US005538420A

# United States Patent [19]

**Klobucar et al.**

[11] **Patent Number: 5,538,420**

[45] **Date of Patent: Jul. 23, 1996**

[54] **HEAT EXCHANGER BAKE OUT PROCESS**

[75] Inventors: **Joseph M. Klobucar**, Plymouth; **Gordon M. Harbison**, Canton, both of Mich.

[73] Assignee: **Durr Industries, Inc.**, Plymouth, Mich.

[21] Appl. No.: **342,730**

[22] Filed: **Nov. 21, 1994**

[51] **Int. Cl.**$^{6}$ .................................................... **F27D 17/00**

[52] **U.S. Cl.** ................................ **432/2**; 432/180; 432/181

[58] **Field of Search** .................................... 432/179, 180, 432/181, 75, 2; 137/309

[56] **References Cited**

U.S. PATENT DOCUMENTS

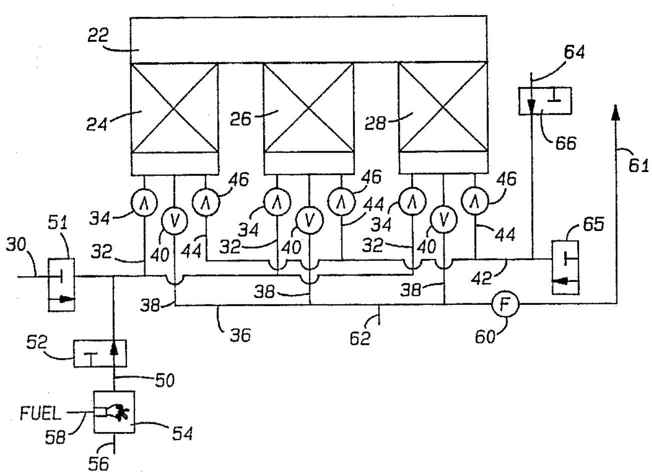
| | | | |
|---|---|---|---|
| 5,101,741 | 4/1992 | Gross et al. . | |
| 5,240,403 | 8/1993 | McAnespie | 432/181 |
| 5,259,757 | 11/1993 | Plejdrup et al. | 432/181 |
| 5,297,954 | 3/1994 | Colagiovanni | 431/5 |

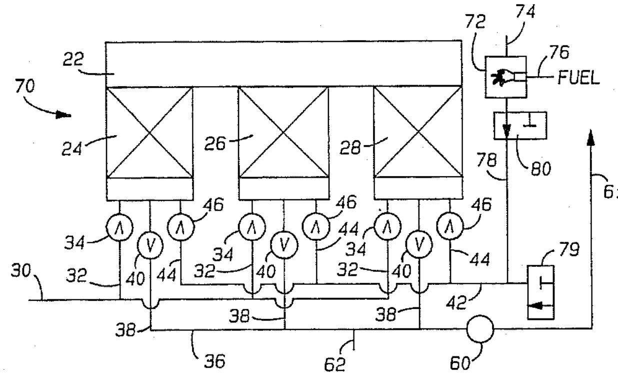
*Primary Examiner*—Thomas E. Denion
*Attorney, Agent, or Firm*—Howard & Howard

[57] **ABSTRACT**

A heat exchanger burn-out process for regenerative thermal oxidizers includes the steps of passing a super-heated gas through one of the heat exchangers and into the combustion chamber. The gas is preferably heated in a selectively opened injection line that includes a burner. The burner is designed to superheat the injection gas to a cleaning temperature. The cleaning temperature is selected to be high enough as to volatilize and/or combust the organic solids that are expected within the heat exchanger. The injection line is associated with one of the heat exchangers, and the other two of the normal three heat exchangers on the regenerative thermal oxidizer are switched between a supplemental injection mode, wherein cooling gas is injected through that heat exchanger, and an outlet mode wherein gas from the combustion chamber leads outwardly through the heat exchanger to an outlet manifold. The supplemental injection line reduces the overall temperature of the gas leaving the system through the outlet manifold. In one embodiment, the heated injection line is associated with the inlet manifold, and the supplemental injection line is associated with the purge manifold. In a second embodiment, the heated injection line is associated with the purge manifold and the supplemental injection line is associated with the inlet manifold.

