

ACIDIC-GAS TREATING AGENT AND ACIDIC-GAS TREATING METHOD

Technical Field

[0001] The present invention relates to an acidic-gas treating agent and an acidic-gas treating method that are used for neutralizing an acidic gas, such as hydrogen chloride or sulfur oxide, included in a flue gas emitted from a waste disposal apparatus or a power boiler.

Background Art

[0002] Calcium-based exhaust gas-treating agents, such as calcium hydroxide, and sodium-based exhaust gas-treating agents, such as sodium hydrogencarbonate, have been used as an acidic-gas treating agent, such as hydrogen chloride or sulfur oxide, included in a flue gas emitted from a waste disposal apparatus or a power boiler.

[0003] In the case where calcium hydroxide is used as an exhaust gas-treating agent, the exhaust gas-treating agent needs to be used in an excessively large amount equal to 3 to 4 times the amount of exhaust gas-treating agent equivalent to the amount of the acidic gas and, consequently, a large amount of dust is produced. In the case where sodium hydrogencarbonate is used, the amount of exhaust gas-treating agent used is small compared with the case where calcium hydroxide is used. However, fine particles of sodium hydrogencarbonate are likely to coagulate with one another to cake.

[0004] The following methods have been proposed for preventing caking of sodium hydrogencarbonate:

A method in which fine particles of fumed silica (hydrophilic anticaking agent) are added to fine baking soda (PTLs 1 and 2).

A method in which wet-process silica is used as an anticaking agent and metal soap is mixed with the agent in an adequate proportion, the metal soap being used for enhancing the releasability of sodium hydrogencarbonate formed on the surface of a filter cloth included in a bag filter (PTL 3).

[0005] PTL 4 proposes an acidic-gas treating agent that includes zeolite, sodium hydrogencarbonate, and synthetic silica. In PTL 4, hydrophilic synthetic silica is used as synthetic silica.

[0006] PTL 5 proposes an exhaust gas-treating agent that includes active carbon that serves as an anticaking agent.

[0007] PTL 1: Japanese Patent Publication 2000-218128 A

PTL 2: Japanese Patent Publication 2001-314757 A

PTL 3: Japanese Patent Publication 2005-186037 A

PTL 4: Japanese Patent Publication 2013-193005 A

PTL 5: Japanese Patent Publication 2004-141718 A

[0008] Dry-process silica having a small average particle diameter, such as fumed silica, is generally expensive and increases the cost of the anticaking agent. While wet-

wet-process silica and hydrophilic synthetic silica are inexpensive and have a large anticaking effect, they have poor flowability due to the hydrophilicity thereof. Therefore, the releasability from the surface of a filter cloth included in a bag filter becomes degraded. This degrades the air permeability of the filter cloth and increases the pressure loss. In the case where active carbon is used, it is necessary to increase the proportion of active carbon to a high level for achieving a sufficiently large anticaking effect.

[0009] The method in which wet-process silica is used for inhibiting caking of sodium hydrogencarbonate and metal soap is mixed with the agent in an adequate proportion, the metal soap being used for enhancing the releasability of sodium hydrogencarbonate formed on the surface of a filter cloth included in a bag filter, increases the costs of the two chemicals, that is, the anticaking agent and the releasability improver.

[0010] For the above reasons, an efficient chemical capable of inhibiting caking and enhancing releasability has been anticipated.

Summary of Invention

[0011] An object of the present invention is to provide an acidic-gas treating agent that includes sodium hydrogencarbonate used for neutralizing an acidic gas, the

agent being resistant to caking and having high releasability. Another object of the present invention is to provide an acidic-gas treating method in which the acidic-gas treating agent is used.

[0012] The inventor of the present invention found that carbon black and hydrophobic silica are capable of inhibiting caking and enhancing releasability and address the above issues.

[0013] The summary of the present invention is as follows.

[0014] [1] An acidic-gas treating agent comprising sodium hydrogencarbonate and an anticaking agent that inhibits caking of sodium hydrogencarbonate, the anticaking agent being carbon black and/or hydrophobic silica.

