The present invention relates to improvements in regenerative air preheaters and particularly to minimizing corrosion of the heat transfer plates in a regenerative preheater of the rotary type.

When air preheaters are operated under such conditions that the temperature of the metallic heat transfer plates is so low as to be at or below the dew point of the gases entering the preheater, moisture condenses from the gases and causes corrosion of the plates especially at the "cold end" i.e. where the cold air enters and the cooled gas is discharged. The present invention contemplates minimizing such corrosion by controlling the heat transfer relation between the streams of hot gas and air flowing through the preheater; more specifically, the amounts and/or temperatures of air and gas entering the preheater are varied with respect to each other.

According to one form of the invention the amount of air passed through the preheater with respect to the amount of heating gases is regulated so that the preheater operates under such conditions that the mean temperature of the heat transfer plates is maintained above the dew point of the heating gases. A damper controlled air by-pass around the preheater is provided so more or less air may be by-passed to maintain the plate temperature above the dew point of the heating gases. This control is based upon the fact that the mean temperature of the heat transfer plates is a definite function of half the total of the temperature existing in the air inlet duct of the preheater and in the gas outlet duct thereof. Accordingly, by providing mechanism for measuring these two temperatures and adding them together the by-pass damper may be automatically adjusted to by-pass air when required and vary the volume of air with respect to the volume of gas flowing through the preheater so as to maintain a predetermined plate temperature.

As an alternative to by-passing cool air some of the heated air may be returned to the air inlet duct and recirculated through the preheater with the result that the temperature of air entering the preheater is raised. In this case the by-pass mentioned above may be connected to the forced draft fan that forces cold air through the preheater.

In another modification of the invention for effecting control by totalized air inlet and gas outlet temperatures a by-pass is constructed around part of the heat absorbing surface ahead of the preheater, such for example as an economizer. Here when hot gases are by-passed around the economizer they enter the preheater at a higher temperature and therefore raise temperature of the plates since the volume of air remains the same.

This application is a continuation-in-part of my application Serial No. 395,352, filed May 27, 1941.

In the drawings:

Figure 1 is a schematic view of an air preheater installation embodying the present invention, and illustrates it as applied to by-passing air around the preheater;

Figure 2 is a similar view illustrating the invention applied to effect recirculation of heated air;

Figure 3 illustrates the application of the invention to controlling by-passing of hot gases around heat absorbing surface in advance of the air preheater.

Referring to Fig. 1, the numeral 10 designates a rotary regenerative air preheater. Air to be preheated is supplied to the preheater by a fan 11 through an inlet duct 12 and carried away from the preheater to the point of use through an outlet duct 13. Hot gases, such as those discharged from a boiler, enter the preheater through a gas inlet duct 14 and pass to the stack or other point of discharge through a gas outlet duct 15.

The preheater is of the well known Ljungstrom type such as disclosed in Ljungstrom Patent 1,522,625, issued January 13, 1925 having a rotor provided with sector compartments carrying metallic heat transfer plates which are first heated by the gases entering through duct 14 and leaving via duct 15 and which are then turned into position to yield their heat to the air entering through duct 12 and discharged through duct 13.

In order to regulate the amount of cool air passing through the preheater so that the temperature of the heat transfer elements may be controlled for the purpose mentioned above, a by-pass duct 16 extends from the air inlet duct 12 to the air outlet duct 13 and has therein a damper 17. If desired, dampers 18 may also be provided in the inlet duct 12 or in the outlet duct 13 ahead of the by-pass and arranged so as to restrict flow through the air preheater and thus divert a greater quantity through the by-pass duct 16.

