A heating system for heating heat-transfer oil using exhaust heat of boiler flue gas. The system includes: a flue, an economizer, an air preheater, and a heat-transfer oil heater. The economizer and the air preheater are disposed in the flue along the flow direction of the flue gas. The heat-transfer oil heater is disposed inside the flue in front of the economizer and is connected to a heat consumption device via a first circulating pipe. The circulating pipe is equipped with a circulating pump.
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FIG. 1
FIG. 2
HEATING SYSTEM FOR HEATING HEAT-TRANSFER OIL USING BOILER FLUE GAS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of International Patent Application No. PCT/CN2011/080030 with an international filing date of Sep. 22, 2011, designating the United States, now pending, and further claims priority benefits to Chinese Patent Application No. 201120069052.6 filed Mar. 16, 2011. The contents of all of the aforementioned applications, including any intervening amendments thereto, are incorporated herein by reference. Inquiries from the public to applicants or assignees concerning this document or the related applications should be directed to: Matthias Scholl P.C., Attn.: Dr. Matthias Scholl Esq., 14781 Memorial Drive, Suite 1319, Houston, Tex. 77079.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The invention relates to absorption and utilization of waste heat from boiler flue gas, and more particularly to a heating system of heat-transfer oil using boiler flue gas.

[0004] 2. Description of the Related Art
[0005] Organic heat carrier furnaces adopt an organic heat carrier as a medium for transferring the heat energy. The heat energy produced from the combustion is transferred to the organic heat carrier through a furnace heating surface for heating the organic heat carrier to a certain temperature. After that, the organic heat carrier is transferred to a heat consumption device by using a circulating oil pump to allow the organic heat carrier to release the heat energy. Thereafter, a low temperature organic heat carrier is returned to the furnace and heated again. The above processes are repeated to realize the supply of heat to a heat consumption device by using the organic heat carrier. The organic heat carrier furnace has the following characteristics: 1. High temperature of the heat carrier can be obtained at a relative low working pressure; 2. The liquid phase is circulated for providing heat, without heat loss resulting from condensation, so that the heat supplying system has a high heat efficiency; 3. The organic heat carrier furnace is capable of satisfying the requirement of accurate process temperature on the heat utilization system because of convenient operation control and uniform heat transfer. Thus, the organic heat carrier furnace is widely applied in petroleum, chemical, textile, printing and dyeing, rubber, leather, food, wood processing and many other industries. Meanwhile, as described in the former that the relatively high temperature heat carrier is obtained in relatively low working pressure, the temperature of such heat carrier is between 200 and 300°C, or much higher.

[0006] The flue gas produced from the combustion of the fuel of the boiler contains acid gas. When the flue gas is at a high temperature, the acid gas passes through various heating surfaces in the form of gas until it is removed in a desulfurization tower. When the temperature of the flue gas is lower than a certain degree, sulfur in the flue gas combines with the water vapor therein and is transformed into sulfuric acid which is corrosive to the heat transfer device. Low temperature corrosion generally occurs in a cool end of the air preheat device and an economizer having a low feedwater temperature. When the temperature of the heating surfaces is lower than a dewpoint of the flue gas, sulfuric acid resulting from the reaction between the water vapor in the flue gas and sulfur trioxide (accounting for a very small part of the sulfuric product produced from the combustion of the coal fuel) is condensed on the heating surfaces, thereby being heavily corrosive to the heating surfaces. In order to prevent the acid dew corrosion on the heating surfaces of a rear part of the boiler, the boiler is designed with a high exhaust temperature. The exhaust temperature of a new boiler is generally 140°C, and after running for a certain period, the exhaust temperature achieves 160°C. The direct discharge of the flue gas results in a large waste of energy.

[0007] As the temperature of the flue gas is generally between 140 and 160°C, and the temperature of the heat carrier is between 200 and 300°C, it is impossible to achieve the heat transfer from the flue gas to the heat-transfer oil using the direct heat transfer techniques. Thus, to recycle this part of low temperature heat energy to heat the heat-transfer oil to a desired temperature of between 200 and 300°C, it is required to rearrange the heating surface in the rear part of the furnace.

