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FOULING DEGREE COMPUTER FOR HEAT EXCHANGER CLEANER

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2 Sheets-Sheet 1

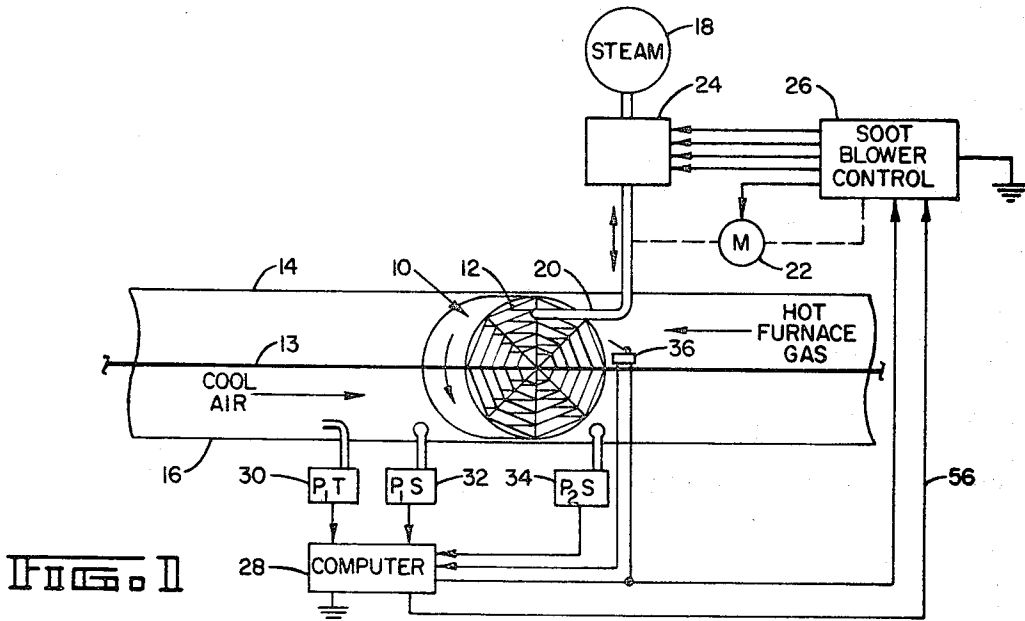


FIG. 1

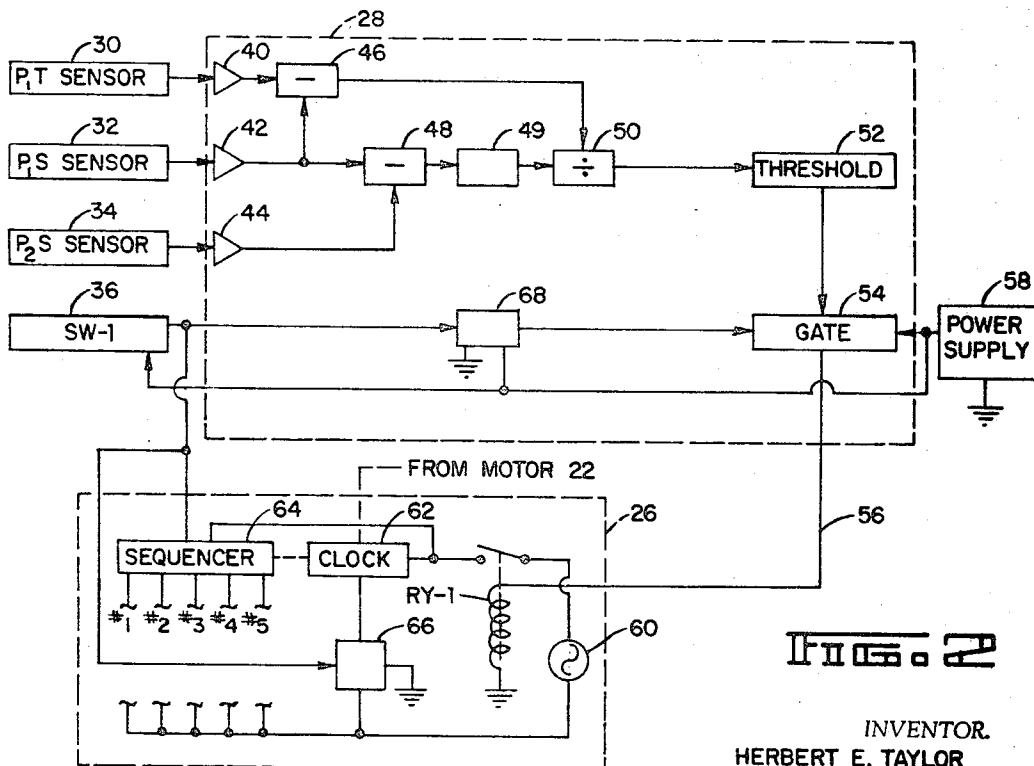


FIG. 2

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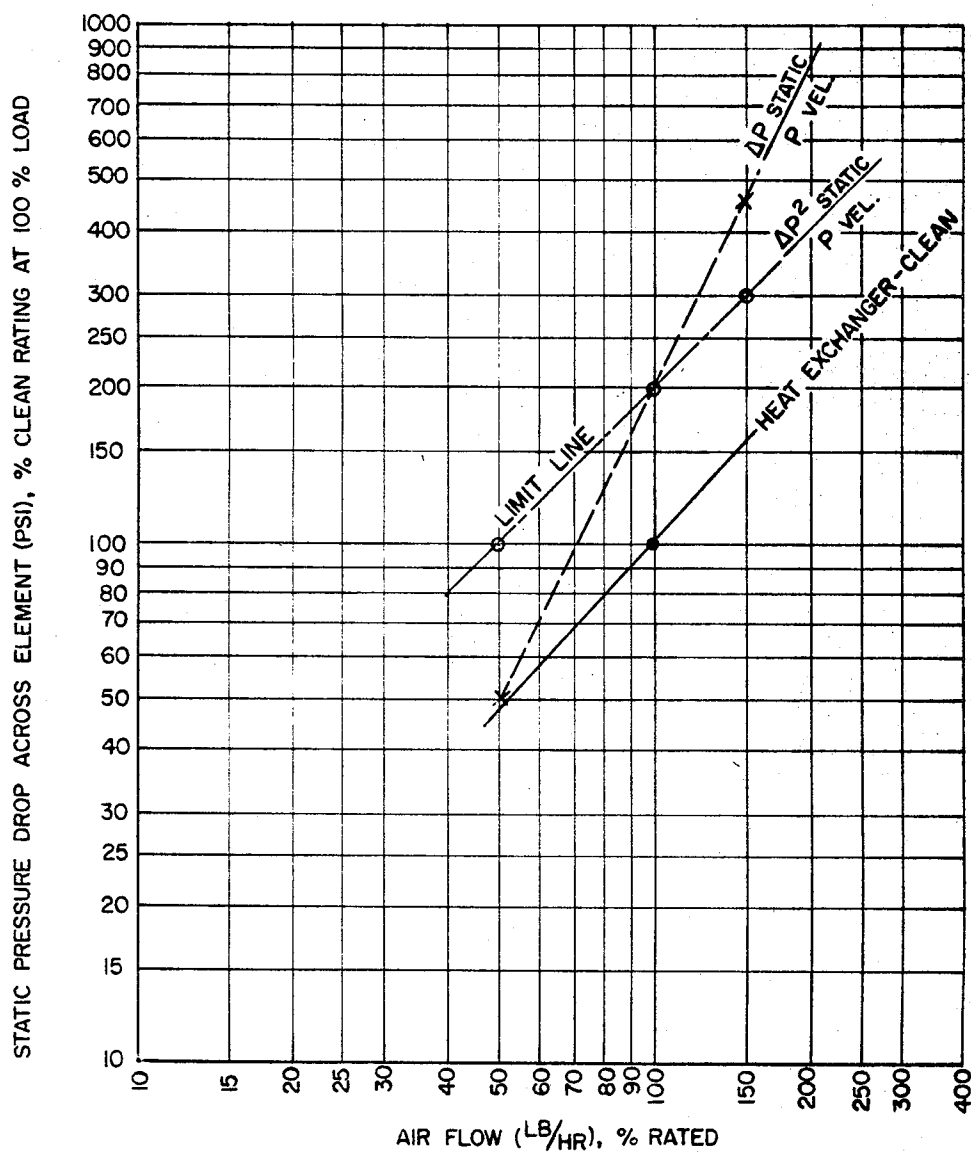


FIG. 3

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FOULING DEGREE COMPUTER FOR HEAT EXCHANGER CLEANER

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ABSTRACT OF THE DISCLOSURE

Apparatus for controlling the operation of soot blowers associated with heat exchanger structure wherein the degree of heat exchanger fouling is computed from signals commensurate with the sensed system parameters of upstream and downstream static pressure and upstream total pressure. Upon the computation of a signal indicative of a predetermined degree of fouling, a cleaning cycle initiation signal will be generated and the computer will be deenergized until a complete cleaning cycle has been accomplished.

