METHOD OF REGULATING VAPOR TEMPERATURE

FIG. 2

PRESSURE TRANSMITTER

FLOW TRANSM.

TEMP. TRANSM.

FLOW TRANSM.

TEMP. TRANSM.

FIG. 3

PRESSURE TRANSM.

FLOW TRANSM.

MOTOR CONTROL

FIG. 4

PRESSURE TRANSM.

FLOW TRANSM.

MOTOR CONTROL
METHOD OF REGULATING VAPOR TEMPERATURE

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1. A method of regulating a vapor temperature, comprising the steps of piping a continuous flow path, along which heat is supplied and from which superheated vapor is discharged to a turbine or other point of usage, wherein the temperature of the vapor is regulated by means of a pump driven by any suitable means, such as a motor or turbine, diagrammatically shown at 12.

2. A controller 12A provided for regulating the speed of the pump 12 and hence the rate at which feed water is forced into and through the generator. Fuel and air for combustion are admitted to the generator through conduits 13 and 14 respectively and the gaseous products of combustion, after passing over the vapor generating and superheating surfaces, are discharged through an outlet, diagrammatically shown at 15. Valves 13A and 14A represent the customary regulating means for the fuel and air respectively.

Dispersion in the inlet to each secondary superheater path or circuit is a spray type, identified by the numbers 17, 18, 19 and 20. Such attemperators are well known in the art and may take any conventional form. Reference may be made, for example, to United States Patent No. 2,550,683 to Fletcher et al. which illustrates and describes a suitable type. Water for the attemperators is supplied through a conduit 21 from any suitable source. Frequently, but not always, the water for the attemperators is obtained from the discharge of the pump 11. The flow of water to each attemperator may be regulated by suitable valves such as shown at 70, 71A, 71B and 71C.

In Fig. 2 I show in diagrammatic form a control system for the generator shown in Fig. 1. In accordance with my invention the control system of Fig. 2 is arranged to control the rate of firing in proportion to the load on the generator with readjustment as required to maintain a predetermined final steam temperature at the outlet at a selected one of the secondary superheater paths. Attemperating water is introduced into the inlet of the selected path or circuit at a predetermined rate sufficient to insure some attemperating water being required in each of the other parallel flow secondary superheater paths to maintain the temperature at the outlet of each of these other paths at the same value as the final steam temperature of the outlet of the aforesaid selected path. Depending upon such conditions as the particular design of the generator under consideration, type of fuel burning equipment and the like, the scheduled rate at which attemperating water is introduced into the selected path may remain constant over the entire range of generator operation, may increase with rating or, in some cases, even decrease with rating. In other words it may be said that in accordance with my invention the rate of firing is adjusted to continually maintain a higher temperature than that desired at the outlets of the superheater paths at the temperature then reduced by attemperation to that desired. By initially adjusting firing rate in accordance with load and having the firing rate readjusted from temperature, the effect of changes in load on final steam temperature is to a great extent minimized and anticipated to the end that relatively minor adjustments of firing rate from temperature are required.

I have chosen to illustrate and describe my invention embodied in a pneumatically operated control system for the reason that such systems, as well as the components...
thertof, are well known and readily understandable by those familiar with the art. It will be apparent, however, as the description proceeds, that my invention could equally well be embodied in a hydraulic or electrically operated system and the principles thereof utilized in manual control of the generator.

Referring now to FIGS. 1 and 2, I show at 22 a transmitter sensing the differential produced by a primary element 22A disposed in the feed pipe to the generator and generating a pneumatic loading pressure proportional to the rate of flow of feed water to the generator. Since the generator 2 is of the forced flow once-through type, the rate of flow of feed water is equal to the rate of vapor generation or load or rating on the unit. The loading pressure generated by transmitter 22 is transmitted through a pipe 23 and by branch pipe 23A to the C chamber of a proportional relay 24 which may be, for example, of the type illustrated and described in U.S. Patent No. 2,805,678 to Michael Panich.

The relay shown at 24, as taught by Panich, may be used to obtain a variety of control actions such as proportional, proportional plus reset and proportional plus rate. A direct acting control may be obtained by introducing a loading pressure into the C or A chamber whereas an inverse acting relay may be obtained by introducing a loading pressure into the B chamber. By introducing loading pressures into both the A and B chambers and opening the C chamber to atmosphere a pressure at D proportional to the difference between the loading pressures introduced at A and B may be obtained, or a pressure at D may be obtained proportional to the sum of the pressures introduced into C and A. I therefore utilize the relay, such as shown at 24, to obtain various desired control actions which will identify as the description proceeds.

The relay 24 serves to generate in output chamber D a control pressure proportional to the loading pressure introduced at C which is transmitted through a pipe 25 and Selector Station 26 to final control elements 29A and 14A controlling the supply of fuel and air respectively to the generator 2. The Selector Station 26 provides a means for transferring the control from Automatic to Remote Manual and may be of the type illustrated and described in U.S. Patent No. 2,747,595 to Paul S. Dickey.