SUMMARY OF THE INVENTION

[0008] In view of the above-described problems, it is one objective of the invention to provide a heating system of heat-transfer oil using exhaust heat of boiler flue gas.

[0009] To achieve the above objectives, in accordance with one embodiment of the invention, provided is a heating system of heat-transfer oil using exhaust heat of boiler flue gas, comprising: an economizer and an air preheater disposed inside a flue along a flow direction of the flue gas. The heating system further comprises a heat-transfer oil heater. The heat-transfer oil heater is disposed inside the flue in front of the economizer; the heat-transfer oil heater is connected to a heat consumption device via a first circulating pipe; and a circulating pump is disposed on the first circulating pipe.

[0010] In a class of this embodiment, the system further comprises an exhaust heat utilization device. The exhaust heat utilization device comprises a heat absorption member and a heat release member communicating with each other through a second circulating pipe. The heat absorption member is disposed inside the flue behind the air preheater. The heat release member is arranged on a water inlet pipe of the economizer or inside an air inlet channel of the air preheater.

[0011] In a class of this embodiment, the exhaust heat utilization device employs a high temperature forced circulating water or naturally circulating steam having a heat transfer coefficient far higher than the side close to the flue gas, so that the temperature of the wall surface is determined by the side close to the working medium. The automatic control device of the system is capable of controlling the temperature of the wall surface according to the variation of the boiler load to ensure the temperature of the wall surface to be always higher than that of the acid dew point of the flue gas, so that the exhaust heat of the flue gas is recycled to the utmost on the basis of preventing the device from acid dew corrosion.

[0012] In a class of this embodiment, when the heat release member is arranged on the water inlet pipe of the economizer, the water inlet pipe of the economizer is provided with a deaerator and a high pressure heater for allowing the boiler feedwater to pass through the heat release member, the deaerator, and the high pressure heater, respectively, to enter the economizer.
In a class of this embodiment, a feedwater pump is arranged on a water pipe by which the deaerator and the high pressure heater are connected.

In a class of this embodiment, a steam inlet pipe of the high pressure heater and a steam inlet pipe of the deaerator communicate; a condensate drainage pipe of the high pressure heater is connected to the deaerator.

In a class of this embodiment, the system further comprises a control system, two temperature sensors, and a plurality of flow control valves. The temperature sensors and the flow control valves are connected to the control system, respectively. A first temperature sensor is disposed on the heat absorption member, and a second temperature sensor is disposed on the flue between the economizer and the air preheater or on a water outlet pipe of the economizer. One branch of boiler feedwater passes through a first flow control valve and enters the deaerator, and another branch of boiler feedwater passes through a second flow control valve and the heat release member and enters the deaerator. A third flow control valve is arranged on the steam inlet pipe of the high pressure heater.

In a class of this embodiment, the heat release member is arranged inside the air inlet channel of the air preheater, the system further comprises a control system, a temperature sensor, and a flow control damper. The temperature sensor and the flow control damper are connected to the control system, respectively. The temperature sensor is arranged on the heat absorption member, and the flow control damper is arranged inside the air inlet channel of the air preheater in front of the heat release member along the flow direction of the air inlet.

In a class of this embodiment, the system further comprises an oil-gas separator; and the oil-gas separator is disposed on the first circulating pipe between the heat-transfer oil heater and the heat consumption device.

In a class of this embodiment, the oil-gas separator is connected to an expansion slot, and the expansion slot is connected to an oiling pump.

Advantages of the invention are summarized below: the heating system of heat-transfer oil using the exhaust heat of boiler flue gas fully utilizes the exhaust heat of the flue gas. By changing the arrangement of the heating surfaces in the rear part of the boiler, the efficiency and the output of the original boiler are ensured, the exhaust gas temperature of the furnace is lowered, part of the exhaust heat of the flue gas is recycled, and the recycled heat energy is used to heat the heat carrier-heat-transfer oil which can be widely applied in petroleum, chemical, textile, printing and dyeing, rubber, leather, food, wood processing and many other industries. Furthermore, on the basis of preventing the devices where the flue gas passes through from dew-acid corrosion, the exhaust heat of the flue gas is recycled to the utmost, the utilization efficiency of the energy is improved, the efficiency of flue gas discharging from the furnace is improved, and the utilization types of the heat energy is various.

