

EXHAUST GAS TREATMENT APPARATUS FOR USE IN INCINERATION EQUIPMENT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an exhaust gas treatment apparatus, for example, for use in a refuse incineration equipment.

Description of Related Art

In a known refuse incineration equipment, exhaust gas discharged from an incinerator is supplied to a bag filter, by which flying ash is caught.

In general, the temperature of the exhaust gas to be supplied to the bag filter should be reduced and, therefore, the exhaust gas is once cooled, for example, from 280°C to 170°C by a temperature adjuster column of water jet type.

After the flying ash in the exhaust gas thus cooled is caught by the bag filter, the exhaust gas is heated again by a heater, then catalytically denitrated in a denitrator, and discharged from a stack into the atmosphere.

The re-heating of the exhaust gas by the heater is required because the exhaust gas should be heated up to about 230°C for the catalytic denitration of the exhaust gas.

In the aforesaid exhaust gas treatment, the exhaust gas is once cooled in the temperature adjuster column, and then heated by the heater. This interferes with the efficient utilization of the heat of the exhaust gas, and is very uneconomical.

It is, therefore, an object of the present invention to provide an exhaust gas treatment apparatus for use in an incineration equipment which is capable of efficiently utilizing the heat of exhaust gas.

SUMMARY OF THE INVENTION

In accordance with one feature of the present invention, there is provided an exhaust gas treatment apparatus for use in an incineration equipment comprising: a temperature adjuster for cooling exhaust gas discharged from an incinerator; a dust collector for removing dust from the exhaust gas cooled by the temperature adjuster; and a denitrator for catalytically denitrating the exhaust gas supplied from the dust collector, the temperature adjuster having a first heat exchanger for cooling the exhaust gas of a high temperature discharged from the incinerator with air and a second heat exchanger for heating the exhaust gas of a lower temperature supplied from the dust collector with the high-temperature exhaust gas discharged from the incinerator.

In the aforesaid exhaust gas treatment apparatus, a heater for heating the exhaust gas is provided in the midst of a pipe line for leading the exhaust gas heated by the second heat exchanger to the denitrator.

In the aforesaid exhaust gas treatment apparatus, a portion of the first heat exchanger which is to be brought into contact with the exhaust gas is coated with a coating material for prevention of acid-dew-point corrosion.

In the aforesaid exhaust gas treatment apparatus, PFA resin is used as the coating material, with which the portion of the first heat exchanger is coated to a thickness of 200 μ m to 1000 μ m by baking finish.

In the aforesaid exhaust gas treatment apparatus, the first and second heat exchangers are transverse multipipe heat exchangers, and the first heat exchanger is divided into two pieces which are disposed integrally and parallel to the second heat exchanger.

In accordance with the aforesaid construction, the exhaust gas from the dust collector is heated up to a temperature required for the catalytic treatment by utilizing the heat of the exhaust gas from the incinerator by means of the second heat exchanger. Therefore, the exhaust gas treatment apparatus of the present invention is more economical than a conventional exhaust gas treatment apparatus that is adapted to heat the once cooled exhaust

gas only by means of a heater.

In addition, the portion of the first heat exchanger which is to be brought into contact with the exhaust gas is coated with PFA resin to a thickness of 200 μ m to 1000 μ m by baking finish. Therefore, a sufficient corrosion resistance is ensured without compromising the thermal conductivity of the first heat exchanger.

Further, the temperature adjuster comprises the two heat exchangers, and one of the heat exchangers is divided into two pieces which are disposed integrally and parallel to the other heat exchanger. Thus, the size of the temperature adjuster can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an exhaust gas treatment apparatus in accordance with one embodiment of the present invention;

Fig. 2 is a diagram illustrating the construction of a temperature adjuster of the exhaust gas treatment apparatus;

Fig. 3 is a front view illustrating the temperature adjuster of the exhaust gas treatment apparatus;

Fig. 4 is a side view illustrating the temperature adjuster of the exhaust gas treatment apparatus;

Fig. 5 is a graphical representation illustrating the characteristics of the thermal conductivity and the anti-

swelling property versus the thickness of PFA resin coating;

Fig. 6 is a front view illustrating a modification to the temperature adjuster;

Fig. 7 is a front view illustrating another modification to the temperature adjuster; and

Fig. 8 is a diagram illustrating the construction of a temperature adjuster in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the present invention will be described with reference to Figs. 1 to 8.

