ABSTRACT: A stream of hot gas and air, exiting from a drying, baking, or curing oven, and containing pollutants, is diverted through an incinerator where the pollutants are converted to harmless water and carbon dioxide vapors. Some of the hot, purified gas effluent from the incinerator is then directed back to the oven, via an arrangement of dampers, at a rate of flow sufficient to maintain the oven at a predetermined temperature. The dampers exhaust excess hot gas to atmosphere and draw in an equivalent volume of fresh, makeup air. Temperature in the oven is maintained by controlled power means which automatically moves the dampers to vary the proportion of cool, makeup air and hot incinerator effluent entering the oven.
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INDUSTRIAL HEATING APPARATUS WITH AIR- POLLUTION CONTROL

BACKGROUND OF THE INVENTION

This invention relates to industrial, drying, baking and curing ovens, and particularly to such an oven combined with an incinerator which substantially completely eliminates the discharge of pollutants into the atmosphere.

Industrial pollution from enamel and paint ovens, metal-coating ovens, coffee roasters, core baking ovens, printing presses, brake-lining ovens, solvent degreasers, automobile body undercoating ovens, varnish kettles, smoke houses, fat rendering cookers, oil and wax extractors, etc., are polluters of the atmosphere to an even greater extent than automobiles, in many industrial areas.

Organic solvents vaporized in these drying, baking and curing operations contain hydrocarbons, alcohols, aldehydes, esters, ethers, ketones and aromatic compounds as well as fumes containing particulate matter in the form of smoke and carbonaceous material.

When subjected to warmth and sunlight, many of these pollutants create smog which stings the eyes and irritates the lungs. They are hazardous to health, even deadly in some concentrations, as well as disagreeable and uncomfortable.

The volume of air passed through (and polluted by) these industrial ovens is enormous. As one example, a paint drying oven with a production of 8,000 cubic feet per hour at standard conditions, takes in and passes through 5 cubic feet of paint solvent driven off. In large operations where products like automobiles, farm implements, or household appliances, are manufactured in quantities, and painted and dried at the rate they are manufactured, the volume of air passing through the drying oven amounts to several million cubic feet per day.

The usual way to rid the air of pollutants is to incinerate it by passing it through high-temperature flames, most commonly fed by natural gas. It is thoroughly mixed with the flames for a sufficient residence or dwell time to convert the contaminants to harmless water and carbon dioxide vapors.

This is expensive. The capital cost for the initial installation and the cost of the gas are high.

As a consequence of the difficulty of handling large quantities of polluted air, and the cost, many of these industrial processes simply discharge the hot gases into the atmosphere.

SUMMARY OF THE INVENTION

A principal object of the present invention is to provide an industrial oven for drying, baking and curing operations which will convert pollutants into harmless airborne ingredients which may be discharged harmlessly into the atmosphere, and at a reasonable cost.

An object of the present invention is to divert hot gas from an oven to an incinerator, pyrolyze it, and recycle a portion with cool makeup air through the oven depending on the heat requirements of the oven, and vent the rest of the purified effluent.

An important feature of the invention is that hot gas from the oven outlet may be recirculated for reuse several times, thereby generating economies in reusing heated air and in avoiding the use of a large, expensive incinerator or heater.

Another important object of the invention is that the relatively cold, makeup air is mixed with the hot incinerator effluent outside of the oven, thereby providing efficient, uniform heating throughout the oven, with no cold spots in the oven itself, which would result if makeup air were admitted directly to the oven.

Another very important feature of this invention is that the sole heat source may be the incinerator burner, thereby providing an additional incineration burner for two purposes.

A specific feature of the present invention is the provision of a novel and effective four-way damper means between the incinerator outlet port and the oven inlet port which automatically mixes incinerator effluent with fresh makeup air to regulate the oven temperature while discharging an amount of incinerator effluent proportional to the volume of makeup air.

Other objects and advantages will be apparent from the following description taken in connection with the appended drawings in which:

FIG. 1 is a schematic elevational view, in longitudinal cross section, showing an industrial oven with pollution control constructed in accordance with the present invention and utilizing two blowers for recycling effective proportions of the oven and incinerator outputs through the oven;

FIG. 2 is a cross-sectional plan view of FIG. 1 taken along the line 2-2;

FIG. 3 is a fragmentary, enlarged view of FIG. 1 showing the damper system in a normal operating position;

FIG. 4 is a view similar to FIG. 3 showing still another operative condition of the dampers;

FIG. 5 is also similar to FIG. 3, showing still another operative condition of the dampers; and

FIG. 6 is a view similar to FIG. 1 of another embodiment of the invention, utilizing a single blower for recycling through the oven and venting the incinerator effluent.