**13 Claims, 1 Drawing Sheet**



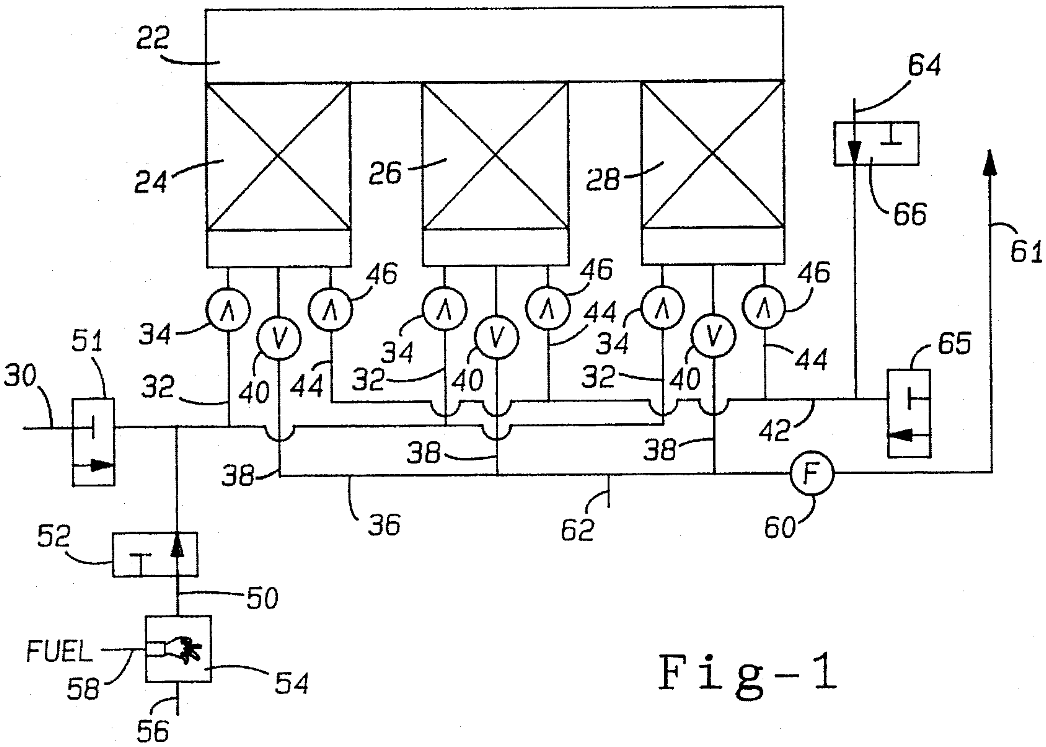

22
24
26
28
64
66
61
46
34
40
44
32
30
51
42
38
65
F
36
62
60
52
50
FUEL
58
54
56

Fig-1

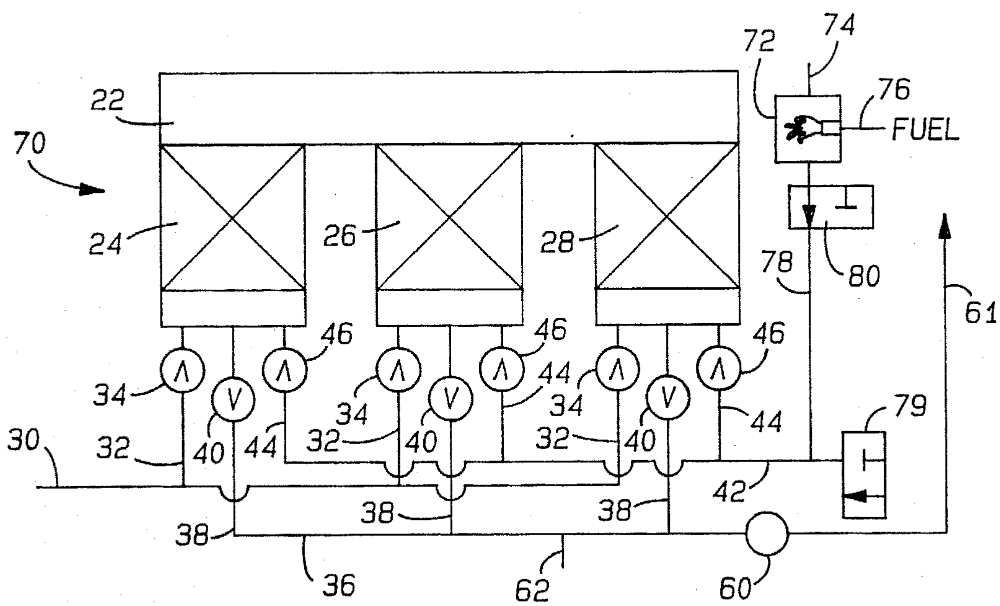

22
70
24
26
28
72
74
76
FUEL
78
80
61
46
34
40
44
32
30
79
42
38
36
62
60

Fig-2

## HEAT EXCHANGER BAKE OUT PROCESS

### BACKGROUND OF THE INVENTION

This invention relates to a method of directing a heated gas through a heat exchanger in a regenerative thermal oxidizer and into the combustion chamber to volatilize or combust any solids that may have accumulated within the heat exchange elements.