Fig. 1 illustrates an exhaust gas treatment apparatus 1 which is to be provided, for example, in a refuse incineration plant (other exemplary incineration plants include an industrial waste incineration plant, a burned-ash or flying-ash melting plant, a power generation plant and an oil refinery plant). In the exhaust gas treatment apparatus 1, flying ash and the like in exhaust gas discharged from a refuse incinerator 2 is removed, and the exhaust gas is denitrated by adding a catalyst thereto, and then discharged from a stack 3 into the atmosphere.

The exhaust gas treatment apparatus 1 comprises a temperature adjuster 11 for cooling the exhaust gas discharged from the refuse incinerator to a predetermined

temperature (e.g., about 170°C which is acceptable to a bag filter to be described later), a bag filter (dust collector) 12 for removing dust from the exhaust gas cooled by the temperature adjuster 11, a denitrator 14 for catalytically denitrating the exhaust gas supplied from the bag filter 12 through an exhaust gas pipe line 13 by use of a predetermined catalyst, and a gas burner (heater) 15 provided in the midst of the exhaust gas pipe line 13 for heating the exhaust gas.

The temperature adjuster 11 includes a first heat exchanger 21 for cooling the exhaust gas of a high temperature discharged from the refuse incinerator with air and a second heat exchanger 22 for heating the exhaust gas of a lower temperature supplied from the bag filter 12 with the high-temperature exhaust gas. The second heat exchanger 22 is disposed upstream of the first heat exchanger 21 in an exhaust-gas flow path.

As shown in Fig. 2, the heat exchangers 21 and 22 are transverse multipipe heat exchangers (shell-and-tube type). The exhaust gas flow and air flow are shown by arrows in Fig. 2.

More specifically, the high-temperature exhaust gas is supplied into a shell 22a of the second heat exchanger 22 disposed on the upstream side, while the lower-temperature exhaust gas from the bag filter 12 is supplied into tubes

22b of the second heat exchanger 22.

The exhaust gas from the shell 22a of the second heat exchanger 22 is supplied into a shell 21a of the first heat exchanger 21 disposed on the downstream side, while coolant air is supplied into tubes 21b of the first heat exchanger 21.

As shown in an enlarged diagram of Fig. 2, the exterior surface of the tubes 21b, the interior surfaces of the shell and tube plates and the other portions of the first heat exchanger 21 which are to be brought into contact with the exhaust gas are coated with a coating material 23 (e.g., fluorocarbon resin coating or ceramic coating) for the prevention of the acid-dew-point corrosion. Thus, the corrosion of the exterior surface of the tubes 21b and the like portions can be prevented. In this embodiment, the first heat exchanger 21 is constructed so as to allow the exhaust gas to flow inside the shell 21a. This is because the coating of the exterior surface of the tubes 21b is easier than the coating of the interior surface thereof.

An explanation will be given to the coating material 23, particularly, to a fluorocarbon resin coating which is used to cover the exterior surface of the tubes 21b of the first heat exchanger 21 for the prevention of the acid-dew-point corrosion. The coating material can also be applied to the interior surfaces of the tube plates and shell and

the other portions of the first heat exchanger 21 which are to be brought into contact with the exhaust gas.

More specifically, the exterior surface of the tubes 21b of the first heat exchanger 21 is coated with PFA (copolymer of tetrafluoroethylene and perfluoroalkyl vinyl ether) resin to a thickness of 200 μ m to 1000 μ m, preferably to a thickness of 200 μ m to 400 μ m, by baking finish. Exemplary materials of the tubes 21b include mild steel and stainless steel.

The bases for the use of PFA resin as the coating material and the preferable thickness range of the coating being from 200 μ m to 400 μ m will be explained with reference to Table 1.