Like parts are referred to by like reference numerals throughout the figures.

The preferred embodiments will now be described, beginning with the embodiment of FIGS. 1-5.

A heater housing generally designated 10, includes an oven compartment 12 and an incinerator compartment 14. As the description proceeds, it will be apparent that these compartments may be in one integral, unitary housing, or for reasons of portability or other factors may be made in two separate housings for assembly at the job site.

The oven 12 has insulated top, bottom, side and back walls 16, 18, 20, 22 and 24. A door 26 provides access to the oven interior. The oven may be of any suitable size ranging from small, laboratory models to full size walk-in or drive-through tunnel types which may be 100 feet long or longer.

The incinerator 14 has an insulated top, bottom, front, rear and side walls 28, 30, 32, 34 and 36. The walls may be made of any suitable material. One wall construction which has been highly satisfactory is a double wall of spaced steel sheets 38, 40 separated by 3 to 6 inches of glass block insulation, "Fiberglass," rock wool, or a combination thereof, this insulation being designated 42 in FIG. 2.

The oven 12 includes a heating compartment 44 within which articles to be heated may be stacked, and a recirculation passage 46 separated by a vertical wall 48.

A main blower 50 is carried on a shaft 52 which passes through backwall 24 and is journaled within bearings 54, 56 fastened to the backwall along with the motor 58. The motor drives the blower through an electric motorless belt 58 and sheaves 60, 62. The blower is surrounded by a shroud 64 to guide air and gas from the blower inlet 66, through the blower. As shown in FIG. 2, air then travels to the left and to the right through passages 70, 72 into diffusion ducts 74, 76 comprising vertical plates 78 with apertures 80 spaced respectively from the walls 28 and 22.

Air passing through the openings 80 travels upward into a duct 82 defined by a horizontal plate 84 spaced downward from the top wall 16. Air enters through openings 84 and passes to the oven compartment outlet 86.

At this point, the air/gas mixture comprising the oven atmosphere, now containing pollutants in the form of vaporized hydrocarbon solvents and the like, is split into two portions. A major portion, preferably 80 percent or more, is drawn downward into the main blower inlet 66 for recirculation through the oven compartment 44.

A minor portion, 20 percent or less, of the air/gas oven atmosphere stream at the oven outlet port 86 is diverted by the small, auxiliary blower 88 through a recycle conduit including ducts 90 and 104. Duct 90 interconnects the oven outlet port 86 and the incinerator inlet port 92. Duct 104 interconnects the incinerator outlet port 106 and the recirculation conduit 46 on the intake side of blower 50.

To provide the required dwell or residence time within the incinerator for proper conversion of the pollutants, the in-
cinerator is made with a vertical wall 94. This lengthens the path of travel of the gases so they are retained within the cinerator, at high reactive temperatures preferably for ¼ to 1 second.

Immediately upon entering the cinerator, the gases pass downward between the walls 94 and 34, through a gas burner 96. The gas burner and its controls will not be described in detail here. However, the burner preferably have a large number of closely adjacent aperture and profile plates to reach temperature quickly with a short flame continuously across the burner area. The gas entering from the oven will usually have sufficient oxygen (above 15 percent) that additional primary oxygen will not have to be supplied to the burner 96, but this may be done (by means not shown), if desired. Secondary oxygen may be supplied, as for example, through an opening diagrammatically illustrated at 98.

For best results, the burner should quickly bring the gas up to a temperature of 1,350° to 1,500°F. As the hot, mixed gases pass down through compartment 100 and up through compartment 102, the pollutants will be substantially completely oxidized to water and carbon dioxide vapors.

Attention is now directed to the novel, simplified four-way damper means 101. This is shown generally in FIG. 1 and in more detail in FIGS. 3, 4, and 5, and includes dampers 118 and 122 which will now be described.