[0015] [2] The acidic-gas treating agent according to [1], wherein the content of the anticaking agent is 0.1% to 2.0% by weight.

[0016] [3] The acidic-gas treating agent according to [1] or [2], wherein the hydrophobic silica has an average particle diameter of 1 to 20 μm .

[0017] [4] The acidic-gas treating agent according to any one of [1] to [3], wherein the carbon black has an average particle diameter of 0.1 to 10 μm .

[0018] [5] The acidic-gas treating agent according to any one of [1] to [4], wherein the sodium hydrogencarbonate has an average particle diameter of 5 to 30 μm .

[0019] [6] An acidic-gas treating method comprising adding the acidic-gas treating agent according to any one of Claims [1] to [5] to an exhaust gas including an acidic gas.

[0020] [7] An anticaking agent that inhibits caking of sodium hydrogencarbonate, the anticaking agent comprising carbon black and/or hydrophobic silica.

Advantageous Effects of Invention

[0021] The carbon black and/or hydrophobic silica that is included in the acidic-gas treating agent according to the present invention and serves as an anticaking agent inhibits caking of sodium hydrogencarbonate and enhances the releasability of sodium hydrogencarbonate that may adhere onto the surface of a filter cloth included in a bag filter. This enables an efficient treatment of an acidic gas due to the following advantageous effects.

[0022] (1) Since the acidic-gas treating agent is resistant to caking and has high flowability, the agent is easy to handle during storage, transportation, and the treatment of an acidic gas.

(2) Since the acidic-gas treating agent does not cake and can be added to an acidic gas in a fine-powder form, the agent is highly reactive with an acidic gas, which increases the treatment efficiency.

(3) Since the acidic-gas treating agent is resistant to adhering onto the surface of a filter cloth included in a

bag filter and easy to remove, an increase in the pressure loss across a bag filter can be limited and, consequently, a consistent treatment may be achieved.

(4) The inhibition of caking and the improvement of releasability can be achieved to sufficient degrees by only using small amounts of carbon black and/or hydrophobic silica. This makes it possible to increase the proportion of sodium hydrogencarbonate, which is used for neutralizing an acidic gas, in the acidic-gas treating agent. Consequently, an acidic-gas treating agent capable of treating an acidic gas with high efficiency may be produced.

(5) Since the carbon black and hydrophobic silica are added to the acidic-gas treating agent at low concentrations, it is possible to provide an inexpensive acidic-gas treating agent by using carbon black and/or hydrophobic silica.

Brief Description of Drawings

[0023] [Fig. 1] Fig. 1 is a cross-sectional view of a load testing apparatus used in Examples.

[Fig. 2] Fig. 2 is a system diagram illustrating a bag filter testing apparatus used in Examples.

Description of Embodiments

[0024] The present invention is described in detail below.

[0025] Hereinafter, when referring to the average particle diameter of a chemical, the term "average particle diameter" refers to weight-median diameter D_{50} measured by a laser

diffraction/scattering method ("SALD-7500nano" produced by Shimadzu Corporation).

[0026] <Sodium Hydrogencarbonate>

The acidic-gas treating agent according to the present invention includes sodium hydrogencarbonate used for neutralizing an acidic gas. The sodium hydrogencarbonate is preferably prepared by pulverizing crude baking soda into particles having an average diameter of 5 to 30 μm .

[0027] If the average particle diameter of the sodium hydrogencarbonate exceeds 30 μm , the reactivity of the sodium hydrogencarbonate with an acidic gas included in an exhaust gas, such as hydrogen chloride or sulfur oxide, and the rate at which the acidic gas is rejected may become significantly degraded. The sodium hydrogencarbonate is preferably fine baking soda having an average particle diameter of 30 μm or less.

[0028] In order to achieve the anticaking effect according to the present invention in an effective manner, the sodium hydrogencarbonate is preferably provided in the form of a fine powder having an average particle diameter of 20 μm or less, which is particularly likely to cake.