The present invention relates to the computation of the degree of fouling of a conduit means through which contaminated gases are passed. More particularly, the present invention is directed to an automatic control for measuring the degree of fouling of a heat exchanger device through which debris laden gases are directed and for causing removal of deposited material from surfaces of the device which are exposed to the gases when the degree of fouling reaches a predetermined level. Accordingly, the general objects of the present invention are to provide new and improved methods and apparatus of such character.

While not limited thereto in its utility, the present invention is particularly well suited for use with a rotary heat exchanger of the regenerative type. Such devices are employed to transfer heat from hot furnace exhaust gases to cool air flowing into the furnace. As such, the heat transfer apparatus comprises metallic plates which define a plurality of compartments or passages through which gas may pass. At least a portion of the heat exchanger structure rotates so that the metallic plates alternately absorb heat while passing through a furnace gas exhaust duct and subsequently yield heat to and thus preheat the inflowing air as the heated metallic members are rotated through an air inlet duct. Thereafter, the cooled metallic plates pass back into the exhaust duct where they again absorb heat from the furnace gas while cooling the gas to a temperature where it may be passed through a cleaning device such as an electrostatic precipitator.

As is well known, soot, ashes and other debris are deposited on the surfaces of the heat exchanger apparatus which are exposed to furnace gas. Well known devices such as soot blowers are ordinarily provided for removing these deposits. In its most basic form, the soot blower comprises a steam generator and nozzle or nozzles through which the generated steam is directed against the heat exchanger surfaces. Typically, the steam nozzle of the soot blower apparatus will be driven by an associated motor and suitable drive such that, as the heat exchanger rotates, all the surfaces thereon will be impinged upon by a steam jet.

In the prior art, the soot blower was manually activated in accordance with a predetermined schedule. For example, it was typical to instruct the equipment operators to initiate a soot blowing operation at predetermined intervals. The cleaning of a heat exchanger in accordance with a predetermined schedule does not, of course, take into account the fact that the build up of deposits on the surfaces of the heat exchanger is not linear with time

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but varies in accordance with a number of factors. The most significant of these factors is the percent load on the furnace. Obviously, as the load on the furnace increases, the amount of debris carried by the exhaust gas also increases and consequently the deposition rate of material on the heat exchanger similarly increases. Also of importance, but to a somewhat lesser degree, is the particular material being burned in the furnace. Some materials are characterized by "dirtier" smoke than are others. As is well known, the furnace itself will have internal soot blowers so as to obviate the need for periodic hand lancing. The rate of build up of deposits on the heat exchanger has been found to vary directly with the use of the furnace soot blowers. That is, if the soot blowers in the furnace are operated regularly and often, large quantities of deposits will not build up inside the furnace itself and thus, although the reason therefor is not entirely understood, the rate of material build up on the heat exchangers will be less than is experienced when the furnace soot blowers are used only occasionally or have not been on for a long time.

From the foregoing, it may be seen that it would be desirable to initiate a cleaning or soot blowing cycle for a heat exchanger device automatically and when the degree of fouling of the heat exchanger reaches a predetermined level. At first glance, it might appear that the sensor function for such an automatic control could be performed merely by detecting the static pressure drop across the heat exchanger structure. However, since the air and gas flows are varied independently by most furnace unit control systems as a function of furnace temperature and pressure, the mere sensing of pressure drop does not provide an adequate measure of the degree of heat exchanger fouling. Restated, the mere sensing of pressure drop does not compensate for furnace load changes and hence, if ΔP alone was the critical parameter in an automatic soot blower control, the cleaning cycle would be activated too soon with heavy loads on the furnace and too late under low loading conditions. Since, in most installations, the load on the furnace is changed often and rapidly, a soot blower control which merely sensed pressure drop would, for all practical purposes, be inadequate.

The present invention contemplates an automatic control for a soot blower or other type cleaner for a heat exchanger device which provides compensation for changes in furnace load. The present invention comprises a system of sensors and associated computer which establish an operational line for the cleaning device. The point at which the cleaning cycle is initiated is varied along this operational line in accordance with weight flow of fluid being delivered to the heat exchanger. A maximum permissible degree of fouling of the heat exchanger is chosen as the cleaning cycle initiation point and the control for the cleaner is made responsive to a signal provided by the computer and commensurate with this degree of fouling. The computer output signal is a function of the actual weight flow such that the cleaning cycle initiation point varies in accordance with furnace loading.