As best shown in FIGS. 1 and 4, recycle conduit duct 104 is part of a casing 105 and connects the cinerator outlet port 106 with a return main temperature opening 108 and a window wall 24 which leads to the main blowers inlet port 66 (FIG. 1). A cross-duct 110 also part of casing 105 connects conduit 104 to a makeup air inlet port 112. Another cross-duct 114 connects the conduit 104 to an exhaust outlet port 116.

A damper 118 is pivoted at the point 120 and is movable between a substantially wide open position as shown in FIG. 4, and a substantially closed position as shown in FIG. 5. It will seldom be fully closed due to the necessity of maintaining at least a small flow of fresh air through the system to maintain proper combustion and purging of pollutants.

Another damper 122 is pivoted at the point 124 and is movable between a position as shown in FIG. 4, where it opens the makeup air port 112 wide and diverts cinerator effluent fully upward to the exhaust port 116; and another position as shown in FIG. 5, where it opens the chamber 107 and conduit 104 wide all the way from the cinerator to the oven. Coincidentally, it almost closes off makeup air conduit 110. Makeup air should seldom be completely shut off for the same reason mentioned in connection with the exhaust.

The two dampers are interconnected for simultaneously opening the makeup air conduit 110 and exhaust conduit 114, and simultaneously closing them. This is accomplished by means 126 and 128 connected, respectively, to the dampers 118 and 122. These levers, and their associated dampers, are interconnected for simultaneous movement, in the same direction, by connecting link 130 pivoted at its ends 132 and 134.

The system, as described so far, can function by suitably manually operating the dampers. If the oven becomes too hot, it can be moved simply by moving the link 130 in an upward direction from its FIG. 5 position, to permit more fresh, cool air to enter the oven. The simultaneous opening of dampers 122 and 118 automatically allows the venting of a volume of cinerator effluent proportional to the volume of fresh makeup air brought in.

Conversely, if the oven becomes too cool, the temperature may be increased simply by recycling a higher proportion of hot gas from the cinerator. This is accomplished by moving the link 130 downward from the FIG. 4 position.

In normal operation, where the oven is operating at a predetermined temperature under equilibrium conditions, the dampers will assume some intermediate position such as that shown in FIG. 3, somewhere between the conditions of FIGS. 4 and 5, FIG. 3. Incinerator effluent will be split, part going out the exhaust conduit 114 and part going past the damper 122, to mix with fresh makeup air entering from the conduit 110.

The novel arrangement of dampers provides a very efficient way of automatically maintaining the temperature at any set condition in the oven. This will now be described.

The oven 44 has a servocontrol which maintains the oven at a selected temperature. This control may be conventional so is not disclosed here in detail. Briefly, the control includes a thermostat 136 having a temperature-sensing element 138 extending through the top wall 16 into the heating chamber 44. The thermostat rotates an input shaft 137 of a servo generator 139 one way or another in response to temperature changes in the oven. A servomotor 144 operates the damper means 101 to automatically direct more or less hot cinerator effluent into the oven to maintain it at a temperature selected by the knob 135. The servo generator and servomotor are connected in parallel to input power lines L1 and L2, usually 115 volts 60 cycles alternating current, and are interconnected by control lines 140, 141, and 142.

The servomotor 144 has a shaft 146 which turns a crank 148 connected by a pivoted link 150 to a crank arm 152 comprising an angular extension of arm 128.

In operation, counterclockwise rotation of shaft 146 moves the dampers from the position of FIG. 4 to the position of FIG. 5; and vice versa.

The automatic temperature control will now be described briefly. Assume the knob 135 of thermostat 136 is set for an oven temperature of 350°F. If the oven temperature drops slightly, thereby requiring more heat to bring the temperature up to the thermostat setting, a signal initiated by the thermostat 136 will pass through control lines 140, 141, 142, calling for counterclockwise rotation of the motor shaft 146. When this occurs, the proportion of cool makeup air through conduit 110 will be reduced and the proportion of hot gas from the cinerator will be correspondingly increased. This will bring the oven back up to temperature. Conversely, if, with a setting of 350°F, the temperature rises slightly, the thermostat 136 will signal the motor 144, causing the latter to turn slightly clockwise, thereby increasing the proportion of cool makeup air and reducing the proportion of hot gas from the cinerator.

