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(54) **Title**: SYSTEM FOR DRYING SLUDGE BY STEAM EXTRACTED FROM BOILER SET WITH THERMAL COMPENSATION

(54) **发明名称** : 带热力补偿的锅炉机组抽汽干化污泥系统

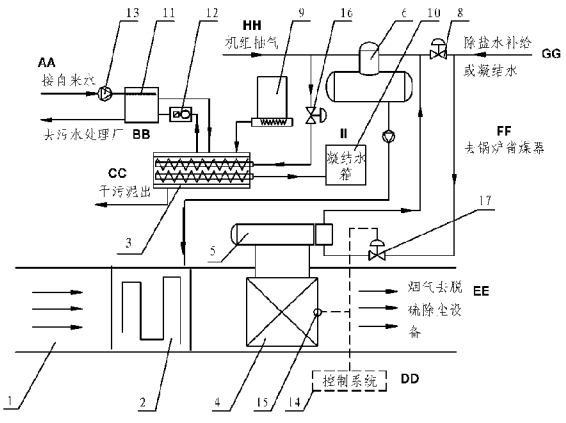

图 1 / Fig. 1

AA connected to tap water
BB to a sewage treatment plant
CC output the dried sludge
DD control system
EE flue gas to equipment for desulfurizing and dedusting
FF to a boiler coal economizer
GG supply of the demineralized water or condensation water
HH boiler set steam extraction
II condensation water tank

(57) **Abstract**: Disclosed is a system for drying sludge by steam extracted from a boiler set with thermal compensation, which system comprises a boiler flue (1), a boiler feed-water pipeline and a boiler set steam extraction system, with a deaerator (6) and a coal economizer (2) being provided in the boiler feed-water pipeline, the coal economizer (2) being disposed as a heat-receiving face within the boiler flue (1), a steam inlet pipe of the deaerator (6) being connected to the boiler set steam extraction system, and a water outlet pipe of the deaerator (6) being connected to a water inlet pipe of the coal economizer (2); the system further comprises a sludge-drying device (3) and a flue gas residual heat utilization device, with the sludge-drying device (3) being connected to the boiler set steam extraction system, the flue gas residual heat utilization device comprising a heat absorption section (4) and a heat discharge section (5) connected to each other via circulation pipelines, the heat absorption section (4) being arranged as the last stage heat-receiving face within the boiler flue (1), and the heat discharge section (5) being disposed on the water inlet pipe of the deaerator (6). With the system, the sludge is dried by making use of the steam from the boiler set and the thermal compensation to the boiler system is carried out by means of a flue gas residual heat recovery device, so as to improve the utilization rate of the flue gas used indirectly in drying the sludge.

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— 包括国际检索报告(条约第 21 条(3))。

(57) 摘要:

一种带热力补偿的锅炉机组抽汽化干化污泥系统，其包括锅炉烟道（1）、锅炉给水管道和机组抽汽系统，锅炉给水管道上设有除氧器（6）和省煤器（2），省煤器（2）作为受热面位于锅炉烟道（1）内，所述除氧器（6）的进汽管与机组抽汽系统相连接，除氧器（6）的出水管与省煤器（2）的进水管相连，还包括污泥干化器（3）和烟气余热利用装置，污泥干化器（3）与机组抽汽系统相连，烟气余热利用装置包括通过循环管道相连的吸热段（4）和放热段（5），吸热段（4）作为最末级受热面设在锅炉烟道（1）内，放热段（5）置于除氧器（6）的进水管上。该系统利用锅炉机组蒸汽干化污泥，并通过烟气余热回收装置进行锅炉系统的热力补偿，来提高烟气间接用于干化污泥的利用率。

SYSTEM FOR DRYING SLUDGE BY STEAM EXTRACTED FROM BOILER SET WITH THERMAL COMPENSATION

FIELD OF THE INVENTION

[0001] The invention relates to a sludge drying system, and more particularly to a sludge drying system by using a boiler unit for steam extraction.