[0029] In the acidic-gas treating agent according to the present invention, the carbon black and/or hydrophobic silica used as an anticaking agent, which is included in the agent in a small amount, suitably inhibits caking and

enhance releasability. This allows the proportions of the carbon black and/or hydrophobic silica to be reduced and the proportion of the sodium hydrogencarbonate, which is the constituent used for treating an acidic gas, to be relatively increased. Consequently, an acidic-gas treating agent capable of treating an acidic gas with a high efficiency may be produced.

[0030] The acidic-gas treating agent according to the present invention includes an anticaking agent at the suitable content described below. The content of the sodium hydrogencarbonate in the acidic-gas treating agent is preferably 95% by weight or more and is particularly preferably 98% by weight or more.

[0031] <Anticaking Agent>

In the present invention, carbon black and/or hydrophobic silica is used as an anticaking agent capable of inhibiting caking and enhancing releasability.

[0032] The average particle diameter of the carbon black is preferably 0.1 to 10 μm and is particularly preferably 0.1 to 1 μm . If the average particle diameter of the carbon black is excessively large, the anticaking effect may become degraded. Carbon black having an excessively small average particle diameter is not useful in terms of ease of handling and costs. Furthermore, the releasability-improving effect may become degraded and, consequently, the pressure loss

across a bag filter may be increased.

[0033] The hydrophobic silica may be prepared by treating the surfaces of particles of silica with a hydrophobizing agent, such as a silicone oil or a silazane. The average particle diameter of the hydrophobic silica is preferably 1 to 20 μm and is particularly preferably 1 to 5 μm . If the average particle diameter of the hydrophobic silica is excessively large, the anticaking effect may become degraded. If the average particle diameter of the hydrophobic silica is less than 1 μm , the releasability-improving effect may fail to be achieved at a sufficiently high level and, consequently, the pressure loss across a bag filter may be increased.

[0034] The content of the carbon black or hydrophobic silica, which serves as an anticaking agent, in the acidic-gas treating agent is preferably 0.1% to 2.0% by weight and is particularly preferably 0.1% to 1.0% by weight. If the content of the anticaking agent is excessively small, the anticaking effect may fail to be achieved at a sufficiently high level. If the content of the anticaking agent is excessively large, the releasability-improving effect may become degraded and, consequently, the pressure loss across a bag filter may be increased.

[0035] The carbon black and the hydrophobic silica may be used in combination as an anticaking agent. In such a case,

the total content of the carbon black and the hydrophobic silica in the acidic-gas treating agent is preferably 0.1% to 2.0% by weight and is particularly preferably 0.1% to 1.0% by weight. In particular, it is preferable to use the carbon black and the hydrophobic silica such that the content of the carbon black is 0.1% to 1.0% by weight and the content of the hydrophobic silica is 0.1% to 1.0% by weight while the total content of the carbon black and the hydrophobic silica falls within the above range.

[0036] <Preparation of Acidic-Gas Treating Agent>

The acidic-gas treating agent according to the present invention can be prepared by, for example, pulverizing crude baking soda into particles having an average diameter of 5 to 30 μm and uniformly mixing the pulverized crude baking soda with carbon black and/or hydrophobic silica in predetermined proportions with a ribbon blender, a Nauta mixer, or the like.

[0037] In the preparation of the acidic-gas treating agent according to the present invention, a chemical other than the sodium hydrogencarbonate or the carbon black and/or hydrophobic silica may be optionally used in addition.

The acidic-gas treating agent according to the present invention may include a chemical other than the sodium hydrogencarbonate or the carbon black and/or hydrophobic silica but preferably consists of the sodium

hydrogencarbonate and the carbon black and/or hydrophobic silica in order to effectively inhibit caking of sodium hydrogencarbonate and enhance the releasability of sodium hydrogencarbonate by using the carbon black and/or hydrophobic silica and to effectively treat an acidic gas by using the sodium hydrogencarbonate.

[0038] <Acidic-Gas Treating Method>

An acidic-gas treating method according to the present invention includes adding the acidic-gas treating agent according to the present invention to an exhaust gas that includes an acidic gas in order to treat the exhaust gas.