As shown in FIG. 1, the auxiliary blower 88 is considerably smaller than the main blower 50 for exhausting some of the heated, fume- and vapor-bearing air from the oven. By thus continuously withdrawing some air from the interior of the oven, fumes and vapor are continuously exhausted as air is recirculated within the oven. The exhaust blower 88 and associated ducts leading to and through the cinerator, have an airflow capacity materially less than the recirculation blower 50, so less air is withdrawn than is recirculated through the oven. The withdrawn air, together with fumes and vapors carried by it to the cinerator is replaced by fresh air taken from the exterior through the makeup conduit 110, past the damper 122.

Referring now to the embodiment shown in FIG. 6, this is substantially the same as FIG. 1 except that the main blower 50 and recirculation passage 46 have been eliminated.

A single diffusion duct 174 is located in the floor of the oven compartment 44 and gases from the damper means 101 pass downward through a duct 176 and through oven inlet port 178 into the plenum space beneath the duct 174. Thence it passes upward through apertures 179 into oven 44. This is, in effect, a simplified version of the FIG. 1 arrangement, in which the single blower 88 furnishes the air and gas circulating power required.

The blower 88 directs the entire oven output through fresh duct 90, the incinerator 14, and second recycle duct 104.

The hot, purified effluent from the cinerator in FIG. 6 is discharged to the four-way damper means 101. As described in connection with FIGS. 1–5, the dampers 118, 122 will operate automatically to proportion the volumes of hot purified incinerator effluent and cool ambient air which are
directed to the oven inlet port 178 and diffusion duct 174, in accordance with the temperature requirements of the oven. Simultaneously, the damper means exhausts a volume of pure, incinerator effluent proportioned to the volume of makeup air.

Changes and modification may be made within the scope and spirit of the following claims which define what is believed to be new, in accordance with the present invention.

I claim:

1. Apparatus for heating objects to drive off combustible waste products including hydrocarbons, and then to convert the waste products to non-air-polluting components, the apparatus including:

an oven and an incinerator each having an inlet port and an outlet port;

a recirculation conduit interconnecting the oven inlet and outlet ports, the recirculation conduit having a main blower effective to move a major portion of the oven atmosphere from the oven outlet port to the oven inlet port for recirculation through the oven;

a recycle conduit interconnecting the oven outlet and incinerator inlet ports and interconnecting the incinerator outlet and oven inlet ports, said recycle conduit having an auxiliary blower effective to move oven atmosphere from the oven outlet port via the incinerator to the recirculation conduit on the intake side of the main blower;

the incinerator having burner means for purifying the oven atmosphere by burning the waste products in the oven atmosphere, the incinerator comprising the major source of heat for the oven;

the auxiliary blower being effective to divert to the incinerator a minor portion of the atmosphere moved from the oven; and

damper means effective to simultaneously draw in ambient makeup air at a selected flow rate, mix the cool ambient air with hot incinerator effluent in a predetermined proportion and direct the mixture to the intake side of the main blower, and vent incinerator effluent at a flow rate corresponding to said selected flow rate at which ambient makeup air is drawn in.

2. Apparatus according to claim 1, in which the damper means is a four-way damper means.

3. Apparatus according to claim 1, in which the damper means varies the flow of ambient makeup air in said mixture while correspondingly varying the flow of hot purified incinerator effluent vented from said recycle conduit, and inversely varying the flow of purified incinerator effluent in said mixture.

4. Apparatus for heating objects to drive off combustible waste products including hydrocarbons, and then to convert the waste products to non-air-polluting components, the apparatus including:

an oven and an incinerator, each having an inlet port and an outlet port;

a recirculation conduit interconnecting the oven inlet and outlet ports;

the recirculation conduit having a main blower effective to move a major portion of the oven atmosphere from the oven outlet port to the oven inlet port for a repass through the oven;

a recycle conduit comprising first and second recycle ducts; the first recycle duct connecting the oven outlet port with the incinerator inlet port;

the first recycle duct having an auxiliary blower effective to divert a minor portion of the oven atmosphere to the incinerator;

the incinerator having burner means for purifying the oven atmosphere by burning the waste products in the oven atmosphere and comprising the major source of heat for the oven;

the second recycle duct connecting the incinerator outlet port with the recirculation conduit on the intake side of the main blower;

the second recycle duct having a casing with a chamber therein and having a makeup air inlet port and gas outlet port; and

four-way damper means in said casing comprising an individual damper for each of the air inlet and gas outlet ports, said dampers being interconnected for simultaneous movement to vary the inflow of ambient air through the air inlet port while proportionately varying the venting of incinerator effluent through the gas outlet port and inversely varying the flow of incinerator effluent to the recirculation conduit.