BACKGROUND OF THE INVENTION

[0002] Urban sewage treatment capacity in China achieved 28 billion tons in 2009, including 20.05 million tons of wet sludge, that is, 55 thousand of wet sludge containing 80% of water was produced each day. The development of the sludge treatment in the world is on the basis of four principles-water reduction, stabilization, harmlessness, and resource saving. However, conventional sludge treating methods have a strict requirement on the water content of the sludge. Generally, wet sludge after preliminary treatment of a sewage treatment plant contains 80% of water, which cannot achieve the requirement of water reduction and resource saving. Thus, the drying of the wet sludge is a must in the sewage treatment.

[0003] The drying of the wet sludge is achieved by heat, which is generally produced by combustion of energy resource. The utilization of the heat is in two forms: direct utilization and indirect utilization.

[0004] However, limited by the existing economic conditions, both the indirect and direct utilization employ the same heat source - the combustion of coal fuel. The boiler provides power source to deferent devices, is the largest consumer of coal fuel and a potential provider of heat source for drying wet sludge. Because sulfur element exists in the fuel of

the boiler, the fume produced from the combustion of the fuel of the boiler contains acid gas. When the fume is at a high temperature, sulfur passes through various heating surfaces in the form of gas until it is removed in a desulfurization tower. When the temperature of the fume is lower than a certain degree, sulfur in the fume 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 preheater and an economizer having a low feedwater temperature. When the temperature of the heating surfaces is lower than a dew-point of the fume, sulfuric acid formed by combining the water vapor in the fume 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 140°C, and after running for a certain period, the exhaust temperature achieved 160°C. The direct discharge of the fume results in a large waste of energy, if the fume is used as a heat source to dry the wet sludge, it will be much economic.

[0005] Direct utilization: the fume at a high temperature is directly introduced to a dryer to allow heat transfer between the fume and the wet material by contact and convection. This means is characteristic in a high efficiency of the heat utilization. But if the dried material has properties of pollutants, the discharge of the dried material still remains a problem. As the high temperature fume continuously enters the flue, the waste gas that has the same flow quantity and directly contact with the wet material is required to be specially treated before the discharge. Besides, acid gas in the fume has a certain degree of corrosive effect on the drying device, thereby affecting the service life of the drying device. Weng Huanxin from Zhejiang University suggested directly mixing this part of fume with the wet sludge in a rotary dryer to dry the wet sludge by using the direct utilization of fume for sludge drying. This means has a high efficiency in resource

utilization, but its disadvantages are obvious and are the same as that discussed in the former. A large amount of fume directly contacted with the material is required to be treated by special process before the discharge, and the fume may contain acid gas that is corrosive to the drying device, so that the service life of the drier is affected. Furthermore, the energy degree of the fume at the temperature of 140°C is low, thereby resulting in a low drying efficiency.

[0006] Indirect utilization: heat energy of the high temperature fume is transferred to a certain medium, which may be conduction oil, water vapor, or the air, by using a heat exchanger. The medium is circulated in a closed loop, and has no contact with the material to be dried. The fume is normally discharged after part of the heat energy is utilized. The indirect utilization has a certain heat loss, and faces the following two problems:

[0007] First, the low temperature fume is corrosive to the device that has a contact surface with the fume, and how to recover the waste heat of this part of the fume?

[0008] Second, compared with the method which directly uses this part of the fume to dry the wet sludge, the indirect utilization has a much lower degree of heat energy, so that it is more difficult to dry the wet sludge.

[0009] However, power plants or thermal systems in standby power plants in medium-sized enterprises using such boilers often are provided with multi-heaters on the water pipe in front of an economizer to heat the feedwater of the boiler to improve the efficiency of the whole unit; and because the heated feedwater has a relative high pressure, the multi-heaters are also called high pressure heaters. For some medium-sized boiler units, a plurality of heaters are also arranged on condensed water pipelines in front of the deaerator (also a heater) to heat the condensed water; as the feedwater pressure is relatively low, and the pressure of the condense water is correspondingly low, thereby the heaters are being called low pressure heater. The heaters containing the deaerator, the low

pressure heater, and the high pressure heater all use steam extracted by the boiler unit as the heat source. The steam parameters are different in accordance with the different boiler units. Generally, the temperature exceeds 160°C; for those large boiler units, the temperatures are higher.

