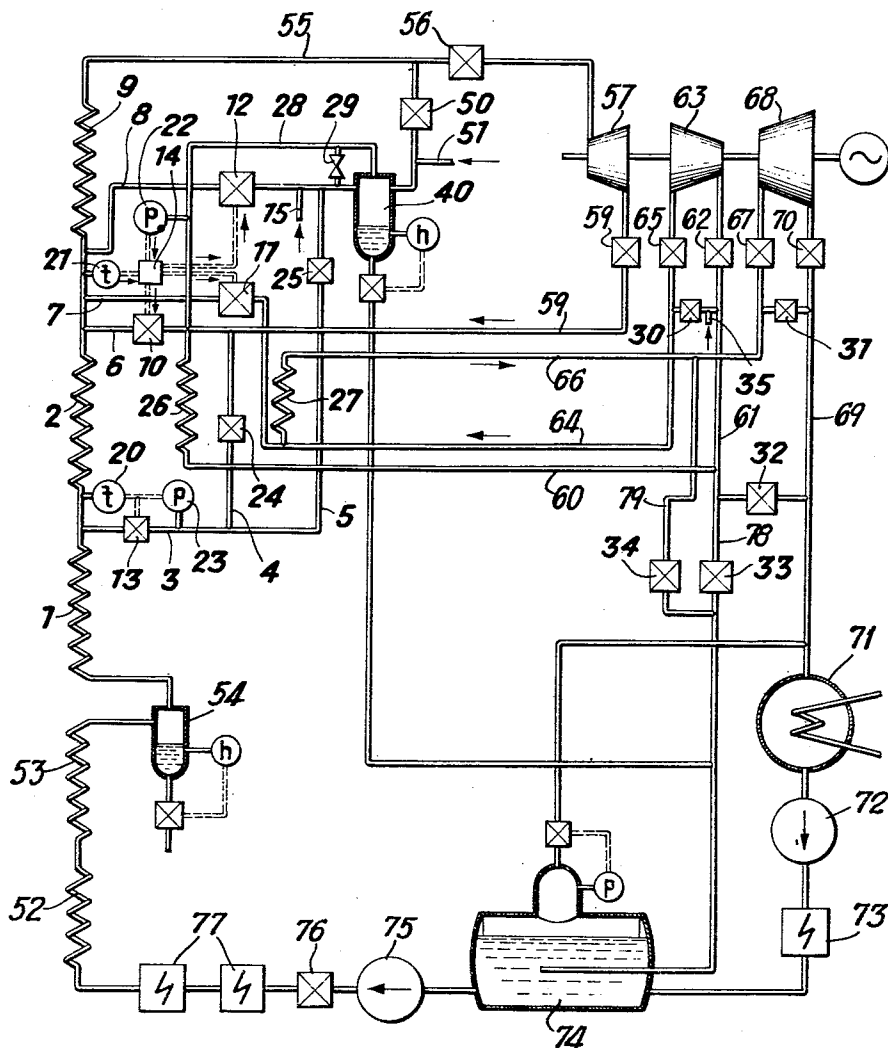
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METHOD OF COOLING RESUPERHEATERS OF A STEAM PLANT

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**METHOD OF COOLING RESUPERHEATERS
OF A STEAM PLANT**

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The present invention relates to cooling of resuperheaters in a steam plant during periods when insufficient partly expanded steam is available for cooling the resuperheaters, i.e. when the steam generator is started and heated-up and when steam generation is stopped, and also during stand-by operation of the steam plant.

When a steam generator including resuperheaters is started, it is desired to bring the output of the steam generator to the desired output in as little time as possible. During this starting period there is usually no or very little partly expanded live steam available for cooling the resuperheater or resuperheaters and other means must be provided for cooling the resuperheater or resuperheaters as efficiently as possible without producing, at least toward the end of the heating-up period, condensate in the pipe lines leading to the consumers of the resuperheated steam.

It is an object of the present invention to provide a method for cooling resuperheaters in a steam plant during periods when insufficient partly expanded live steam is available for cooling the resuperheaters whereby, particularly during starting and heating-up of the steam generator, the cooling medium leaves the resuperheater or resuperheaters as soon as possible as superheated steam.