Regenerative thermal oxidizers ("RTO") are known, and are often utilized to remove volatile organic compounds ("VOC's") from an air stream. The air stream is typically process gas from another industrial process, such as a paint spray booth. The RTO removes the VOC's from the air stream by passing the process or "dirty" gas through a first previously heated heat exchanger and into a combustion chamber. The "dirty" gas is combusted and cleaned in the heat exchanger chamber. At the same time, a second heat exchanger is receiving heated clean air from the combustion chamber. After a period of time, the flow of cool dirty gas and heated clean gas are switched between the heat exchangers. Thus, the first heat exchanger that had previously been hot and was heating the dirty gas is switched to receiving the hot clean gas. The first heat exchanger is then again heated. The second heat exchanger that had been receiving the hot clean gas is switched to receiving the cool dirty gas and preheats that gas on its way to the combustion chamber. In this way, the regenerative thermal oxidizer continuously processes gas and efficiently removes impurities from a gas flow.

In many prior art RTO systems, a purge cycle is also included. When the heat exchangers are switched from receiving the dirty gas to the cool clean gas, there may sometimes be some residual dirty gas remaining in the heat exchanger. The clean gas is directed back to atmosphere, and no dirty gas should remain in the heat exchanger that begins to receive the clean gas. Thus, the prior art has included the purge cycle which drives residual dirty gas from a heat exchanger prior to that heat exchanger being switched to an outlet mode where it receives the clean gas. In many applications, RTO systems include a third heat exchanger such that the processing can continue at all times, with one heat exchanger being in an inlet mode receiving cool dirty gas, one heat exchanger being in an outlet mode receiving hot clean gas, and the third heat exchanger being in the purge mode.

Problems exist with such systems in that the heat exchange elements within the heat exchanger often accumulate organic solids from the air flow. The air flow containing the dirty gas tends to be in a first direction through the heat exchanger, and the air flow containing the clean gas is typically in an opposed direction. The heat exchange elements are often small particles of ceramic or other materials with good heat transfer properties. Such small particles or saddles, as they are typically known, provide numerous complex surface areas that can easily accumulate a good deal of organic waste. Thus, the heat exchanger elements will often accumulate organic solids. Further, the flow lines leading to the heat exchanger, and in particular the inlet manifold valves and flow lines often also build up accumulated solids.

The prior art has typically cleaned these heat exchangers by locking the valves in a first position such that the outlet gas continues to pass through a given heat exchanger for an unusual length of time. That outlet gas raises the temperature of the heat exchange elements to bake out any accumulated organic solids. However, this system has not been as efficient as desired. Moreover, since the cleaning gas is passing in a different direction than the direction at which the organic solids are placed on the heat exchange elements, it may not always be as effective as would be desirable.



### SUMMARY OF THE INVENTION

In a disclosed embodiment of this invention, flow structure is modified to include an optional burn-out injection passage selectively communicating with one of the standard flow passages leading through the heat exchanger and into the combustion chamber. The injection line is also provided with a cleaning burner. When a heat exchanger is being cleaned, the standard flow passage is closed and the injection line is opened to the heat exchanger. Cleaning air passes through the cleaning burner and is heated to a cleaning temperature. The cleaning temperature is selected to be above the temperature at which the accumulated solids on the heat exchanger would be volatilized and/or combusted. This heated air passes through the flow manifold and valves, through the heat exchanger being cleaned, and into the combustion chamber. At the same time, clean air is passing from the combustion chamber through another of the heat exchangers.

Since the heated cleaning air is passing through the heat exchanger in a different direction than that normally taken by the process heated clean air, the optional burn-off cleaning air passing through that heat exchanger provides a thorough and efficient cleaning of the heat exchange elements.