SUMMARY OF THE INVENTION

[0010] In view of the above-described problems, it is one objective of the invention to provide a sludge drying system of a boiler unit having thermal compensation by extraction of steam.

[0011] A sludge drying system of a boiler unit having thermal compensation by extraction of steam, the sludge drying system comprises: a boiler flue, boiler feedwater pipes, and an extraction system, a deaerator and an economizer being disposed on the boiler feedwater pipes. The economizer functions as a heating surface and being arranged in the boiler flue. A steam inlet pipe of the deaerator is connected to the extraction system. A water outlet pipe of the deaerator being connected to a water inlet pipe of the economizer. The sludge drying system further comprises a sludge drier and a waste heat utilization device. The sludge drier is connected to the extraction system. The waste heat utilization device comprises a heat absorption member and a heat release member which communicate with one another through circulating pipes. The heat absorption member functions as a final heat surface and is disposed in the boiler flue. The heat release member is disposed on a water inlet pipe of the deaerator.

[0012] The sludge drier comprises a steam heater comprising a steam inlet pipe and a steam outlet pipe, the steam inlet pipe is connected to the extraction system, and the steam outlet pipe is connected to a condensate tank.

[0013] The sludge drying system further comprises a sludge tank and a steam recovery

system, the sludge tank is connected to the sludge drier, and the sludge drier is connected to the steam recovery system via an air circulating pipe.

[0014] The steam recovery system comprises a condenser, a blower, and a sewage treatment system, the condenser is connected to the sludge drier via the air circulating pipe, the blower is disposed on the air circulating pipe, and a water outlet of the condenser is connected to the sewage treatment system.

[0015] The condenser is equipped with a sprinkler, and the sprinkler is connected to a water supply pump.

[0016] The water inlet pipe of the deaerator comprises two branches, both branches comprising a flow control valve, and the heat release member is disposed on one of the branches.

[0017] The sludge drying system further comprises a control system and a temperature sensor. The temperature sensor is disposed on the heat absorption member, the steam inlet pipe of the steam heater is equipped with a flow control valve, and the temperature sensor and the flow control valves all are connected to the control system.

[0018] The sludge drying system further comprises a low pressure heater, the low pressure heater and the heat release member are disposed on two water inlet branches of the deaerator, respectively, and a steam inlet pipe of the low pressure heater is connected to the extraction system.

[0019] The steam inlet pipe of the steam heater is connected to the steam inlet pipe of the low pressure heater.

[0020] The steam inlet pipe of the steam heater is connected to the steam inlet pipe of the deaerator.

[0021] In the above technical scheme, the sludge drying system of the invention employs part of the extracted steam of the boiler unit to heat and dry the sludge. Based on the

prevention of acid dew corrosion, the waste heat of the discharged fume from the boiler is recovered at an utmost degree; the fume is prevented from contact with the sludge. Thus, the production of the harmful waste gas is prevented, the energy consumption and the cost for drying the wet sludge and are lowered.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a schematic diagram of a sludge drying system of a boiler unit by extraction of steam in accordance with one embodiment of the invention; and

[0023] FIG. **2** is a schematic diagram of a sludge drying system of a boiler unit by extraction of steam in accordance with another embodiment of the invention.