[0039] Examples of the exhaust gas that is to be treated with the acidic-gas treating agent or acidic-gas treating method according to the present invention include exhaust gases that include an acidic gas, such as hydrogen chloride or sulfur oxide, emitted from a waste disposal facility or a power boiler, such as a coal boiler or a biomass boiler.

[0040] The amount of the acidic-gas treating agent according to the present invention which is to be added to an exhaust gas is not limited and is set such that the content of the agent in the exhaust gas is 0.1 to 10 g/m³. The amount of the acidic-gas treating agent used is determined appropriately in accordance with the concentration of the acidic gas and the like. Since the proportion of the sodium hydrogencarbonate, which is an

active constituent for the treatment of an acidic gas, in the acidic-gas treating agent according to the present invention can be increased as described above, it is possible to achieve an efficient treatment while reducing the amount of agent required by the treatment.

[0041] After the acidic-gas treating agent according to the present invention has been added to an exhaust gas that includes an acidic gas, commonly, the exhaust gas is passed through a bag filter in order to remove dust particles. Since the releasability of the acidic-gas treating agent according to the present invention has been improved with the carbon black and/or hydrophobic silica, an increase in the pressure loss across the bag filter can be limited, which enables a consistent treatment to be continued.

EXAMPLES

[0042] The present invention is described more specifically with reference to Examples below.

[0043] [Chemicals]

The following chemicals were used as treatment chemicals in Examples, Comparative examples, and Reference examples below.

[0044] Sodium hydrogencarbonate: Crude sodium hydrogencarbonate pulverized into particles having an average diameter of 10 μm

(hereinafter, referred to as "pulverized baking

soda")

Carbon black: Carbon black having an average particle diameter of 0.25 μm

Hydrophobic silica: Hydrophobic silica having an average particle diameter of 1.55 μm , which was prepared by making the surfaces of silica particles hydrophobic with a silicone oil

Wet-process silica: Wet-process silica having an average particle diameter of 13.85 μm

Calcium stearate: Calcium stearate having an average particle diameter of 4.22 μm

Natural zeolite: Natural zeolite having an average particle diameter of 8.10 μm .

[0045] [Examples 1 to 5, Comparative Examples 1 and 2, and Reference Examples 1 to 4]

Acidic-gas treating agents having the chemical compositions described in Table 1 were prepared. Each of the acidic-gas treating agents was subjected to the load test and the bag filter test described below. Table 1 describes the results.

[0046] <Load Test>

The evaluation of caking properties was made by the following method with the load testing apparatus illustrated in Fig. 1.

[0047] Into a boxed container 1 having a size of 100 mm $\times$

100 mm, 100 g of the acidic-gas treating agent 2 was charged. A load 3 of 10 kg was placed on the agent for 3 hours. Subsequently, the acidic-gas treating agent was placed on a stainless steel sieve having an opening of 355 μm and fine powder particles were fallen through the sieve. The weight of coarse powder particles that remained on the sieve was measured. The ratio (weight%) of the weight of the coarse powder particles to the weight of the treating agent used in the test was calculated. The smaller the proportion of the particles that remained on the sieve, the higher the degree of inhibition of caking and the larger the amount of fine powder particles fallen through the sieve.

[0048] The sample (10 g) was fallen from the upper portion of a glass cylinder having a height of 600 mm onto a watch glass disposed at the lower portion of the cylinder. The weight Mg of a part of the sample which remained on the watch glass was measured. The degree of dispersion (the ratio of the weight of the dispersed particles to the weight (10 g) of the sample) was calculated using the following formula. The higher the degree of dispersion, the higher the dispersibility of the sample and the higher the degree of inhibition of caking.

$$\text{Degree of dispersion (\%)} = \{(10 - M)/10\} \times 100$$

[0049] <Bag Filter Test>

The evaluation of releasability was made in accordance

with an increase in the pressure loss across a bag filter caused by the acidic-gas treating agent, which was determined by measuring the pressures at the inlet and outlet of the bag filter with the bag filter testing apparatus illustrated in Fig. 2.