It is therefore an object of the present invention to compute the degree of fouling of conduits.

It is also an object of the present invention to automatically cycle the operation of apparatus for removing deposits from surfaces exposed to a contaminated fluid.

It is another object of the present invention to prevent the fouling of a heat exchanger by automatically cycling cleaning apparatus associated therewith.

It is a further object of the present invention to provide for the automatic cycling of a soot blower.

It is yet another object of the present invention to vary the initiation of a self-cleaning or soot blowing operation in accordance with the weight flow of material through the apparatus to be cleaned.

It is still another object of the present invention to establish an operational line for the initiation of a self-cleaning or soot blowing procedure in a heat transfer apparatus equipped with cleaning devices.

These and other objects and advantages of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing and the description thereof which follows. In the drawing like reference numerals refer to like elements in the various figures, and:

FIGURE 1 is a schematic representation of a first embodiment of the present invention in a typical operating environment.

FIGURE 2 is a block diagram of the embodiment of the present invention depicted in FIGURE 1.

FIGURE 3 is a graphical representation of the operation of the present invention.

As will be obvious to those skilled in the art, the present invention has wide utility. As an example of an environment wherein the awareness of the need for the present invention is particularly keen, reference may be had to the literature relating to the kraft process for paper making. The typical kraft pulp mill includes a recovery furnace for burning a byproduct, known as black liquor, which results from the washing of the raw pulp. The black liquor is burned in the recovery furnace in order to recover, through a process well known in the art, a solution, known as green liquor, which may be further treated with lime to produce the white liquor used for cooking the wood chips to form the pulp. In addition to being economically advantageous, the recovery of the black liquor serves to minimize air and water pollution. When black liquor is burned in a recovery furnace, the exhaust gases from the furnace are characterized by a heavy concentration of fine white ash. This ash also contains chemicals which it is desired to recover. Accordingly, the ash laden exhaust gases are passed through an electrostatic precipitator before being exhausted to the atmosphere. For maximum efficiency of operation, it is desired to cool the furnace exhaust gases before passing them through the precipitator and to preheat the incoming air which supports combustion within the recovery furnace. Thus, a heat exchanger will be disposed intermediate the recovery furnace and electrostatic precipitator. The heat exchanger will typically be a rotary device having metallic plates which define passages therethrough for gas. The heat exchanger and the furnace exhaust and intake ducts are so positioned that the heat exchanger elements, as they rotate, will alternately be exposed to the exhaust gases and the inflowing cool air. As the exhaust gases pass through the heat exchanger, they give up heat to the metallic plates therein and the gas is thus cooled sufficiently to enable it to be passed through the precipitator. The heated plates are then rotated into the air inflow duct and are cooled by transferring heat to the inflowing air thus preheating the air.

As the hot furnace gases pass through the heat exchanger, the aforementioned fine white ash is deposited on the exposed surfaces of the heat exchanger. These ash deposits build up on the surfaces of the heat exchanger at rates which, as noted above, vary erratically and in accordance with various furnace operating conditions. The build up of deposited material on the heat exchanger plates causes fouling of the heat exchanger and a reduction in the efficiency of the recovery system. Restated, as fouling occurs, in order to maintain a fixed weight flow of gas through the furnace as called for by the furnace control, the fans which force air through the intake duct require more power to deliver the same volume of air. Eventually, if the build up was allowed to continue, the furnace would be starved for lack of air.

The deposition of material on the heat exchanger plates, while it can be minimized by careful design of the heat exchanger, cannot be eliminated. Accordingly, it is necessary to provide the heat exchanger with one or more de-

vices which will promote self-cleaning. In a kraft pulp mill, the cleaning device will comprise either one or a plurality of soot blowers. As is well known in the art, the soot blower is a device which directs a steam jet against the surface to be cleaned thus removing deposits therefrom. It is neither necessary nor desirable to operate cleaning devices such as soot blowers continuously. Accordingly, the present invention comprises a control apparatus which will automatically initiate a cleaning cycle when the degree of fouling of the heat exchanger reaches a predetermined level.