The dampers 17 and 18 are connected to be actuated by an air operated damper motor diagrammatically represented as consisting of a piston cylinder 22 which is stationary and a movable yoke 24 which is connected to the piston of the motor and also to the dampers 17, 18.
The temperature of the cool air entering the air preheater is measured by a thermostat 20 and the temperature of the gas leaving the preheater after having been partially cooled by imparting heat to the air is measured by the thermostat 21. These thermostats are the primary control elements and in accordance with the invention a by-pass damper, such as the damper 17 controlling the by-passing of air, is to be operated in response to variations from a predetermined total temperature of the entering cool air and outgoing cooled gas so as to maintain the heat transfer plates at a temperature high enough to prevent condensation of moisture therein from the heating gases. Any suitable apparatus whether mechanical, electrical or otherwise actuated which in its operation would act to add together the temperatures in the air inlet duct 12 and gas outlet duct 15 and cause the by-pass damper to open or close in response to fluctuations from a predetermined total would be suitable for carrying out the present invention. For the purpose of providing a complete description of the invention one form of such apparatus, which the "Hagan" pneumatic control apparatus, will be described hereinafter although it is to be understood that the invention is not to be considered as limited to employment of this apparatus. The thermostats 20 and 21 which are the primary control elements, are associated with other control elements actuated by compressed air and adapted to add the totals of the temperatures measured by these thermostats and eventually cause movement of the dampers 17 when a predetermined total temperature is departed from. Compressed air from a suitable source at constant pressure flows to a pilot valve 33A through a conduit 30 having an air filter 31 and pressure reducing valve 32 therein. The pilot valve 33A is connected to the movable element 27 of the thermostat 20 on the air side so that as temperature changes occur in duct 12 the pilot valve 33A is opened more or less thereby varying the air pressure communicated through a conduit 34 to a diaphragm 36 of a Hagan "totalizer." In like manner the movable element of the thermostat 21 on the gas side controls the air pressure communicated via a conduit 35 to act on another diaphragm 37 of the totalizer in the same sense that the air pressure in conduit 34 acts on the diaphragm 36. The diaphragms 36 and 37 are interconnected and accordingly the forces acting on the two of them are added together. The diaphragms are connected to and actuate a pilot valve 33T to regulate the air pressure in a conduit 38 in proportion to fluctuations in the total of the temperatures existing at the air inlet and gas outlet of the preheater. The air pressure created in the conduit 38 to reflect the total of the temperatures in the air inlet 12 and gas outlet 15 is compared with a standard representing the predetermined temperature at which it is desired to maintain the heat transfer surface of the preheater. A hand-set regulating or pilot valve 33M may be set so that the pressure of air in the conduit 40 constitutes a standard representing the predetermined temperature at which it is desired to maintain the heat transfer surface. The air pressure in conduit 38 representing the actual existing total temperatures of the air entering and the gas leaving the preheater acts on one side of a diaphragm 41 and is opposed by the standard pressure in conduit 40 representing the temperature at which it is desired to maintain the heat transfer surface. The diaphragm 41 is connected to the pilot valve 33C which therefore responds to create a pressure variation in a line 42 in accordance with departures of the actual existing temperature total from a predetermined total temperature. The pressure in line 42 acts against a spring on a diaphragm 43 connected to a valve 44 to admit air from a high pressure line 45 through pipes 46 or 47 to one side or the other of the piston in the cylinder 22 of the air motor that operates the damper 17. When the total of the temperatures existing in the air inlet duct 12 and gas outlet duct 15 falls below the predetermined temperature total the control apparatus produces a pressure in line 42 which causes the valve 44 to be positioned so that air from the pressure line 45 passes through the pipe 46 to the upper end of the piston cylinder 22 thereby moving yoke 28 downwardly causing operation of the air motor in a direction to partially open the damper 17. Consequently, part of the cool air previously passing through the preheater flows through the bypass duct 16. The spring resisting the diaphragm 43 is so arranged as to tend to return valve 44 to a neutral position so as to stop the air motor when the damper 17 has opened proportionately to the pressure variation in line 42 caused by decrease in the temperature total. The amount of air passing through the preheater 10 from the inlet duct 12 is thus reduced and therefore absorbs less heat from the heat exchange plates. The temperature of these plates is thus maintained at a high enough value to prevent condensation. In other words when the temperature of entering air falls so low or its relation with respect to the temperature of the outlet gases is such that the air would cool the heat transfer plates to a temperature such that on entering the gas side of the preheater condensation will take place, part of the cool air is by-passed and the plates retain a part of the heat imparted to them by the gases which previously they had yielded to the larger volume of air. When the total temperature measured by the thermostats 20 and 21 exceeds a predetermined value, the resultant action of the control system lowers the pressure in conduit 42 and the spring associated with diaphragm 43 causes the valve 44 to be moved to a position in which the air from pressure line 45 is supplied through the pipe 47 to the lower end of the piston cylinder 22 thereby producing movement of the damper 17 in the closing direction. In the arrangement illustrated in Figure 2 a conduit 50 connects the heated air outlet duct 13 with the inlet of fan 11 to which the cold air supply duct 51 is also connected. Dampers 50 and 52 are provided for regulating the relative amounts of fresh cool air and re-circulated heated air supplied by the fan 11 to the air inlet duct 12 of the preheater 10 as the aggregate of the temperatures measured by the thermostats 20, 21 fluctuates from predetermined total to results in actuation of damper motor 22 as described above. Consequently, the return of heated air to the air inlet duct 12 raise the temperature of the heat transfer elements at the cold end of the preheater so as to maintain them above the dew point of the gases.