In the conventional systems operating medium is diverted from the medium leaving the last superheater of the steam generator, i.e. from the medium entering the steam main which conducts live steam when the plant is in normal operation. When starting a steam generator, particularly a forced flow steam generator, the operating medium does not immediately have the highest temperature at the outlet of the last superheater section. The operating medium is hottest somewhere between the evaporating part of the steam generator and the superheater outlet, depending on the structural arrangement and location of the heating surfaces in the stream of the combustion gas. Parts of the tubular heating surfaces through which the operating medium passes consecutively may be less favored with heat than other portions, and, particularly when starting firing, parts subsequently passed by the operating medium may be cooler than previously passed portions of the heating surface so that the temperature of the operating medium does not increase and may even decrease in said subsequent parts. The point of highest temperature travels toward the end of the superheater as the heating-up operation proceeds.

For the aforesaid reasons operating medium which is conducted from the outlet of the last superheating section in the conventional manner into the resuperheater may be so wet that its moisture is not fully evaporated in the resuperheater and liquid operating medium may accumulate in the discharge pipe of the resuperheater and flow into a turbine connected thereto. This undesirable situation can be overcome in conventional systems only by considerably extending the heating-up period.

According to the invention the resuperheater is not cooled by operating medium leaving the last superheater, i.e. leaving the steam generator, but by operating medium diverted from the operating medium at such parts

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of the heating surface of the steam generator wherein the operating medium is hottest during the periods when the steam generator is heated-up, cooled down, or acting as a stand-by. As the hottest point of the heating surfaces travels toward the outlet of the steam generator during the heating-up period, the point where operating medium is diverted from the stream of the operating medium passing through the steam generator is advanced as the heating-up period proceeds, i.e. operating medium is diverted first from a heating surface section which is relatively cool during normal operation of the steam generator and is subsequently taken from a heating surface section which is relatively hot during normal operation of the steam generator. The diverted portion of the operating medium is either exclusively used or cooling the resuperheater or resuperheaters or is used together with operating medium diverted elsewhere from the stream of operating medium passing through the plant.

If there are several resuperheaters, it may be of advantage or necessary to cool only one resuperheater.

The pressure of the diverted cooling medium may be reduced before it enters the resuperheater or resuperheaters. It may be desirable to pass the diverted operating medium through a water separator so that only steam is passed into the resuperheater. The separated water is preferably returned to a feedwater tank from which the steam generator is fed. If it is desired that wet steam enters the resuperheater or the resuperheaters, a portion of the diverted operating medium is by-passed around the water separator and directly introduced into the resuperheater or resuperheaters.

The consecutive steps forming the method according to the invention may be performed either according to a predetermined timetable or in response to predetermined operating conditions, i.e. predetermined temperatures and pressures of the operating medium from which medium is diverted for cooling the resuperheater or the resuperheaters; for example, the diversion of operating medium from the superheater may be controlled in response to the position of the point in the superheater where the operating medium has the highest temperature during periods when no partly expanded live steam is available for cooling the superheater. As has been explained supra, this point travels from the superheater inlet to the superheater outlet when the steam generator is started and during the heating-up period.

If two resuperheaters operating normally at different pressures are arranged in parallel relation with respect to the cooling medium flowing therethrough when the plant is heated-up, it may be advisable to provide two pipe lines for diverting operating medium from the main stream of the operating medium, one pipe line for each resuperheater, whereby the pipe lines may be connected to different sections of the superheater. If both resuperheaters are to be cooled by operating medium taken from the same point of the heating surface of the steam generator, a pipe connected thereto may be divided into two pipe lines which are individually connected to the two resuperheaters.

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 diagrammatically illustrates a steam generating and resuperheating plant according to the invention.

Referring more particularly to the drawing, numerals 1, 2 and 9 designate three superheaters which are arranged in series relation and receive steam separated in

a separator 54 forming part of a forced flow steam generator including a water heating section 52 and an evaporating section 53 arranged in series relation to the water heating section and discharging operating medium into the separator 54.

When the plant is in normal operation, the superheated steam discharged from the last superheater section 9 is conducted through a live steam pipe 55 provided with a valve 56 into a high pressure turbine 57. The steam exhausted by the latter is conducted through a pipe 58 provided with a valve 59 to a first resuperheater 26. The resuperheated steam is conducted through a pipe 60 into a pipe 61 provided with a valve 62 and into a medium pressure turbine 63. The exhaust of the latter is conducted through a pipe 64 provided with a valve 65 to a second resuperheater 27, the resuperheated steam being conducted through a pipe 66 provided with a valve 67 to a low pressure turbine 68. The exhaust of the latter is conducted through a pipe 69 provided with a valve 70 into a condenser 71. The condensate is conducted in the conventional manner to a feedwater reservoir 74 by means of a pump 72 and through a heater 73. The water heating section 52 of the steam generator is fed from the reservoir 74 by means of a pump 75, a valve 76 and feedwater heaters 77 being interposed in the feed pipe between the pump 75 and the tube section 52.