5. Apparatus according to claim 4, having means for regulating the temperature in the oven, including a temperature-sensing element in the oven and power means for automatically moving the dampers in response to a signal from the temperature-sensing element to change the proportion of cool ambient air and hot purified incinerator effluent recycled to the oven.

6. Apparatus for heating objects to drive off combustible waste products including hydrocarbons, and then to convert the waste products to non-air-polluting components, the apparatus including:

housing means containing an oven and an incinerator, each having an inlet port and an outlet port;

a recirculation conduit interconnecting the oven inlet and outlet ports;

a main blower in the recirculation conduit effective to recirculate a major portion of the oven atmosphere from the oven outlet port to the oven inlet port;

a first recycle duct connecting the oven outlet port with the incinerator inlet port;

a second recycle duct connecting the incinerator outlet port with the recirculation conduit on the intake side of the main blower;

an auxiliary blower in the first recycle duct effective to divert the incinerator a minor portion of the oven atmosphere from the oven;

the incinerator having burner means for purifying the oven atmosphere by burning the waste products in the oven atmosphere and comprising the major source of heat for the oven; and

four-way damper means in the second recycle duct comprising a casing having separate passages connected, respectively to: the main blower intake; the incinerator outlet port; an ambient air makeup inlet port; and an incinerator effluent exhaust port; a pair of dampers being interconnected for movement between

a, a first position to direct the flow of makeup air from the ambient air makeup inlet port to the main blower intake, while directing the flow of incinerator effluent to the incinerator effluent exhaust port; and

b, a second position to direct substantially maximum flow of incinerator effluent from the incinerator outlet port to the main blower intake, while substantially closing the ambient air makeup inlet port and the incinerator effluent exhaust port.

7. Apparatus according to claim 6 in which movement of the dampers between their said first and second positions varies the inflow of makeup air through the makeup inlet port in direct proportion to variation of outflow of incinerator effluent through the exhaust port, and in inverse proportion to variation of flow of incinerator effluent to the recirculation conduit.

8. Apparatus for heating objects to drive off combustible waste products including hydrocarbons, and then to convert the waste products to non-air-polluting components, the apparatus including:

an oven and an incinerator each having an inlet port and an outlet port;

a recycle conduit interconnecting the oven outlet and incinerator inlet ports and interconnecting the incinerator outlet and oven inlet ports, said recycle conduit having a blower effective to move oven atmosphere from the oven outlet port to the oven inlet port via the incinerator;
the incinerator having burner means for purifying the oven atmosphere by burning the waste products in the oven atmosphere, the incinerator comprising the major source of heat for the oven, and damper means located in the recycle conduit between the incinerator outlet port and the oven inlet port effective to simultaneously draw in ambient makeup air at a selected flow rate, mix the cool ambient air with hot incinerator effluent in a predetermined proportion and direct the mixture to the oven inlet port, and vent incinerator effluent at a flow rate corresponding to said selected flow rate at which ambient makeup air is drawn in.

9. Apparatus according to claim 8, in which said damper means is four-way damper means.

10. Apparatus according to claim 8, in which said damper means includes a casing having a chamber connected, respectively, to the incinerator outlet port and the oven inlet port, an air inlet port, a gas outlet port, and individual dampers for the air inlet and gas outlet ports, said dampers being interconnected for simultaneous movement in a direction to correspondingly vary the volume of makeup air entering the air inlet port and incinerator effluent vented through the gas outlet port while inversely varying the volume of incinerator effluent recycled to the oven.

11. Apparatus according to claim 10, including a temperature-sensing element in the oven, power actuated means for moving the dampers, and control means for the power actuated means to move the dampers in a direction to change the proportion of hot incinerator effluent and cool ambient air in the mixture directed to the oven inlet port in response to change of temperature of the sensing element.

12. Apparatus according to claim 11, in which the power actuated means is effective to increase the proportion of hot incinerator effluent in the mixture directed to the oven inlet port in response to a drop in temperature below a predetermined value sensed by said element, and is further effective to increase the proportion of cool ambient air in the mixture directed to the oven inlet port in response to an increase in temperature above a predetermined value sensed by said element.