Referring now to FIGURE 1, a rotary, regenerative type heat exchanger is shown generally at 10. Heat exchanger 10 comprises a plurality of metal plates 12 which define passages through the heat exchanger for fluid, in this case hot furnace gases and cool air. Heat exchanger 10 is rotated, by means not shown, about an axis which corresponds to the dividing wall 13 between a pair of adjacent ducts or conduits 14 and 16. The hot exhaust gases from the furnace, not shown, pass through conduit 14 on the way to a smoke stack or electrostatic precipitator. The air for supporting combustion in the furnace is forced or drawn through duct 16 by fan means, not shown. The gases in ducts 14 and 16, as indicated on FIGURE 1, usually flow in opposite directions.

As heat exchanger 10 rotates, heat is transferred from the hot furnace gases to plates 12 thus heating the plates and cooling the furnace exhaust gases. The heated plates 12 then pass into duct 16 where they are cooled by the inflowing air thus transferring heat to and preheating the air. As noted above, as the furnace gases pass through heat exchanger 10 material, which may be in the form of ash, will be deposited on plates 12. As the deposits build up on plates 12, the efficiency of the recovery furnace system in general and particularly of the means which draws the air into the furnace decreases. Accordingly, cleaning apparatus for heat exchanger 10 is provided. While the present invention is not limited to use therewith, the cleaning apparatus shown in FIGURE 1 is a soot blower. The soot blower comprises a steam generator 18, a movable steam nozzle 20 and a motor 22 for driving nozzle 20. Disposed between steam generator 18 and nozzle 20 is apparatus 24 which, in response to commands from a soot blower control 26, prepares the soot blower for operation. That is, apparatus 24 comprises means for draining, purging and preheating the soot blower nozzle means 20 prior to the actual delivery of steam through the nozzle. It has been found to be generally desirable, and in connection with a kraft pulp mill essential, to drain, purge and preheat the soot blower in order to prevent condensation from forming on the inside of nozzle 20. The white ash which results from the burning of black liquor in a pulp mill recovery furnace will solidify and form a cement-like mass if mixed with water. Accordingly, means must be provided to purge and preheat nozzle 20 to insure against the condensation of water on the inner surfaces thereof when steam is released there-through. Without preheating, the condensate in the form of water droplets would be blown from nozzle 20 onto plates 12 and would cause formation of a deposit which the steam could not remove.

Once the soot blower has been prepared for operation by the combined operation of control 26 and means 24, motor 22 will be energized and nozzle 20 will be driven slowly inwardly from the vicinity of the outer wall of conduit 14 to the vicinity of dividing wall 13 between conduits 14 and 16. While nozzle 20 is driven inwardly, steam is delivered thereto from steam generator 18 and the deposits are steam blasted off plates 12. As nozzle 20 moves inwardly, heat exchanger 10 continues to rotate and thus the entire end of heat exchanger 10 which faces upstream, in the direction of furnace gas flow, is impinged upon by the steam jet. It should be noted that the steam from nozzle 20 may actually be delivered against plates 12 at an angle thus facilitating the removal

of deposits. It should also be noted that, while only a single nozzle 20 has been shown in FIGURE 1, in actual practice there may be a plurality of nozzles and the nozzles may be located adjacent both the upstream and downstream ends, in the direction of furnace gas flow, of heat exchanger 10.

The means for providing a cleaning cycle initiation signal to soot blower control 26 comprises a computer 28 and associated sensors 30, 32 and 34. For the purposes to be explained below, sensor 30 senses the total pressure of inflowing air in duct 16 at a point upstream, in the direction of airflow, from heat exchanger 10. Sensor 30 may comprise a pitot tube and associated electromechanical transducer for sensing total pressure and generating an electrical signal commensurate therewith. It should be noted that while the actual pressure sensing elements of sensors 30, 32 and 34 may be placed in either of ducts 14 or 16 at appropriate points with relation to the heat exchanger taking the direction of gas flow into consideration, is preferable to place the sensors in air inflow duct 16. This is particularly true in the case of the paper making process briefly described above since the heavy ash content of the exhaust gases would prevent accurate measurement of the pressure and would cause rapid fouling of the sensors. Sensors 32 and 34 respectively sense the static pressure of the air upstream and downstream, in the direction of airflow, from heat exchanger 10. Sensors 32 and 34 may comprise standard bulb or bellows-type pressure sensors and associated electromechanical transducers which provide electrical output signals commensurate with the sensed pressure. The electrical output signals from sensors 30, 32 and 34 are applied as inputs to computer 28. A microswitch 36 also provides input to computer 28. Switch 36 is mounted such that it will be closed when nozzle 20 has been driven inwardly to a point adjacent dividing wall 13 between the ducts 14 and 16. In the interest of clarity, switch 36 has been shown in FIGURE 1 as being actually mounted on dividing wall 13 between ducts 14 and 16. However, in actual practice, switch 36 will be mounted outside of duct 14 and will be closed by any convenient means such as a cam on the drive train between motor 22 and nozzle 20.