In a preferred embodiment of this invention, the RTO includes at least a third heat exchanger, and the third heat exchanger is also placed in a mode such that it passes gas through the heat exchanger and into the combustion chamber. Thus, in a preferred method according to this invention, the heated burn-out gas is passed into a first heat exchanger, and a second or supplemental cool gas is passing into the combustion chamber through a second of the heat exchangers. The two gas flows combine in the combustion chamber and together pass outwardly through the third heat exchanger. Most preferably the second and third heat exchanger are cyclically switched as the first heat exchanger is maintained in the burn-out mode. The supplemental cool gas passing minimizes the temperature of the gas passing outwardly of the third heat exchanger. The RTO system is configured such that it typically combusts a gas passing through the first heat exchanger that was initially cool, rather than the super-heated cleaning gas. Thus, the temperature leaving the third heat exchanger may be higher than is desirable. By passing the supplemental cool gas through the second heat exchanger, that temperature in the third heat exchanger is somewhat lowered. In a most preferred embodiment of this invention, a fan is placed on the discharge passage downstream of the heat exchangers, and an air bleed is added to provide additional cooling air to the discharge passage, as necessary, to protect the fan from super-heated temperatures.

In a first embodiment of this invention, the optional burn-out gas is provided into the inlet manifold. In this method, the supplemental gas flows through the purge manifold. The supplemental gas is preferably distinct from the normal purge gas provided from the discharge passage.

In a second embodiment according to this invention, the optional burn-out gas is provided through the purge line, and is a gas other than the standard purge gas. In this method, the supplemental gas would typically be through the inlet line. This supplemental gas may be the normal process gas or may be a clean gas from some other source.

The apparatus according to this invention includes a RTO including at least two heat exchangers. Preferably, it would be a three-heat exchanger RTO. The passages leading into the heat exchanger and through the heat exchanger to the combustion chamber are provided with a separate injection line and a burner mounted on that separate injection line. The burner is capable of heating the air to a cleaning temperature above the temperature at which the organic solids that are to be expected on the heat exchanger elements would be volatilized and/or combusted. It should be understood that once the particular organic solids that are expected on the heat exchanger are identified, a worker of ordinary skill in the art would be able to identify the required cleaning temperature. It would then be a simple matter to determine the size of the cleaning burner necessary to heat the burn-out air leading through the heat exchanger for cleaning.

In a method according to this invention, air is heated and injected at the cleaning temperature through a first heat exchanger. The second and third heat exchangers are cyclically switched between being in an outlet and a supplemental injection mode. In the supplemental injection mode, a relatively high volume of air is passed into the heat exchanger to add additional air into the combustion chamber, to provide some cooling of the air leaving the other heat exchanger.

These and other features of this invention can be best understood from the following specification and drawings, of which the following is a brief description.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a regenerative thermal oxidizer including a first embodiment bake out system.

FIG. **2** is a schematic view of a second embodiment bake out system.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A regenerative thermal oxidizer **20** incorporates a combustion chamber **22** and three heat exchangers **24**, **26** and **28**. Combustion chamber **22** is typically provided with a burner. As is known, an inlet manifold **30** communicates a dirty process gas through one of the inlet branches **32** leading to each of the heat exchangers **24**, **26** and **28**. Inlet valves **34** are mounted on each inlet branch **32**. An outlet manifold **36** communicates with an outlet branch **38** from each of the three heat exchangers. An outlet valve **40** is mounted on each outlet branch **38**. A purge manifold **42** communicates with the source of clean gas, shown here as the outlet manifold **36**. Purge manifold **42** communicates through a purge branch **44** with each of the heat exchangers **24**, **26** and **28**. Each purge branch **44** incorporates a purge valve **46**.

As is known, when processing dirty air from inlet manifold **30**, one inlet valve **34** is typically open. Air passes through that inlet valve, and into one of the heat exchangers **24**, **26** and **28**, which had been previously heated by clean outlet gas passing into the discharge manifold **36**. The process air leading through the inlet branch **32** is thus preheated by the heat exchanger, and is combusted in the combustion chamber **22**. That heated clean gas then moves through one of the other heat exchangers which has an open outlet valve **40**, and into the outlet manifold **36**. The heat exchangers are cyclically switched between being in the inlet and outlet mode. Between the time a heat exchanger is in the inlet mode and the time it is switched to the outlet mode, it may undergo a purge cycle. In the purge cycle, the inlet valve **34** and the outlet valve **40** are typically closed, and the purge valve **46** is opened on that heat exchanger. Purge gas passes through the heat exchanger to remove any residual gas. Various modifications of this basic operation are known, and the above is intended as a basic description of the typical regenerative thermal oxidizer operation.