Table 1

Resin	Acid-corrosion resistance	Heat resistance	Ductility
PFA	Excellent	Excellent	Excellent
FEP	Acceptable	Acceptable	Excellent
PTFE	Unacceptable	Acceptable	Excellent
PCTFE	Excellent	Unacceptable	Excellent

A corrosion resistance test, a thermal cycle load test and a bending test were carried out on steel pipes (25.4 mm ϕ) coated with various fluorocarbon resins. Used as reference examples of the fluorocarbon resins were copolymer of tetrafluoroethylene and hexafluoropropylene (FEP), polytetrafluoroethylene (PTFE) and polychlorotrifluoroethylene (PCTFE). The corrosion resistance test was performed under conditions of 80% sulfuric acid (at 140°C) and of 20% chloric acid (at the boiling point) simulating the severest use environment. The thermal cycle load test was performed by repeating cooling (to 0°C) and heating (to 200°C). The test results are shown in Table 1. As can be seen from table 1, PFA resin is the most excellent in the acid-corrosion resistance, heat resistance and ductility.

Next, how the thickness of PFA resin influences the anti-swelling property observed in acid dipping under temperature gradient and the thermal conductivity was examined. In this case, a stainless steel having a thickness of 1.5mm was used as a substrate to be coated with PFA resin. The results are shown in Fig. 5.

As can be seen from Fig. 5, the thickness of the PFA resin coating is preferably 200 μ m to 400 μ m, more preferably 300 μ m to 400 μ m, which satisfies requirements for the corrosion resistance and anti-swelling property without compromising the thermal conductivity.

A corrosion resistance test was carried out under conditions simulating an actual use environment, in which the exterior surface of a steel pipe (25.4mm ϕ) coated with PFA resin to a thickness of 200 μ m to 400 μ m was subjected to 80% sulfuric acid (at 140°C) and to 20% chloric acid (at the boiling point) while the interior surface thereof was cooled with air. Further, a thermal cycle test was carried out under conditions simulating the actual use environment, in which the exterior surface of the steel pipe was repeatedly cooled to the room temperature and heated to 180°C while the interior surface thereof was cooled with air. These tests revealed that the PFA resin coating having a thickness of 200 μ m to 400 μ m exhibited an excellent performance.

Another exemplary heat-conductive pipe exhibiting a good corrosion resistance is a steel pipe mechanically coated with PTFE resin. However, the PTFE resin coating suffers from a bad adhesiveness to the steel pipe, resulting in a deteriorated heat-conductivity and corrosion resistance. In addition, even a small mechanical damage to the PTFE resin coating results in a large tear of the resin coating. Further, if subjected to a thermal cycle, the PTFE resin coating is slacked.

With reference to Figs. 3 and 4, the construction of the temperature adjuster 11 will be described more specifically.

In the temperature adjuster 11, the second heat exchanger 22 is disposed in an upper portion within the frame 31, and the first heat exchanger 21 is divided into two pieces 21A and 21B which are connected in series and disposed parallel to the second heat exchanger 22 thereunder. If two heat exchangers each having the same size as that of the second heat exchanger were used as the first heat exchanger 21, the length of the first exchanger 21 would be about double the length of the second heat exchanger 22. In this embodiment, however, the first heat exchanger 21 is divided into two pieces which are disposed parallel to the second heat exchanger 22 thereunder, so that the size of the temperature adjuster 11 can be reduced.

A known exhaust gas treatment apparatus capable of treating exhaust gas from the refuse incineration at a rate of 40,000Nm³/hr, for example, requires a heat exchanger having a size of 2m x 2m x 5m (height) in addition to a temperature adjuster column of water jet type having a size of 10m (height) x 2.5m to 3m (diameter). In contrast therewith, the two heat exchangers 21 and 22 of the temperature adjuster 11 according to this embodiment only occupy a space of 2.5m x 1.8m x 2.5m (height), so that the size of the temperature adjuster 11 can be reduced in comparison with the known temperature adjuster column and heat exchanger.

The air which has absorbed heat from the exhaust gas in the first heat exchanger 21 is supplied into the exhaust gas discharged from the denitrator 14 to prevent the exhaust gas from being discharged as white smoke from the stack 3. (The term "white smoke" is herein defined as exhaust gas in which water vapor included therein looks white because the temperature thereof is low. In view of environmental concerns, preventive measures are taken against the white smoke.)

The exhaust gas of a high temperature (e.g., 280°C) discharged from the refuse incinerator flows through the second heat exchanger 22 and the first heat exchanger 21 so that the temperature thereof is lowered. Calcium hydroxide is added to the exhaust gas cooled, for example, to about 170°C in the heat exchangers 22 and 21 on the way to the bag filter 12. After flying ash is removed from the exhaust gas by means of the bag filter 12, the exhaust gas is heated in the second heat exchanger 22. The exhaust gas is further heated, for example, to about 230°C by the gas burner 15 provided in the midst of the exhaust gas pipe line 13 and, thereafter, supplied into the denitrator 14 to be catalytically denitrated.