**Brief Description of the Drawings**

**Fig. 1** is a structural diagram of a heating system of heat-transfer oil using exhaust heat of flue gas from a boiler in accordance with one embodiment of the invention; and

**Fig. 2** is a structural diagram of a heating system of heat-transfer oil using exhaust heat of flue gas from a boiler in accordance with another embodiment of the invention.

**Detailed Description of the Embodiments**

A heating system of heat-transfer oil using exhaust heat of flue gas from a boiler, the system comprises an economizer 3 and an air preheater 4 being disposed inside a flue 1 along a flow direction of the flue gas. The system further comprises a heat-transfer oil heater 2 disposed inside the flue 1 in front of the economizer 3. The heat-transfer oil heater 2 is connected to a heat consumption device 19 via a first circulating pipe. A circulating pump 12 is disposed on the first circulating pipe.

As shown in **Fig. 1**, the heat-transfer oil heater 2, the economizer 3, and the air preheater 4 are disposed inside the flue 1 along the flow direction of the flue gas. The heat-transfer oil heater 2 is connected to the heat consumption device 19 via the first circulating pipe. The circulating pump 12 is disposed on the first circulating pipe for driving the circulation of a heat carrier of the heat-transfer oil heater 2. In a rear part of the flue 1, part of the heat energy of the flue gas is transferred to the heat carrier of the heat-transfer oil heater 2 (the heat carrier comprises but is not limited to heat-transfer oil). Driven by the circulating pump 12, the heat carrier releases heat energy inside the heat consumption device 19 and is circulated again, so that the processes of heat absorption and heat release are repeated. The heat consumption device 19 can be applied in petroleum, chemical, textile, printing and dyeing, rubber, leather, food, wood processing and many other industries. The heat-transfer oil heater 2 is arranged in front of the economizer 3 inside the flue 1 to absorb the exhaust heat of the flue gas entering to the economizer 3. Thus, flue gas in the position of the heat-transfer oil heater 2 has a high temperature and heat energy, and the exhaust heat of the flue gas from the boiler is fully utilized.

An oil-gas separator 18 is disposed on the first circulating pipe between the heat-transfer oil heater 2 and the heat consumption device 19. An oil inlet pipe of the oil-gas separator 18 is connected to an oil outlet of an expansion slot 17, and an oil inlet of the expansion slot 17 is connected to an oiling pump 16. The expansion slot 17 is further connected to an oil storage tank 15. The oil storage tank 15 functions in storing the heat-transfer oil when the device is stopped for running for overhaul. The oiling pump 16 functions in injection of new oil and discharge of old oil. The expansion slot 17 is used to buffer the heated and expanded heat-transfer oil. The oil-gas separator is used to separate the water mixed in the heat-transfer oil and improve the heat transfer effect of the heat-transfer oil.

The arrangement of the heat-transfer oil heater results in a lower temperature of flue gas entering the economizer and the subsequent air preheater, which may influence the use of the economizer and the air preheater. An improvement of the invention, an exhaust heat utilization device is arranged behind the air preheater 4 along the flow direction of the flue gas. The exhaust heat utilization device is capable of recycling part of the exhaust heat of the flue gas for compensating the heat energy to the economizer or the air preheater.

Preferably, the exhaust heat utilization device comprises a heat absorption member 5 and a heat release member 6 communicating with each other through a second circulating pipe. The heat absorption member 5 is disposed inside the flue behind the air preheater 4 for absorbing part of the exhaust heat of the flue gas. The heat release member 6 is arranged on a water inlet pipe of the economizer 3. The flue
gas enters a desulfurization device for treatment after passing through the heat absorption member 5.