A pipe 3 is connected to a pipe connecting the superheater sections 1 and 2 and pipes 6, 7 and 8 are connected to a pipe interconnecting the superheater sections 2 and 9. A pipe 4 provided with a valve 24 is connected to the pipe 3 downstream of a valve 13 and is connected to the pipe 58 for conducting operating medium from the superheater section 1 into the first resuperheater 26, when the valve 59 is closed. Also connected to the pipe 3 is a pipe 5 provided with a valve 25 and adapted to discharge operating medium received from the superheater section 1 into a water separator 40. The steam space of the latter is connected by means of a pipe 28 to the inlet of the resuperheater 26. A by-pass pipe provided with a valve 29 affords passing of operating medium from the pipe 5 directly into the pipe 28 so that a desired moisture content of the steam entering the resuperheater 26 can be maintained by suitable manipulation of the valve 29.

The pipes 6, 7 and 8 which are connected to the conduit interconnecting the superheater sections 2 and 9 are provided with valves 10, 11 and 12, respectively. The pipe 6 is connected to the inlet of the resuperheater 26 downstream of the valve 10. The pipe 7 is connected to the second resuperheater 27 downstream of the valve 11. The pipes 6 and 7 with the valves 10 and 11 afford passage of operating medium discharged by the superheater section 2 in parallel relation through the resuperheaters 26 and 27 for cooling the resuperheaters, for example when starting the plant. The pipe 8 which is connected to the conduit connecting the superheater sections 2 and 9 terminates in the separator 40. Relatively cool operating medium may be injected into the pipe 8 through a conduit 15 for cooling the operating medium received by the separator 40 from the pipe 8. When the resuperheater 26 is cooled by operating medium received from the superheater section 2, the operating medium, after passing through the resuperheater 26, is conducted through pipe 60 into the pipe 61 which is connected to a pipe 78 controlled by a valve 33 and terminating in the feedwater reservoir 74. The cooling medium leaving the resuperheater 26 may be alternatively conducted from the pipe 60 through a conduit connecting the pipes 61 and 69 and provided with a valve 32 into the condenser 71.

The cooling steam passing through the resuperheater 27 may be conducted through the pipe 66 and a pipe 79 connected to the pipe 66 and provided with a valve 34 into the pipe 78 downstream of the valve 33 and into the feedwater reservoir 74. A connection in which a valve 31 is interposed is provided between the pipes 66 and 69

for alternatively returning the cooling medium passing through the resuperheater 27 to the condenser 71.

By suitable manipulation of the valves 13, 10, 24, 32, 33, 30, 11, 34 and 31, the resuperheaters 26 and 27 may be arranged in series relation during the periods when they are cooled by operating medium received either through pipe 3 or through pipe 7. When the resuperheaters are arranged in series relation, the cooling steam passes first through the resuperheater 26 and therefrom through pipes 60 and 61 into a connection provided with the valve 30 and connecting the pipe 61 to the pipe 64. If the cooling medium leaving the first resuperheater 26 is too hot for effectively cooling the second resuperheater 27, water may be injected through a pipe 35 into the pipe connection between the pipes 61 and 64 upstream of the valve 30.

The valve 13 may be controlled in response to the temperature of the operating medium entering the superheater 2 by means of a conventional temperature responsive control device 20. The valve 13 may also be controlled in response to the pressure in the pipe 3 by means of a conventional pressure responsive control device 23. This automatic control may be so set that the valve 13 is opened when the temperature sensed by the device 20 exceeds a predetermined limit and is closed when the pressure sensed by the device 23 exceeds a predetermined limit.

The valves 10, 11 and 12 may be connected to a control apparatus 14 which is actuated by a conventional temperature sensitive device 21 sensing the temperature of the operating medium flowing into the superheater section 9. The apparatus 14 is also actuated by a pressure sensitive device 22 which is responsive to the pressure in the pipe 28.