The air which has absorbed heat by cooling the exhaust gas in the first heat exchanger 21 is supplied to the exhaust gas discharged from the denitrator 14 for white

smoke prevention, and then the exhaust gas is discharged from the stack 3.

The exhaust gas discharged from the bag filter 12 is heated up to a temperature required for the catalytic denitration by utilizing the heat of the exhaust gas from the refuse incinerator by means of the second heat exchanger 22. Therefore, the exhaust gas treatment apparatus of the present invention is much more economical than a conventional exhaust gas treatment apparatus that is adapted to heat the once cooled exhaust gas only by means of a heater.

Further, since the temperature adjuster 11 has two heat exchangers 21 and 22 vertically disposed therein and one heat exchanger 21 is divided into two pieces which are disposed parallel to each other and to the other heat exchanger 22, the size of the temperature adjuster 11 can be significantly reduced.

Though the first heat exchanger divided into two pieces is disposed parallel to the second heat exchanger thereunder in the aforesaid embodiment, the pieces 21A and 21B of the first heat exchanger 21 may be disposed parallel to the second heat exchanger thereabove as shown in Fig. 6 or, alternatively, may be disposed vertically and parallel to each other beside the second heat exchanger 22 as shown in Fig. 7.

Further, though the aforesaid embodiment is adapted to supply the high-temperature exhaust gas to the shell 22a of the second heat exchanger 22, the high-temperature exhaust gas may be supplied to the tubes 22b of the second heat exchanger 22 as shown in Fig. 8. However, the construction shown in Fig. 2 which allows the exhaust gas to flow outside the tubes 22b facilitates a cleaning operation for cleaning the interior surface of the second heat exchanger 22 on which dust such as flying ash in the exhaust gas adheres.

Still further, though the gas burner (heater) is provided in the midst of the exhaust gas pipe line 13 for leading the exhaust gas from the second heat exchanger to the denitrator in the aforesaid embodiment, the gas burner may not be necessarily required.

While the present invention has been described above by way of a specific embodiment thereof, it should be understood that various modifications and changes may be made without departing from the spirit and scope of the present invention, as defined in the appended claims.



What is claimed is:

1. An exhaust gas treatment apparatus for use in an incineration equipment comprising a temperature adjuster for cooling exhaust gas discharged from an incinerator, a dust collector for removing dust from the exhaust gas cooled by the temperature adjuster, and a denitrator for catalytically denitrating the exhaust gas supplied from the dust collector, characterized in that

the temperature adjuster has a first heat exchanger for cooling the exhaust gas of a high temperature discharged from the incinerator with air and a second heat exchanger for heating the exhaust gas of a lower temperature supplied from the dust collector with the high-temperature exhaust gas discharged from the incinerator.

2. An exhaust gas treatment apparatus as set forth in claim 1, wherein a heater for heating the exhaust gas is provided in the midst of a pipe line for leading the exhaust gas heated by the second heat exchanger to the denitrator.

3. An exhaust gas treatment apparatus as set forth in claim 1, wherein a portion of the first heat exchanger which is to be brought into contact with the exhaust gas is coated with a coating material for prevention of acid-dew-point corrosion.



4. An exhaust gas treatment apparatus as set forth in claim 2, wherein a portion of the first heat exchanger which is to be brought into contact with the exhaust gas is coated with a coating material for prevention of acid-dew-point corrosion.

5. An exhaust gas treatment apparatus as set forth in claim 3, PFA resin is used as the coating material, with which the portion of the first heat exchanger to be brought into contact with the exhaust gas is coated to a thickness of 200 μ m to 1000 μ m by baking finish.

6. An exhaust gas treatment apparatus as set forth in claim 4, PFA resin is used as the coating material, with which the portion of the first heat exchanger to be brought into contact with the exhaust gas is coated to a thickness of 200 μ m to 1000 μ m by baking finish.

7. An exhaust gas treatment apparatus as set forth in any of claims 1 to 6, wherein the first and second heat exchangers are transverse multipipe heat exchangers, and the first heat exchanger is divided into two pieces which are disposed integrally and parallel to the second heat exchanger.