[0024] In the drawings, the following reference numbers are used: **1**. Boiler flue; **2**. Economizer; **3**. Sludge drier; **4**. Heat absorption member; **5**. Heat release member; **6**. Deaerator; **7**. Low pressure heater; **8**, **16**, and **17**. Flow control valve; **9**. Sludge tank; **10**. Condensate tank; **11**. Condenser; **12**. Blower; **13**. Feedwater pump; **14**. Control system; and **15**. Temperature sensor.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] As shown in FIGS. **1** and **2**, a sludge drying system of a boiler unit having thermal compensation by extraction of steam, the sludge drying system comprises a boiler flue **1**, boiler feedwater pipes, and an extraction system, a deaerator **6** and an economizer **2** being disposed on the boiler feedwater pipes. The economizer functions as a heating surface and is arranged in the boiler flue. A steam inlet pipe of the deaerator **6** is connected to the extraction system. A water outlet pipe of the deaerator **6** is connected to a water inlet pipe of the economizer. The sludge drying system further comprises a sludge drier **3** and a waste heat utilization device. The sludge drier is connected to the extraction system, the

waste heat utilization device comprises a heat absorption member 4 and a heat release member **5** which communicate with one another through circulating pipes, the heat absorption member **4** functions as a final heat surface and is disposed in the boiler flue. The water inlet pipe of the deaerator comprises two branches, and the heat release member **5** is disposed on one of the branches. The sludge drying system of the invention employs the extracted steam of the extraction system of the boiler unit to dry the sludge and allow the fume to not contact with the sludge and the waste heat of the fume to be fully utilized. In a constant steam quantity extracted by the extraction system, as one part of the extracted steam is used to dry the sludge, the volume of extracted steam for heating the boiler correspondingly decreases. Thus, the heat quantity of the water entering the economizer decreases. In order to compensate this part of heat loss, thermal compensation was employed to ensure the thermodynamic equilibrium of the boiler unit.

[0026] Thermal compensation is achieved by using a waste heat utilization device to absorb the waste heat of part of the fume and allow the heat to return to the thermal system of the boiler unit by means of heating the make-up water of the boiler or the condensed water. An exhaust temperature of the boiler is between 140 and 160°C, whereas a temperature of the heated make-up water of the boiler or the condensed water is between 20 and 60°C. If the fume directly transfers heat to the make-up water 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 **4** and a heat release member **5**. The heat absorption member **4** is disposed inside the boiler flue for absorbing heat and transferring the heat to a working medium; and in the heat release member **5**, 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 high temperature forced circulating water or naturally circulating steam having a heat transfer coefficient far

higher than the side close the fume, so that the temperature of the wall surface is determined by the side close the working medium.

[0027] The sludge drying system further comprises: a sludge tank **9**, a condensate tank **10**, and a steam recovery system. The sludge tank **9** is connected to the sludge drier **3**. A steam heater inside the sludge drier **3** comprises a steam outlet pipe being connected to the condensate tank **10**. The steam is condensed and transformed into condensed water after drying the sludge. The condensed water is stored inside the condensate tank **10** and can be added to the deaerator or for other use. The sludge drier **3** is connected to the steam recovery system via the circulating pipe. The steam recovery system comprises a condenser **11**, a blower **12**, and a sewage treatment system. The condenser **11** is connected to the sludge drier **3** via the air circulating pipe. The blower is disposed on the air circulating pipe, and a water outlet of the condenser is connected to the sewage treatment system. The condenser **11** is equipped with a sprinkler, and the sprinkler is connected to a water supply pump **13**.

[0028] The wet sludge from the water treatment plant often contains 80% of water. The sludge was stored in the sludge tank **9** that is provided with a push plate. The push plate is driven by a hydraulic or electric device to prevent the sludge from being agglomerated on the push plate and from affecting the discharge of the dried sludge. The sludge drier **3** transfers the heat of the steam to the sludge so that water in the sludge is evaporated into steam and discharged out by the circulating air. The blower **12** in the steam recovery system extracts the steam produced in the sludge drier **3** and part of evaporated gas to the condenser **11** by the circulating pipe, and to the sludge drier **3** again after being condensed. The condenser **11** works by spraying water to achieve condensation. The condensed water is pumped by the water supply pump **13** from a water tank into the spraying condenser. The water is atomized by the sprinkler and then fully contact with the circulating air for cooling the air. The cooled air is discharged from an upper part of the condenser **11**. Part of water vapor in the circulating air after being cooled is condensed

into liquid water, discharged from the water outlet at a bottom of the condenser, and enters the sewage treatment system. One or more sludge driers are provided according to the water treatment capacity, the drying degree of the sludge, the temperature and the flow rate of the fume.