With the present invention, an injection line is provided to inject a super-heated air through one of the heat exchangers **24**, **26** and **28** to burn out that heat exchanger and remove any accumulated organic solids.

In the embodiment **20** shown in FIG. **1**, the injection line **50** communicates through a normally closed damper valve **52** with the inlet manifold **30**. A normally open damper valve **51** is positioned upstream on manifold **30** from the location of conduit **50**. During normal operations, damper **51** is opened and damper **52** is closed. However, when it is desired to clean one of the heat exchangers **24**, **26** and **28**, then damper **51** is preferably closed and damper **52** is opened, as shown in FIG. **1**. A burner **54** is positioned upstream on injection line **50** and a source of air **56** passes through burner **54**. Fuel is added to burner **54** through a fuel line **58**. The air **56** is heated to the cleaning temperature for the heat exchanger. The cleaning temperature is selected to be high enough that it would volatilize and/or combust the organic solids which are to be expected in the heat exchanger **24**, **26** and **28**. Although the cleaning temperature may vary for the particular expected organic solvents, it would typically be above 600° F. A worker of ordinary skill in the art would be able to identify the necessary cleaning temperature for the particular expected organic solids, and would also be able to identify the amount of heat that must be added by the burner **54** to achieve that cleaning temperature in the desired volume of cleaning bake out air passing through injection line **50**.

A fan **60** is positioned on outlet manifold **36** and serves to draw air from the combustion chamber to an outlet stack **61**. An optional cooling air bleed **62** may be positioned on the outlet manifold **36** to insure that the air passing to fan **60** is not so hot that it may damage the fan **60**.

In addition, a separate air inlet or supplemental injection line **64** may communicate with the purge manifold **42**. The gas is preferably cooler than the gas in outlet stack **61**. A damper **65** is preferably mounted on the normal purge tap and a second damper **66** is mounted on the supplemental injection line **64**. During normal operation, damper **66** is maintained closed while damper **65** is open. The operation of the regenerative thermal oxidizer would continue as is normal to process gas from the inlet manifold **30**.

When it is desired to bake out a particular heat exchanger, as heat exchanger **24** shown in FIG. **1**, then damper **51** is closed and damper **52** is open. At the same time, damper **65** is closed and damper **66** is open. Heated air passes through conduit **50** and through the inlet branch **32** into the heat exchanger **24**. This inlet gas is at the cleaning temperature and would volatilize and/or combust the organic solvents that may have accumulated within the heat exchanger **24**. That gas passing into the combustion chamber **22** is then combined with a supplemental gas from purge branch **44** passing through heat exchanger **28**. The supplemental injection gas is at a relatively low temperature, and serves to reduce the overall temperature of the combined gas flows passing out of combustion chamber **22**, through heat exchanger **26**, and into outlet manifold **36**. Since the gas passing from injection line **50** and into the inlet branch **32** is at temperatures much higher than would typically be passing into the combustion chamber **20**, it can be expected that the outlet temperature would be much higher than typically experienced by a regenerative thermal oxidizer. For that reason, the supplemental injected gas serves to reduce the overall temperature of the gas leaving the heat exchanger **26**. Even so, the optional air bleed **62** will ensure that the temperature of the air approaching fan **60** is not so high as to be destructive to the fan.

The heat exchangers **26** and **28** are preferably cycled between the supplemental injection and outlet mode. This process continues until a sufficient time has passed that the heat exchanger **24** is thoroughly cleaned. At that time, the system may move to a mode wherein the heat exchanger **26** or **28** is cleaned. Alternatively, it may be preferable to have a period of no burn-out between the completion of cleaning of one of the heat exchangers to allow the overall system to return to a normal process temperature.

A second embodiment **70** is illustrated in FIG. 2. All elements which are identical to those shown in the first embodiment are identified with the same reference numerals. In this embodiment, the heated cleaning gas passes into the purge manifold **42** through a burner **72**. Burner **72** communicates with a source of gas **74**, which leads to an injection line **78**. Injection line **78** is associated with a pair of dampers **79** and **80**. Damper **79** serves to close off the purge source from the outlet stack **61**. Damper **80** serves to open communication between injection line **78** and the purge manifold **42**. As with the first embodiment, when a heat exchanger, here heat exchanger **28**, is in the cleaning mode, the other two heat exchangers cycle between a supplemental injection mode and an outlet mode. Here, heat exchanger **24** is shown receiving supplemental injection air through the inlet manifold **30**. This supplemental injection air may be the normal process gas, or may be an outside clean gas.