In the preheater installation of Figure 3 an economizer 60 (or other heat absorbing surface
which may be part of a boiler) is located in advance of the preheater 10 in the direction of gas flow. As shown the economizer is mounted in the gas inlet duct 14 with a gas by-pass conduit 66 connected around it. Damper 68 in the conduit 66 and damper 67 in the duct 14 are operable in response to fluctuations of the temperatures measured by the thermocouples 20, 21 from the predetermined aggregate to by-pass gas through conduit 66 around the economizer 68 when required in order to raise the gas inlet temperature and to maintain a predetermined total for the entering of air and discharged gases.

In the several embodiments of the invention described above the by-passing of air around the preheater (Fig. 1), the recirculation of heated air (Fig. 2) of the by-passing of gases around heat absorbing surface in advance of the preheater (Fig. 3) in response to fluctuations from a predetermined total for temperatures existing in the air inlet and gas outlet ducts results in varying the heat transfer relation between the gas and air flowing through the preheater so as to maintain the heat transfer plates above the dew point of the gases.

What I claim is:

1. In a regenerative air preheater having inlet and outlet ducts for a heating gas, similar ducts for air to be heated, and a rotor carrying heat transfer elements for absorbing heat from the gases and imparting it to the air; means for measuring the temperature of air entering said preheater; means for measuring the temperature of gas leaving the preheater; means associated with said measuring means for obtaining the total of said temperatures; and means operable by said totalizing means for varying the heat transfer relation between gas and air flowing through said air preheater to maintain said predetermined total temperature.

2. In a regenerative air preheater having inlet and outlet ducts for a heating gas, similar ducts for air to be heated, and a rotor carrying heat transfer elements for absorbing heat from the gases and imparting it to the air; means for measuring the temperature of air entering said preheater; means for measuring the temperature of gas leaving the preheater; means associated with said measuring means for obtaining the total of said temperatures; damper means disposed to control fluid flow through said preheater and operable to vary the heat transfer relation existing between the gas and air flowing through said preheater; and means controlled by said totalizing means and responsible to fluctuations of said temperature total from a predetermined value for operating said damper means.

3. In a regenerative air preheater having inlet and outlet ducts for a heating gas, similar ducts for air to be heated, and a rotor carrying heat transfer members for absorbing heat from the gases and imparting it to the air; a conduit connecting the air inlet duct to the air outlet duct; damper means operable to regulate the amount of air flowing through said conduit; means for measuring the air temperature in the inlet duct therefor and the gas temperature in the gas outlet duct; means for obtaining the total of said temperatures; and means associated with said totalizing means and responsible to fluctuation of said temperature total from a predetermined total for operating said damper means.

4. In a regenerative air preheater having inlet and outlet ducts for a heating gas, similar ducts for air to be heated, and a rotor carrying heat transfer members for absorbing heat from the gases and imparting it to the air; a conduit connecting the air outlet duct to the air inlet side of the preheater; means for causing heated air to flow through said conduit to the air inlet of the preheater damper means operable to regulate the amount of air flowing through said conduit; means for measuring the air temperature in the inlet duct therefor and the gas temperature in the gas outlet duct; means for obtaining the total of said temperatures; and means associated with said totalizing means and responsive to fluctuation of said temperature total from a predetermined total for operating said damper means.

5. In a regenerative air preheater having inlet and outlet ducts for a heating gas, similar ducts for air to be heated, and a rotor carrying heat transfer elements for absorbing heat from the gases and imparting it to the air; means for measuring the temperature of gas leaving and air entering the preheater; means associated with said measuring means for obtaining the total of said temperatures; other heat absorbing elements disposed in said gas inlet duct in advance of said air preheater; a gas by-pass around said heat absorbing elements; damper means operable to control the amount of gas flowing through said by-pass duct; and means associated with said totalizing means and responsive to fluctuation of said temperature total from a predetermined value for operating said damper means.

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