[0029] As part of the evaporated gas in the sludge continuously enters the circulating air, the volume of the circulating air increases. Exhaust pipes are arranged on the circulating pipe to introduce the gas to an adjacent incinerator. The energy of the evaporated gas is recovered by combustion, and the odor is removed. Or other methods are employed to reduce the environment pollution.

[0030] As an embodiment of the invention, as shown in FIG. **1**, the deaerator **6** and the economizer **2** are disposed on the boiler feedwater pipes. The water outlet pipes of the deaerator **6** are connected to the water inlet pipe of the economizer **2** via the water pump. The steam heater is arranged inside the sludge drier **3**, the steam inlet pipe of the steam heater communicates with a steam inlet pip of the deaerator **6**, and a steam outlet pipe of the steam heater communicates with the condensate tank. The water inlet pipe of the deaerator **6** comprises two branches and the heat release member **5** is disposed on one of the branches. The feedwater of the boiler enters the deaerator **6** from two branches. One branch of feedwater passes through the heat release member **5** for absorbing heat and enters the deaerator **6**; and the other branch of feedwater directly enters the deaerator **6**. The feedwater from the deaerator **6** passes through the water pump and enters the economizer **2**. A first flow control valve **17** is arranged on the water inlet pipe of the heat release member **5**. A second flow control valve **8** is arranged on the other branch of the water inlet pipe of the deaerator **6**. A constant water quantity entering the deaerator **6** is ensured by controlling the first and the second flow control valves **17**, **8**.

[0031] The sludge drying system of the invention further comprises: a control system **14**, a temperature sensor **15**, and the first and the second flow control valves **17**, **8**. The

temperature sensor **15** and the flow control valves are connected to the control system. The temperature sensor **15** is disposed on the heat absorption member **4**. The water inlet pipe of the heat release member **5** is provided with the first flow control valve **17**. The other branch of the water inlet pipe of the deaerator **6** is provided with the second flow control valve **8**. The steam inlet pipe of the steam heater is equipped with a third flow control valve **16** for controlling the steam quantity entering the sludge drier. By controlling the temperature sensor **15** arranged on the heat absorption member **4** of the waste heat utilization device and the first flow control valve **7** arranged on the water inlet pipe of the heat release member **5** by the control system, the control system is capable of adjusting the wall temperature of the heat absorption member to allow the wall temperature of the heat absorption member be always higher than the acid dew point of the fume in accordance with the load of the boiler, so that the waste heat of the fume can be recovered to the utmost.

[0032] As another embodiment of the invention, as shown in FIG. **2**, the boiler feedwater pipes are also provided with the low pressure heater **7** besides the economizer and the deaerator. The deaerator and the low pressure heater are respectively connected to the extraction system. The low pressure heater **7** and the heat release member **5** are disposed on two branches of the water inlet pipes of the deaerator **6**, respectively. One branch of feedwater passes through the low pressure heater **7** and enters the deaerator, and the other branch of the feedwater passes through the heat release member to enter the deaerator. The steam inlet pipe of the steam heater is connected to the steam inlet pipe of the deaerator **6**, or connected to the steam inlet pipe of the low pressure heater **7**. The third flow control valve **16** is disposed on the steam inlet pipe of the steam heater. Whenever the sludge drier is connected to the deaerator or connected to the low pressure heater, the sludge drier employs the extracted steam to dry the sludge.