The aforesaid automatic control may be so adjusted that the valve 13 is opened by the device 20 when the operating medium entering the superheater section 2 has a predetermined temperature so that a portion of the operating medium leaving the superheater section 1 flows through the open valve 24 into the first resuperheater 26. The valve 10 is closed at this time because the operating medium leaving the superheater section 2 does not have the predetermined temperature. After the hottest point of the superheater 1, 2, 9 has traveled from the inlet of the section 2 to the outlet thereof, the device 21 causes opening of the valve 10 so that also operating medium discharged by the superheater section 2 is passed into the first resuperheater 26. This causes an increase of the pressure in the pipe 3 so that the device 23 closes the valve 13. In the illustrated example in which parallel arrangement of the resuperheaters is possible during the periods when the resuperheaters must be cooled by operating medium taken from the steam generator, the control apparatus 14 actuates the valve 11 so that a portion of the operating medium can be passed through the resuperheater 27 while the resuperheater 26 is cooled by operating medium received through the pipe 6. When the temperature sensed by the device 21 reaches a predetermined value, the valve 12 is opened so that a portion of the operating medium is diverted from the final superheater section 9 into the separator 40. Therefore, the pressure in the pipe 28 sensed by the device 22 rises, whereupon the control apparatus 14 closes the valves 10 and 11. Operating medium which is in the state of substantially dry steam flows now from the separator 40 in series relation through the resuperheaters 26 and 27 for drying out the resuperheaters. The valve 12 is closed by the control apparatus 14 upon increase of the pressure in the pipe 28 above a predetermined value so that the entire operating medium passing through the superheaters is conducted through a pipe provided with a valve 59 and connecting the steam main 55 with the separator 40. The valve 56 is still closed at this time. The live steam passing through the valve 50 may be cooled by injecting water through a pipe 51 into the steam before it reaches the separator 40. The re-

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superheaters 26 and 27 can now be fed by steam taken from the steam main 55.

If it is desired that both resuperheaters are arranged in series relation also during the beginning of the starting period, the pipe 7 and the valve 11 may be omitted. In this case the cooling medium flows from the resuperheater 26 through the valve 39 into the resuperheater 27 and may be cooled by injecting water through the pipe 35.

The system according to the invention is not only useful for starting or heating-up a steam generating plant including resuperheaters, but is also useful when stopping and cooling-down such a plant, or for cooling the resuperheaters during stand-by periods when the plant has the character of a stand-by plant.

I claim:

1. The method of operating a steam generator having a tubular evaporating part for evaporating the operating medium of the steam generator, a tubular superheater connected in series to said evaporating part with respect to the flow of the operating medium, and a resuperheater for resuperheating partly expanded steam, the method comprising sensing the temperature of the operating medium in two consecutive parts of said superheater passed through consecutively by the operating medium flowing through the superheater, diverting operating medium from the first part of said superheater into said resuperheater in response to a predetermined temperature sensed in the first part of the superheater, and subsequently diverting operating medium from the second part of the superheater downstream of said first part into said resuperheater in response to a predetermined temperature sensed in the second part of the superheater downstream of said first part.

2. The method defined in claim 1, including reducing

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the pressures of the diverted operating media prior to entry of the diverted operating media into the resuperheater.

3. The method defined in claim 1, including separating the water from at least one of the diverted operating media prior to entry of the diverted operating medium into the resuperheater.

4. The method defined in claim 1, including injecting cooling water into at least one of the diverted operating media prior to entry of the diverted operating medium into the resuperheater.

5. The method of operating a steam generator having a tubular evaporating part for evaporating the operating medium of the steam generator, a tubular superheater connected in series to said evaporating part with respect to the flow of the operating medium, and a plurality of resuperheaters for resuperheating steam partly expanded to different pressures, the method comprising sensing the temperature of the operating medium in two consecutive parts of said superheater passed through consecutively by the operating medium flowing through the superheater, diverting operating medium from the first part of said superheater into one of said resuperheaters in response to a predetermined temperature sensed in the first part of the superheater, and diverting operating medium from the second part of the superheater downstream of said first part into a second of said resuperheaters in response to a predetermined temperature sensed in the second part of the superheater downstream of said first part.

References Cited in the file of this patent

UNITED STATES PATENTS

2,900,792	Buri	Aug. 25, 1959
2,901,887	Buri	Sept. 1, 1959