Referring now to FIGURE 2, computer 28 is shown in block form. While the computation function could be performed by digital computer means, computer 28 is shown as an analog computer. Computer 28 comprises amplifiers 40, 42 and 44 which respectively amplify the pressure signals supplied by sensors 30, 32 and 34. The amplified pressure signals from upstream total pressure sensor 30 and upstream static pressure sensor 32, as provided by amplifiers 40 and 42, are applied to a comparator circuit 46 of a type well known in the art. For example, amplifiers 40 and 42 may be chopper-type amplifiers which provide an AC output signal and comparator 46 may be a subtraction circuit comprising a transformer having a pair of oppositely wound primary windings and a single secondary winding. The use of chopper amplifiers and AC signals is desirable since it eliminates the drift problems inherent in direct current amplifiers. The output signal from comparator 46 is a signal commensurate with the velocity head or dynamic pressure P_v . As is well known, P_v is a function of weight flow in a fixed duct system, presuming constant fluid density.

The signals commensurate with the static pressure from upstream pressure sensor 32 and downstream pressure sensor 34, after amplification in amplifiers 42 and 44, respectively, are applied to a second comparator or subtraction circuit 48. Comparator 48 provides an output signal commensurate with the static pressure drop, ΔP_s , across heat exchanger 10.

As noted above, the signal commensurate with static pressure drop across the heat exchanger must be modified by the weight flow of air being delivered to the furnace in order to provide a useful indication of degree of

heat exchanger fouling. However, before compensating for weight flow, it is usually desirable to modify the ΔP_s signal in accordance with the relationship between velocity head pressure and weight flow. As is well known, the dynamic pressure of a flowing fluid, as measured by a device such as a pitot tube, is a function of the square of the velocity of the fluid. Thus, the relation between weight flow, W_a , and velocity head, employing a Pitot tube as the velocity head or dynamic pressure (P_v) sensor, is a square function. This square function may clearly be seen from FIGURE 3 and is in accordance with the following formula:

$$W_a = A \sqrt{2g\rho_a} \sqrt{P_v}$$

Compensation for this square function relationship is provided by a squaring circuit 49 which receives and squares the ΔP_s output signal from comparator 48.

The output signals from comparator circuit 46 and squaring circuit 49 are applied to a division circuit 50. Circuit 50 performs the following computation:

$$\frac{(P_{1s} - P_{2s})^2}{P_{1t} - P_{1s}} = \frac{\Delta P_s^2}{P_v} = X$$

where:

- P_{1t} = Upstream total pressure
- P_{1s} = Upstream static pressure
- P_{2s} = Downstream static pressure
- ΔP_s = Static pressure drop
- P_v = Velocity head (dynamic) pressure
- X = Degree of fouling

The signal commensurate with the degree of fouling X from division circuit 50 is applied to a threshold circuit 52. Circuit 52 may, for example, comprise an adjustable reference voltage source which provides a signal for comparison with the output of division circuit 50. The reference voltage is adjusted so as to provide a signal having a phase or polarity opposite to the output from division circuit 50 and a magnitude equal to the output from circuit 50 at a preselected maximum degree of fouling. In the usual instance, the reference voltage is adjusted to be commensurate with twice the output that would be provided by circuit 50 with the furnace operating at 100 percent load. When the actual output from circuit 50 exceeds the reference level, threshold circuit 52 will provide a direct current gating control signal to a gate circuit 54. Gate circuit 54 may be a bistable circuit such as a Schmitt trigger. When switched by an output from threshold circuit 52, gate circuit 54 will permit current flow, via conductor 56, from a power supply 52 to the solenoid of a relay RY1 in soot blower control 26. In the manner to be described below, current flow through the solenoid of relay RY1 will initiate a cleaning cycle. It should be noted that the circuit established by the closing of the contacts of relay RY1 will not be broken when, due to partial cleaning of the heat exchanger, an input signal of the proper magnitude and polarity to switch gate circuit 54 no longer appears at the output of threshold circuit 52. That is, once gate circuit 54 has been switched by a signal indicative of a predetermined degree of fouling of the heat exchanger, it will remain switched and current will continue to flow via conductor 56 through the solenoid of relay RY1 until the gate circuit 54 is returned to its original state in the manner to be described below.