[0033] The sludge drying system of the invention further comprises: the control system **14**, the temperature sensor **15**, and the first and the second flow control valves **17**, **8**. The

temperature sensor **15** and the flow control valves are connected to the control system. The temperature sensor **15** is disposed on the heat absorption member **4**. The water inlet pipe of the heat absorption member **4** is provided with the first flow control valve **17**. The other branch of the water inlet pipe of the deaerator **6** is provided with the second flow control valve **8**. The steam inlet pipe of the steam heater of the sludge drier is equipped with a third flow control valve **16** for controlling the steam quantity entering the sludge drier. The invention employs the recovered waste heat of the fume to heat the feedwater of the boiler, and further employs the steam of the feedwater to dry the sludge. Thus, the equilibrium of the original thermodynamic system is ensured, and the waste heat of the fume discharged from the boiler is utilized to dry the sludge.

SYSTEM FOR DRYING SLUDGE BY STEAM EXTRACTED FROM BOILER SET WITH THERMAL COMPENSATION

CLAIMS

1. A sludge drying system using extracted steam from a boiler unit having thermal compensation, the sludge drying system comprising a boiler flue (1), boiler feedwater pipes, and an extraction system, a deaerator (6) and an economizer (2) being disposed on the boiler feedwater pipes, the economizer functioning as a heating surface and being arranged in the boiler flue, a steam inlet pipe of the deaerator (6) being connected to the extraction system, a water outlet pipe of the deaerator (6) being connected to a water inlet pipe of the economizer, **characterized in that** the sludge drying system further comprises a sludge drier (3) and a waste heat utilization device, the sludge drier is connected to the extraction system, the waste heat utilization device comprises a heat absorption member (4) and a heat release member (5) which communicate with one another through circulating pipes, the heat absorption member (4) functions as a final heat surface and is disposed in the boiler flue, and the heat release member (5) is disposed on a water inlet pipe of the deaerator (6).

2. The sludge drying system of claim 1, **characterized in that** the sludge drier comprises a steam heater comprising a steam inlet pipe and a steam outlet pipe, the steam inlet pipe is connected to the extraction system, and the steam outlet pipe is connected to a condensate tank (10).

3. The sludge drying system of claim 2, **characterized in that** the sludge drying system

further comprises a sludge tank (9) and a steam recovery system, the sludge tank (9) is connected to the sludge drier (3), and the sludge drier (3) is connected to the steam recovery system via an air circulating pipe.

4. The sludge drying system of claim 3, **characterized in that** the steam recovery system comprises a condenser (11), a blower (12), and a sewage treatment system, the condenser (11) is connected to the sludge drier (3) via the air circulating pipe, the blower is disposed on the air circulating pipe, and a water outlet of the condenser is connected to the sewage treatment system.

5. The sludge drying system of claim 4, **characterized in that** the condenser (11) is equipped with a sprinkler, and the sprinkler is connected to a water supply pump (13).

6. The sludge drying system of claim 2, **characterized in that** the water inlet pipe of the deaerator comprises two branches, both branches comprising a flow control valve (8, 17), and the heat release member (5) is disposed on one of the branches.

7. The sludge drying system of claim 6, **characterized in that** the sludge drying system further comprises a control system (14) and a temperature sensor (15), the temperature sensor is disposed on the heat absorption member (4), the steam inlet pipe of the steam heater is equipped with a flow control valve (16), and the temperature sensor (15) and the flow control valves (8, 16, 17) all are connected to the control system.

8. The sludge drying system of claim 6, **characterized in that** the sludge drying system further comprises a low pressure heater (7), the low pressure heater (7) and the heat release member (5) are disposed on two water inlet branches of the deaerator (6), respectively, and a steam inlet pipe of the low pressure heater (7) is connected to the extraction system.

9. The sludge drying system of claim 8, **characterized in that** the steam inlet pipe of the steam heater is connected to the steam inlet pipe of the low pressure heater (7).

10. The sludge drying system of claim 2, **characterized in that** the steam inlet pipe of the steam heater is connected to the steam inlet pipe of the deaerator (6).