While I have shown fuel and air controlled in parallel in accordance with generator load, as common in the art, sub-loop controls would normally be incorporated in the control system to maintain a predetermined fuel-air ratio, furnace draft and the like.

The control so far described operates to control firing in proportion to the load on the generator. By so doing approximately the correct temperature will be maintained at the outlet of the superheater paths 6, 7, 8 and 9. However, as previously stated, in accordance with my invention the firing is readjusted to maintain the desired outlet temperature in a selected one of the superheater paths. In the drawings I have shown a temperature transmitter 27 arranged to generate a loading pressure in accordance with the vapor temperature at the outlet of superheater path 6. This loading pressure is transmitted through a pipe 28 to a proportional plus reset relay 29. That is to say, the control pressure generated by the relay at output chamber D is a function both of the changes in loading pressure introduced into the relay and the time integral of the difference between the actual loading pressure and a predetermined or Set Point value of the loading pressure. As it is desired to have the rate of firing vary inversely with changes in temperature, the loading pressure is introduced into the B chamber so that an increase in loading pressure, for example, causes a corresponding decrease in control pressure in D. The control pressure generated by relay 29 is transmitted through a pipe 30 to the A chamber of the relay 24 and hence changes therein produce proportionate changes in the output pressure of this last named relay.

Relay 29 being adjusted so that the Set Point corresponds to the desired outlet temperature, the control operates to vary the firing rate in accordance with changes in load and to readjust the firing rate as required to maintain the desired outlet temperature. By virtue of the difference in time constants of the load responsive control loop and the temperature responsive control loop, the control from temperature is inherently slow acting and serves to readjust the firing rate after the initial and anticipating adjustment from load. As will be appreciated the set of relays provided in relays 24 and 29 may be utilized to adjust the control in accordance with the system time constants or if necessary additional relays or control elements may be incorporated in the system for this purpose.

To insure that the firing rate is maintained at a rate requiring some attemperation in superheater paths 7, 8 and 9 to maintain the desired temperature at the outlet of each of the paths, attemperating water is introduced into superheater path 6 at a rate corresponding to generator load. The loading pressure generated by transmitter 22 is transmitted through pipe 33B to a proportional relay 31, the output pressure of which is transmitted through a pipe 32 to a proportional plus reset relay 33, the output pressure of which in turn is transmitted through a pipe 34, Selector Station 35 to attemperator valve 70. Also introduced into relay 33 is a signal proportional to the rate of flow of water to the attemperator 17 as generated by a flow transmitter 36.

It may be said that the control system for attemperator 17 incorporates a constant flow control the Set Point of which is adjusted in accordance with generator load.

That is to say, the control pressure generated by relay 31 is a function of load and this pressure introduced into the proportional plus reset relay 33 serves to establish the Set Point of this relay which is included in the constant flow control loop comprising valve 70 and flow transmitter 36. Hence the control assures that a predetermined rate of flow of water to attemperator 17 will be maintained for each and every generator load. The control components may be provided with the necessary adjustments for establishing any desired relationship between generator load and attemperating water flow as will be apparent to those familiar with the art. The consideration being that the flow of attemperating water to attemperator 17 be maintained at the minimum required to assure some attemperation being required to maintain the desired outlet temperatures in superheater paths 7, 8 and 9. Ordinarily an increasing amount of attemperating water will be required with increasing load; however, with some generator designs a constant flow of attemperating water may be required over the entire range of operation of the generator or even a decreasing amount of attemperating water with increasing generator load.

If due to malfunction of the control or for any other reason the temperature at the outlet of superheater path 6 should materially increase above the Set Point, the flow of attemperating water should be increased above the scheduled value to avoid damage to the generator and associated equipment. To provide for this contingency incorporated in the control is a limit or over-riding control from the temperature at the outlet of superheater path 6. As shown the loading pressure generated by temperature transmitter 27 is transmitted by way of branch pipe 28A to a proportional plus reset relay 37, the output pressure of which is introduced into the C chamber of relay 31. The Set Point of relay 37 is adjusted to be materially above the Set Point normally maintained by the control from firing. For example, the control from firing may be adjusted for a Set Point of 1050°F and the over-riding control for a Set Point of 1060°F. Hence, normally the output pressure of relay 37 will remain at an...
extreme fixed value and have no effect on the normal control. However, should the temperature at the outlet of the superheater paths above the predetermined limit the outlet pressure of relay 37 will correspondingly vary causing an increase in the attempering water as required to hold the temperature at or below the limit value.

The temperature control for each of the superheater paths 7, 8 and 9 is the same and I will therefore describe the control for superheater path 7 only. I have on the drawing indicated corresponding control elements for the control of the superheater paths 7, 8 and 9 by the same reference numbers followed by reference letters A, B and C respectively.

Temperature transmitter 38A generates a loading pressure corresponding to the temperature at the outlet of superheater path 7 which is transmitted by pipe 39A to a proportional plus reset relay 40A, hence to a proportional relay 41A, Selector Station 42A to attemperator valve 71A. The Set Point of relay 40A is adjusted so that the flow of the attempering water is varied as required to maintain the desired outlet temperature.