[0027] The water inlet pipe of the economizer is provided with a deaerator 14, a feedwater pump 7, and a high pressure heater 11. Boiler feedwater enters the deaerator 14 through two branches. One branch of the boiler feedwater passes through a first flow control valve 21 and directly enters the deaerator 14, and the other branch of the boiler feedwater passes through a second flow control valve 9 and the heat release member 6 for absorbing heat and enters the deaerator 14. After being discharged from the deaerator 14, the feedwater passes through the feedwater pump 7 and enters the high pressure heater 11. The feedwater is heated in the high pressure heater 11 and enters the economizer 3. Furthermore, a steam inlet pipe of the high pressure heater 11 and a steam inlet pipe of the deaerator 14 communicate. A third flow control valve 13 is arranged on the steam inlet pipe of the high pressure heater 11. A condensate drainage pipe of the high pressure heater 11 is connected to the deaerator 14. The high pressure heater and the deaerator share the same steam source. One part of the steam from the steam source directly enters the deaerator 14, and the hot steam of the boiler feedwater through the high pressure heater 11. After releasing the heat energy, the steam is condensed and transformed into condensed water that enters the deaerator through the condensate drainage pipe between the high pressure heater 11 and the deaerator 14.

[0028] The system further comprises a control system, two temperature sensors 8, 10, and a plurality of flow control valves 9, 13, 21. The temperature sensors and the flow control valves are connected to the control system, respectively. A first temperature sensor 8 is disposed on the heat absorption member 5 for measuring a temperature of a wall surface of the device; and a second temperature sensor 10 is disposed on the flue between the economizer 3 and the air preheater 4 or on a water outlet pipe of the economizer 3. By controlling the first flow control valve 9 and the second flow control valve 21, the water content that enters the deaerator 14 is maintained constant; the required heat is controlled by adjusting the water content entering the heat release member 6, so that the heat absorption member 5 of the exhaust heat utilization device is prevented from the acidic dew corrosion, and the exhaust heat of the flue gas is recycled to the utmost.

[0029] The heat-transfer oil heater 2 absorbs exhaust heat in the flue gas to heat the heat-transfer oil, and the heat absorption is determined by the acidic dew point of the flue gas. Supposing the exhaust gas temperature at the preheater 4 of the original boiler system is \( T_{e} \), and the acid dew point is \( T_{2} \) to prevent the heat absorption member 5 of the exhaust heat utilization device from the acidic dew corrosion, the temperature of the wall surface of the heat absorption member 5 contacting with the flue gas is required to be at least 10° C. (a safe margin) higher than \( T_{2} \). Meanwhile, a heat transfer temperature difference is required between the temperature of the flue gas and the temperature of the wall surface of the heat absorption member 5 to ensure an economically reasonable arrangement of the heat surfaces of the exhaust heat utilization device. Thus, the exhaust heat temperature of the exhaust heat utilization device is \( T_{e} + 10° C \) of the safe margin (approximately 15° C) (the temperature difference for heat transfer), labeled as \( T_{e} \). An energy-saving temperature drop of the original boiler system is calculated as \( T_{1} - T_{2} \). As the exhaust heat utilization device is used to indirectly compensate the heat transfer loss of the economizer 3 and does not provide heat energy to other devices, the recycled and saved heat energy is provided to other heat consumption device by the heat-transfer oil heater 2. Apparently, the temperature difference of the flue gas close to the inlet and outlet of the heat-transfer oil heater is required to be no larger than \( T_{1} - T_{2} \) to lower the influence of the addition of the heat-transfer oil heater on the thermal system of the original boiler as much as possible.