Closing of the contacts of relay RY1 connects an alternating current source 60 to a clock or timer 62 and to a sequencer 64. Clock 62 is mechanically coupled to sequencer 64 so as to cause sequencer 64, which may be a form of rotary switch, to complete a plurality of electrical circuits in a predetermined time sequence. Thus, energization of clock 62 will close, in the proper order, connections to a solenoid operated drain valve, purging device and preheater for the soot blower. After a time interval sufficient to accomplish the purging and preheating of the

soot blower, the clock will cause breaking of the circuits to the preparing apparati and the simultaneous closing of contacts which result in energization of the main steam valve and motor 22. The actual soot blowing operation of the cleaning cycle will then begin and will continue until switch 36 is closed in the manner above described. Closing of the switch 36 causes a signal to be delivered to sequencer 64 which, through the operation of a stepping solenoid, steps the sequencer to its next position thus closing the main steam valve and reversing the electrical connections to motor 22. As long as the contacts of relay RY1 remain closed, motor 22 will run in the reverse direction thus returning nozzle 20 to its starting position.

The signal generated by the closing of switch 36 is also applied to a normally closed, pneumatic time delay relay 66 which is connected between clock 62 and source 60. The closing of switch 36, by sending a current pulse through the solenoid of relay 66, causes opening of the circuit between source 60 and clock 62. The circuit remains open, due to the action of relay 66, a sufficiently long time to enable the completion of the cleaning cycle as will be described below. The output shaft of motor 20 is connected, via a one-way clutch, to clock 62 such that, as the motor operates in the reverse direction to return nozzle 20 to its starting position, clock 62 will be reset.

Closing of switch 36, through the operation of sequencer 64, causes motor 22 to immediately begin running in the reverse direction. Thus, switch 36 is only momentarily closed and delivers a current pulse to sequencer 64 and relay 66. This current pulse, if applied directly to gating circuit 54, would cause the gating circuit to switch back to its initial state thus causing opening of the contacts of relay RY1. It is necessary to maintain relay RY1 in the closed position for a sufficient time to enable motor 22 to drive nozzle 20 back to its starting position. Opening of relay RY1 would, of course, deenergize the motor. In order to delay the application of the termination signal generated by switch 36 to gate 54, a delay device 68 is connected between switch 36 and gate 54. Delay device 68, which may be of a type well known in the art, provides an output pulse a predetermined period after an input pulse is applied thereto. The output pulse may be generated by momentarily connecting power supply 53 to the second input of gate 54 after a delay which is long enough for the nozzle 20 to be returned to its starting position. The pulse thus applied to gating circuit 54 switches the gate circuit back to its initial state and terminates the flow of current through the solenoid of relay RY1. Opening of relay RY1 deenergizes motor 22. The cleaning apparatus is now ready for the next cleaning cycle.

FIGURE 3 graphically represents the operation of the present invention. FIGURE 3 comprises a plot of percent airflow through a heat exchanger, which is proportional to furnace load, against the static pressure drop across the heat exchanger as a percent of the clean rating at 100 percent load. The solid line on the graph represents the drop in static pressure with increased air or gas flow through a clean heat exchanger. If the static pressure drop ΔP_s alone was used as a measure of heat exchanger fouling, a line commensurate with a predetermined percent static pressure drop would define the cleaning cycle initiation point. For example, if the static pressure drop alone was the controlling parameter and it was desired to initiate a cleaning cycle when the static pressure drop was twice that which would be experienced with a clean heat exchanger at 100 percent load, the horizontal line commensurate with a static pressure drop of 200 percent of the clean rating would be the cleaning cycle initiation point. As can clearly be seen, with this initiation point, the cleaning cycle would be initiated too soon at 150 percent load. At 50 percent load, the heat exchanger would be completely fouled before the 200 percent ΔP_s (clean at 100 percent load) level was reached. This demonstrates that there must be compensation for