Because of the relatively long time constants usually encountered it is sometimes desirable to superimpose upon the proportional plus reset control a rate action. As shown in FIG. 2, I may incorporate in the control a proportional plus rate relay 43A which serves to generate an output proportional to the error in the amount and rate of temperature change. This pressure is transmitted by way of pipe 44A to relay 41A so that it serves to modify the control pressure transmitted to valve 71A in accordance with the rate of change in the outlet temperature of superheater path 7.

It is sometimes desired to vary the temperature Set Point in accordance with generator load or to modify it from some factor such as, for example, exhaust hood temperature of a turbine supplied with vapor from the generator. I have shown in FIG. 2 the control arranged so that the Set Point of the temperature control is varied as a function of generator rating, it being apparent therefrom how modifying controls in general may be incorporated in the system if desired.

The loading pressure generated by flow transmitter 22 is transmitted to a proportional relay 45, then through pipe 46 to the B chambers of relays 37, 40A, 40B and 40C. The control pressure established by relay 45 varying with generator rating thus serves to correspondingly adjust the Set Points of the last named relays and hence the temperature maintained at the outlet of superheater paths 6, 7, 8 and 9.

The output of the loading pressure generated by transmitter 22 introduced into the C and B chambers of relay 45 as illustrating the flexibility of the control to provide any desired functional relation between generator rating and the temperature Set Point. By adjustment of the proportional band of relay 45 the output pressure generated thereby may be made to increase with rating or decrease with rating. Manual Loader 47 and 3-way valve 48 are provided for transferring the temperature Set Point control from Automatic to Remote Manual. The 3-way valve is shown in the Automatic position. In the second position the loading pressure manually established in Loader 47 is transmitted to show to the A chambers of relays 37, 40A, 40B and 40C and provides a means for establishing a desired Set Point independent of generator load.

In the arrangement shown in FIGS. 1 and 2, generator rating is adapted to load requirements by adjusting the rate of flow of feed water to maintain a desired outlet pressure in each of the superheater paths. Temperature transmitter 50 generates a loading pressure corresponding to the pressure of the vapor in the turbine vapor supply distributor 10 which is transmitted through a pipe 51 to a proportional plus reset relay 52 and thence by way of a pipe 53, Selector Station 54, and pipe 55 to motor control unit 12A.

In FIGS. 3 and 4 I show an alternate arrangement of load control wherein the pressure in the turbine supply line 49 is maintained at desired value by means of a back pressure control valve 56. With this alternate arrangement the loading pressure generated by transmitter 50 is transmitted from Selector Station 54 through a pipe 57 to the back pressure control valve 56. The Selector Station 54 may be provided with a manually adjustable loader for manually establishing a loading pressure transmitted through a pipe 58 to the B chamber of relay 52 to thereby provide a means for adjusting the Set Point of the control.

Further in accordance with the arrangement shown in FIGS. 3 and 4 feed water flow is controlled to a constant value by having the loading pressure generated by transmitter 22 introduced into a proportional plus reset relay 60, the output pressure of which is transmitted by wire 59 of a Selector Station 61 to motor control unit 12A. As shown, the Set Point of the constant flow control is manually adjusted from Selector Station 61. It will be apparent however that if desired the Set Point may be adjusted automatically from any desired factor arranged to generate a proportionate loading pressure which is introduced into the A chamber of relay 60.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the apparatus disclosed in the drawings without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of regulating vapor temperature in a fuel-fired forced flow vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

2. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

3. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

4. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

5. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

6. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

7. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

8. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

9. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

10. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

11. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

12. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

13. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.

14. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by superimposing a rate action upon the proportional plus reset control a rate action.
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3. The method of regulating vapor temperature in a fuel-fired forced flow once-through vapor generator wherein the entering liquid is vaporized and then passed in parallel flow relation to a plurality of parallel flow vapor superheating circuits, which comprises maintaining the temperatures of the vapor discharging from said superheater circuits at a substantially uniform and constant predetermined value over a wide range of loads by supplying attemperating liquid to one of said circuits in response to deviations of the vapor temperature therein from said predetermined temperature value in direction tending to increase the attemperating liquid supply rate as the vapor temperature increases and vice versa, and by varying the firing rate in response to deviations of the vapor temperature in the other of said circuits from said predetermined temperature value in direction tending to increase the firing rate as the vapor temperature in said other circuit drops below said predetermined value and vice versa, while continuously supplying attemperating liquid to said other circuit throughout said predetermined load range in quantities sufficient to assure that said one circuit will always require some attemperating liquid to hold the vapor temperature therein at said predetermined temperature value.

References Cited in the file of this patent

UNITED STATES PATENTS

2,752,899 Kasak ----------------- July 3, 1956
2,840,054 Rowand --------------- June 24, 1958

FOREIGN PATENTS

787,006 Great Britain -------- Nov. 27, 1957