[0030] The temperature difference between the heat-transfer oil in the inlet and outlet of the heat-transfer oil heater 2 is generally controlled at 30° C, based on which an appropriate circulation flow of the heat-transfer oil is selected to transfer the absorbed heat energy to the heat consumption device 19. Part of the heat energy of the flue gas is absorbed by the heat-transfer oil heater 2 so that the heat energy absorbed by the economizer 3 and the air preheater 4 is decreased. As an improvement of the invention, the high pressure heater 11 is arranged on the water inlet pipe of the economizer 3. By thermodynamic calculation, the boiler feedwater is adjusted to allow the flue gas temperature and the water temperature at the outlet of the economizer 3 are close to or higher than those of the original system, so that the influence of the addition of the heat-transfer oil heater on the economizer 3 and the air preheater 4 is decreased.

[0031] The heat source of the high pressure heater 11 is extracted steam transported to the deaerator 14, which is originally used to heat the boiler feedwater in the deaerator 14. When the part of extracted steam is used as the heat source of the high pressure heater 11, it is required a substituted heat source to heat the feedwater in the deaerator 14 to maintain the total extracted steam constant. An exhaust temperature of the boiler is between 140 and 160° C, whereas a temperature of the heated feedwater of the boiler or the condensed water is 20° C. If the fume directly transfers heat to the feedwater of the boiler or the condensed water, a temperature of the wall surface of the heat exchanger is close to an acid dew point of the fume, thereby resulting in acid dew corrosion on the heat exchanger. In order to prevent the problem, the waste heat utilization device is composed of a heat absorption member 5 and a heat release member 6. The heat absorption member 5 is disposed inside the boiler flue for absorbing heat and transferring the heat to a working medium; and in the heat release member 6, the working medium transfers the heat to the make-up water or the condensed water. Working principle of the working medium is that the working medium is generally a high temperature forced circulating water or naturally circulating steam having a heat transfer coefficient far higher than the side close to the fume, so that the temperature of the wall surface is determined by the side close to the working medium. The temperature of the working medium is controlled to prevent the heat absorption member 5 from acidic dew corrosion.

[0032] As shown in FIG. 2, as another embodiment of the heating system of heat-transfer oil using the exhaust heat of the flue gas of the invention, technical features thereof are the same as the above except that the heat release member 6 of the exhaust heat utilization device is arranged inside the air channel of the air preheater 4. The exhaust heat utilization device is primarily used to heat the inlet air of the air preheater. The water inlet pipe of the economizer is provided with a low pressure heater or other devices. The control system is connected to a temperature sensor 8 and a flow control damper 20. The temperature sensor 8 is arranged on the heat absorption member 5 for testing the temperature of the wall.
The flow control damper 20 is arranged inside the air inlet channel of the air preheater in front of the heat release member 6 along the flow direction of inlet air for adjusting the heat absorption of the heat absorption member. The absorbed heat of the exhaust heat utilization device herein is used to heat the air entering the air preheater, and the compensation of the heat energy on the air preheater is lowered.

The system of claim 3, wherein a feedwater pump (7) is arranged on a water pipe by which the deaerator (14) and the high pressure heater (11) are connected.

5. The system of claim 3, wherein a steam inlet pipe of the high pressure heater (11) and a steam inlet pipe of the deaerator (14) communicate; and a condensate drainage pipe of the high pressure heater (11) is connected to the deaerator (14).

6. The system of claim 5 further comprising a control system, two temperature sensors (8, 10), and a plurality of flow control valves (9, 13, 21), wherein the temperature sensors and the flow control valves are connected to the control system;

7. The system of claim 2, wherein the heat release member (6) is arranged inside the air inlet channel of the air preheater (4); the system further comprises a control system, a temperature sensor (8), and a flow control damper (20); the temperature sensor (8) and the flow control damper (20) are connected to the control system; and the temperature sensor (8) is arranged on the heat absorption member (5), and the flow control damper (20) is arranged inside the air inlet channel of the air preheater in front of the heat release member (6) along the flow direction of inlet air.

8. The system of claim 1, wherein the system further comprises an oil-gas separator (18); and the oil-gas separator (18) is disposed on the first circulating pipe between the heat-transfer oil heater (2) and the heat consumption device (19).

9. The system of claim 8, wherein the oil-gas separator (18) is connected to an expansion slot (17), and the expansion slot (17) is connected to an oiling pump (16).