the weight flow through the heat exchanger. The broken line represents the operation of the embodiment of the control depicted in FIGURE 2 wherein the static pressure drop is squared to adjust for the relationship between weight flow and velocity head pressure and modified by a signal commensurate with velocity head pressure. As in the example discussed above relative to employing static pressure drop alone, a reference level is selected for a cleaning cycle initiation point which is commensurate with a static pressure drop at 100 percent load which is twice that experienced with a clean unit. However, by employing weight flow compensation, an operation or limit line which maintains a uniform margin of 200 percent above the clean rated pressure drop over the entire range of weight flows is established. Under some conditions it might be advantageous to skew the limit line so that a smaller build up of deposits is tolerated at low loads than is permitted at higher loads. This arrangement may be preferable since there is a much slower rate of ash build up at low gas flows. The dashed line of FIGURE 3 represents such a skewed limit line. Operation along the skewed limit line of FIGURE 3 is achieved merely by eliminating squaring circuit 49 from the embodiment of FIGURE 2 thereby no longer compensating for the relationship between dynamic pressure and weight flow.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the present invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

What is claimed is:

1. In combination with a heat exchanger and cleaning apparatus therefor, the cleaning apparatus being operated intermittently to remove debris deposited on the walls of passages for gas through said heat exchanger, a cleaner apparatus control comprising:

first sensor means adapted to be positioned upstream in the direction of gas flow from the heat exchanger for sensing the static pressure of gas being delivered to the heat exchanger and for generating a signal commensurate with such upstream static pressure;

means for sensing the dynamic pressure of gas being delivered to the heat exchanger and for generating a signal commensurate with such dynamic pressure;

second sensor means adapted to be positioned downstream in the direction of gas flow from the heat exchanger for measuring the static pressure of gas passed through the heat exchanger and for generating a signal commensurate with such downstream static pressure; and

means responsive to said signals commensurate with dynamic and static pressure for generating a cleaning cycle initiation signal for application to the cleaner apparatus.

2. The apparatus of claim 1 wherein said means for sensing dynamic pressure comprises:

means positionable upstream in the direction of gas flow from the heat exchanger for sensing the total pressure of gas being delivered to the heat exchanger and for generating a signal commensurate therewith; and

means responsive to said total pressure signal and to a signal commensurate with upstream static pressure signal for generating a signal commensurate with the difference therebetween, said difference signal being commensurate with dynamic pressure and having a known relationship to the weight flow of gas passing through the heat exchanger.

3. The apparatus of claim 2 wherein said means for generating a cleaning cycle initiation signal comprises: means responsive to said signals commensurate with upstream and downstream static pressure for generating a signal commensurate with the difference therebetween; and

means responsive to said signals commensurate with dynamic pressure and static pressure difference for generating a cleaning cycle initiation signal.

4. The apparatus of claim 3 further comprising:

means responsive to said cleaning cycle initiation signal for energizing the cleaner apparatus;

means for maintaining the cleaner apparatus in an energized condition until a cleaning cycle has been completed; and

means responsive to the termination of the cleaning cycle for deenergizing the cleaner apparatus.

5. In combination with a soot blower associated with a rotary regenerative heat exchanger, said soot blower being operated intermittently to remove material deposited on said heat exchanger, portions of said heat exchanger passing alternately through a first conduit by means of which hot contaminated gas exits a furnace and through a second conduit by means of which clean air is supplied to the furnace, said heat exchanger serving to preheat said clean air, a soot blower control comprising:

first pressure sensor means positioned within the second conduit upstream in the direction of airflow from the heat exchanger for measuring the static pressure of the air being delivered to the heat exchanger and for generating a signal commensurate with such upstream static pressure;

second pressure sensor means positioned in the second conduit upstream in the direction of airflow from the heat exchanger for measuring the total pressure of the air being delivered to the heat exchanger and for generating a signal commensurate with such total pressure;

third pressure sensor means positioned in the second conduit downstream in the direction of airflow from

the heat exchanger for measuring the static pressure of the air downstream of the heat exchanger and for generating a signal commensurate with such downstream static pressure;

means responsive to said signals commensurate with total and static pressure upstream of the heat exchanger for generating a signal commensurate with the difference therebetween;

means responsive to said signals commensurate with static pressure upstream and downstream of the heat exchanger for generating a signal commensurate with the difference therebetween;

means responsive to said difference signals for generating a signal commensurate with the degree of heat exchanger fouling;

means responsive to said fouling signal for generating a cleaning cycle initiation signal when the degree of fouling reaches a predetermined level;

means responsive to said cleaning cycle initiation signal for energizing the cleaner;

means for maintaining the cleaner in an energized condition until a cleaning cycle has been completed; and

means responsive to the termination of a cleaning cycle for deenergizing the cleaner.

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