Preferred embodiments of this invention have been disclosed. A worker of ordinary skill in the art would recognize, however, that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine true scope and content of this invention.

We claim:

**1**. A method of cleaning a heat exchanger in a regenerative thermal oxidizer comprising the steps of:

providing a regenerative thermal oxidizer including a combustion chamber and at least two heat exchangers, each of said heat exchangers communicating with said combustion chamber at a first end of said heat exchanger and communicating with a source of process gas to be cleaned at a second end of said heat exchanger, said second end of said heat exchangers also communicating with an outlet manifold to direct a clean gas passing from said combustion chamber through said heat exchangers and to a destination for clean gas;

providing an injection line for passing a heated gas into said heat exchanger through said second end towards said first end and into said combustion chamber, a valve being provided on said injection line and a source of heat being provided on said injection line upstream of said valve;

heating and injection gas in said injection line with said source of heat; and

passing said heated injection gas through said injection line and into said heat exchanger at said second end, passing said gas over said heat exchanger from said second end toward said first end and into said combustion chamber through a first of said heat exchangers, and passing gas from said combustion chamber through a second of said heat exchangers to said outlet manifold.

**2**. A method as recited in claim **1**, wherein said gas passing into said injection line is heated to a cleaning temperature selected to be high enough to volatilize organic solids which are expected to be on said heat exchanger.

**3**. A method as recited in claim **2**, wherein said cleaning temperature is above 600° F.

**4**. A method as recited in claim **1**, wherein a fan is positioned on said outlet manifold for assisting in driving the air, and a tap is provided upstream of said fan, said tap being opened to provide supplemental cooling air to a outlet gas flow to prevent damage to said fan.

**5**. A method as recited in claim **1**, wherein a period of cool down time is provided after completion of burn-out of a first of said heat exchangers prior to beginning a burn-out of said second of said heat exchangers.

**6**. A method of cleaning a heat exchanger in a regenerative thermal oxidizer comprising the steps of:

providing a regenerative thermal oxidizer including a combustion chamber and at least two heat exchangers, each of said heat exchangers communicating with said combustion chamber at a first end of said heat exchanger and communicating with a source of process gas to be cleaned at a second end of said heat exchanger, said second end of said heat exchangers also communicating with an outlet manifold to direct a clean gas passing from said combustion chamber through said heat exchangers and to a destination for clean gas;

providing an injection line for passing a heated gas into said heat exchanger through said second end towards said first end and into said combustion chamber;

passing a heated injection gas through said injection line and into said heat exchanger at said second end, passing said gas over said heat exchanger from said second end toward said first end and into said combustion chamber through a first of said heat exchangers, and passing gas from said combustion chamber through a second of said heat exchangers to said outlet manifold;

said gas passing into said injection line being heated to a cleaning temperature selected to be high enough to volatilize organic solids which are expected to be on said heat exchanger; and

wherein there are at least three of said heat exchangers, with a first of said heat exchangers receiving said heated gas, a second of said heat exchangers receiving said outlet gas, and a third of said heat exchangers passing a cool supplemental injection gas through said third heat exchanger from said second end toward said first end and into said combustion chamber.

**7**. A method as recited in claim **6**, wherein said heated gas is injected into an inlet manifold for directing a process gas into said heat exchanger.

**8**. A method as recited in claim **7**, wherein a damper closes communication between a source of process gas and said inlet manifold, and a second damper opens communication between said injection line and said inlet manifold.

**9**. A method as recited in claim **7**, wherein the cool gas passing into said third heat exchanger is supplied from a purge manifold for purging said heat exchanger.

**10**. A method as recited in claim **6**, wherein said heated gas is directed through a purge manifold associated with a purge mode for said heat exchanger,

**11**. A method as recited in claim **10**, wherein a separate injection line is selectively added into said purge manifold for delivering said heated gas.

**12**. A method as recited in claim **10**, wherein said supplemental injection gas is a cool gas directed through said inlet manifold into said third heat exchanger.

**13**. A method as recited in claim **12**, wherein said cool gas injected through said inlet manifold is a normal process gas for the regenerative thermal oxidizer.

* * * * *