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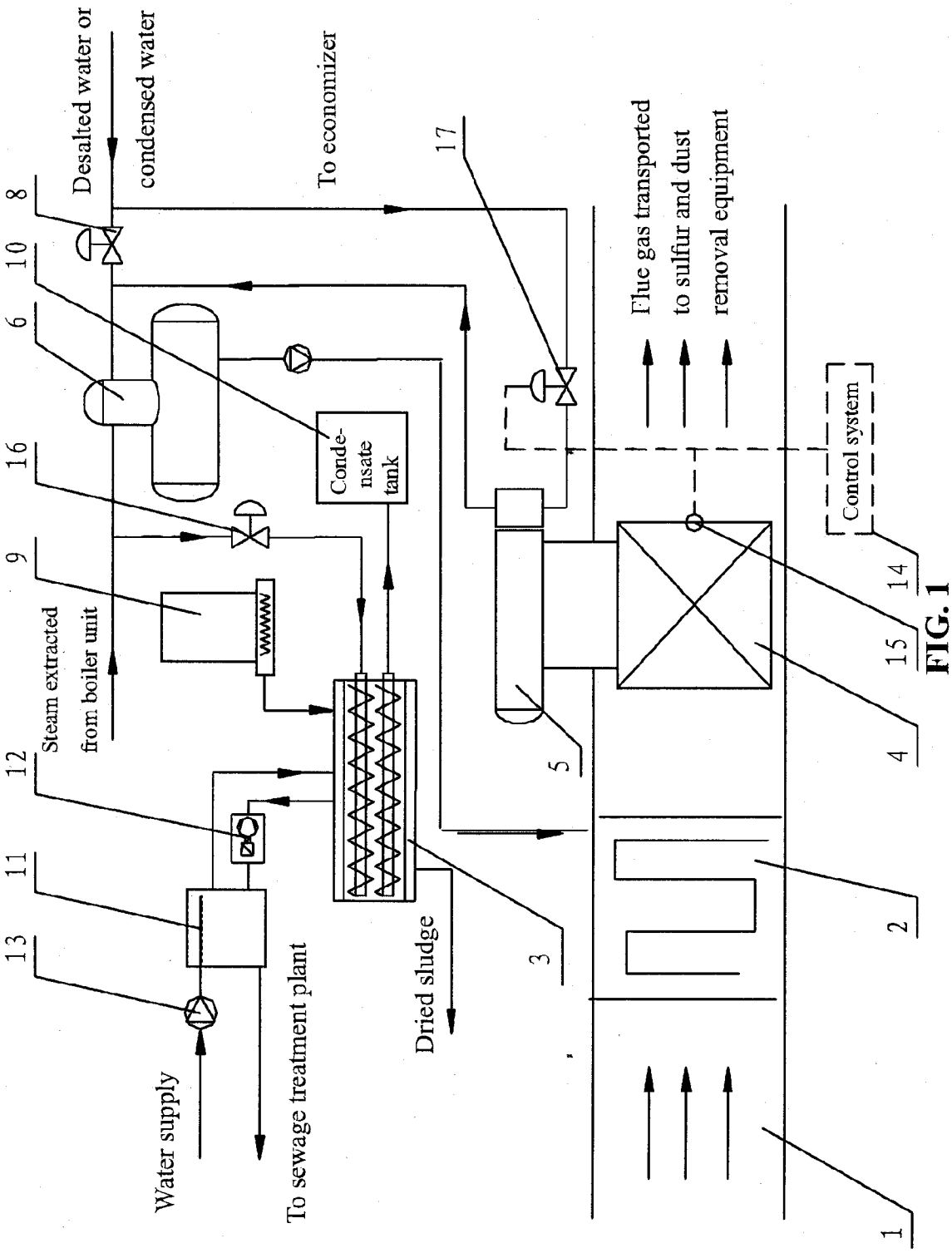
Desalted water or
condensed water
To economizer
Flue gas transported
to sulfur and dust
removal equipment
Control system
Conde-
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tank
Steam extracted
from boiler unit
Water supply
To sewage treatment plant
Dried sludge
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FIG. 1

2/2

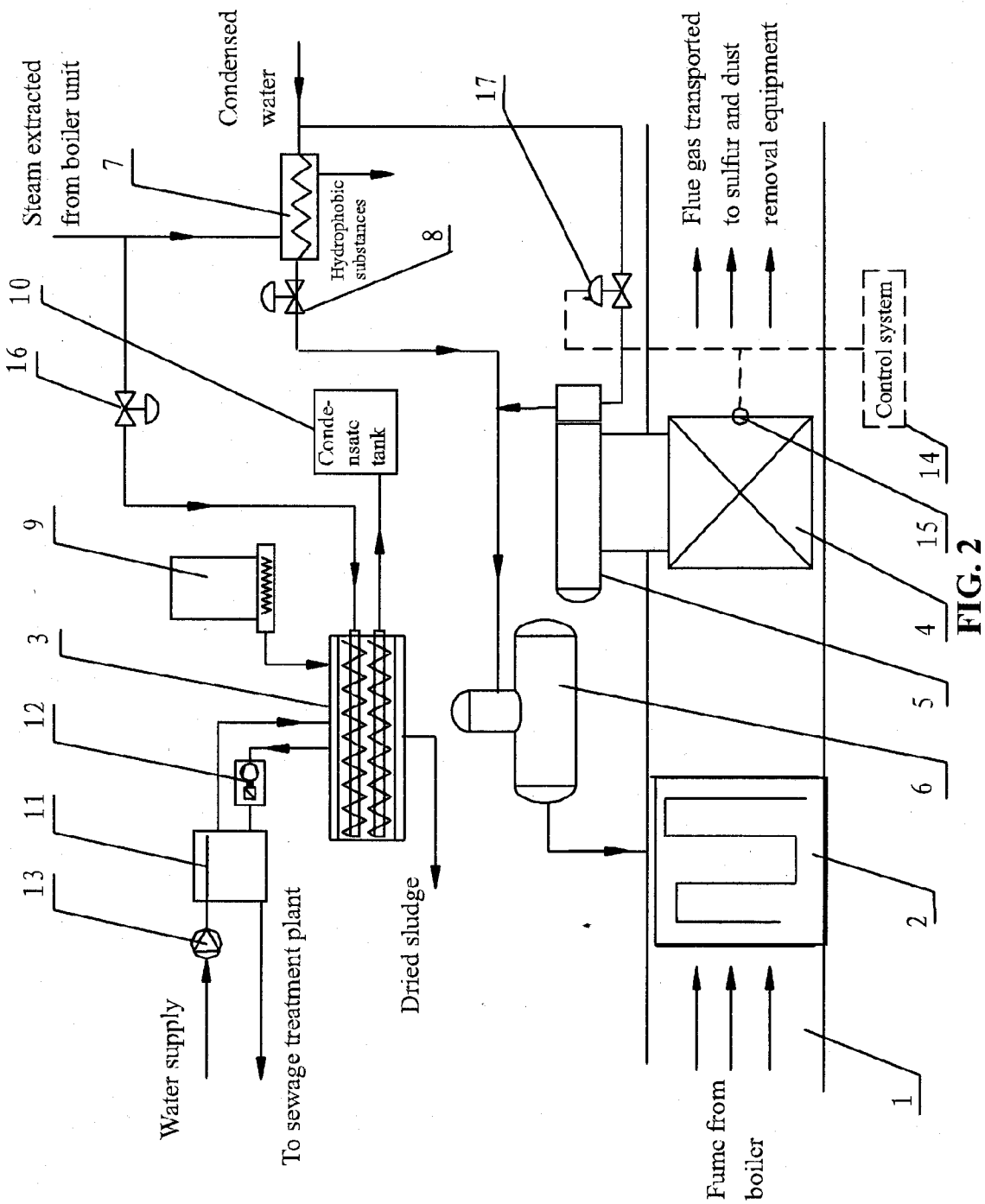
Steam extracted from boiler unit
Condensed water
Hydrophobic substances
Flue gas transported to sulfur and dust removal equipment
Control system
Condensate tank
Water supply
To sewage treatment plant
Dried sludge
Fume from boiler
1
2
3
4
5
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FIG. 2