[0050] In Fig. 2, Reference numeral 11 denotes a heater. A high-temperature acidic gas emitted from the heater 11 is fed to a bag filter 15 through a pipe 12. The acidic gas pipe 12 is supplied with the acidic-gas treating agent that is fed from a volumetric chemical feeder 13 through a pipe 14. The pipe 12 is provided with a manometer P1 disposed at the inlet of the bag filter, which measures the inlet pressure. The gas from which dust particles have been removed through the bag filter 15 is transported through a pipe 16, subsequently treated in a cooling tower 17 and a neutralization tower 18 successively, and emitted with an induced draft fan 19 through pipes 20 and 21. The pipe 16 is provided with a manometer P2 disposed at the outlet of the bag filter 15, which measures the outlet pressure.

[0051] The following test conditions were used.

Gas volume: $0.43 \text{ m}^3/\text{min}$

Filtration area of bag filter: 0.43 m^2

Filtration rate of bag filter: $1 \text{ m}/\text{min}$

Temperature of dust chamber of bag filter: 180°C

Amount of chemical added: $116 \text{ g}/\text{m}^3$

Pressure: 0.5 kPa

(bag filter was back-washed automatically when the pressure loss across the bag filter reached 0.5 kPa)

Testing time: 70 minutes

[0052] The smaller the number of times backwashing was performed during the testing time, the higher the releasability and the higher the degree at which an increase in the pressure loss across the bag filter was limited.

[0053] [Table 1]

	Primary constituent	Anticaking agent			Results of load test		Results of bag filter test
		Type	Average particle diameter (μ m)	Content (weight%)※	On sieve (weight%)	Degree of dispersion (%)	Number of backwash (times)
Example 1	Pulverized baking soda	Hydrophobic silica	1.55	0.5	20.12	41.23	3
Example 2	Pulverized baking soda	Hydrophobic silica		0.2	60.01	24.67	1
Example 3	Pulverized baking soda	Carbon black	0.25	0.2	43.00	35.37	1
Example 4	Pulverized baking soda	Carbon black		0.1	51.84	25.40	0
Example 5	Pulverized baking soda	Hydrophobic silica + Carbon black	1.55	0.5 + 0.1	66.74	21.73	1
			0.25				
Comparative example 1	Pulverized baking soda	Wet-process silica + Calcium stearate	13.85	2.0 + 0.2	51.04	24.17	0
			4.22				
Comparative example 2	Pulverized baking soda	Natural zeolite + Wet-process silica	8.10	2.0 + 1.0	52.60	21.90	1
			13.85				
Reference example 1	Pulverized baking soda	Carbon black	0.25	0.05	83.62	9.27	0
Reference example 2	Pulverized baking soda	Carbon black	0.25	3.0	3.17	71.90	13
Reference example 3	Pulverized baking soda	Hydrophobic silica	1.55	0.05	66.37	11.90	0
Reference example 4	Pulverized baking soda	Hydrophobic silica	1.55	3.0	31.05	41.50	8

※ Content in the acidic-gas treating agent

[0054] The results described in Table 1 confirm the following facts.

[0055] The results of the load test conducted in Example 1 confirm that the anticaking effect achieved in Example 1 was larger than that achieved in any of Comparative examples. However, in Example 1, the pressure loss across the bag filter was larger than that determined in any of Comparative examples.

[0056] In Example 2, where the proportion of the anticaking agent was reduced from that used in Example 1, an anticaking effect and a pressure loss that are comparable to those determined in Comparative examples were achieved. Since the proportion of the anticaking agent was lower than that used in any of Comparative examples, the proportion of the pulverized baking soda, which is the constituent used for treating an acidic gas, was advantageously increased.

[0057] In Examples 3 and 4, the results of the load test confirmed an anticaking effect higher than that achieved in any of Comparative examples and the pressure loss across the bag filter was comparable to the pressure losses determined in Comparative examples. Since the proportion of the anticaking agent was lower than that used in any of Comparative examples, the proportion of the pulverized baking soda, which is the constituent used for treating an acidic gas, was advantageously increased.

[0058] In Examples 5, where two anticaking agents were used, an anticaking effect and a pressure loss that are

comparable to those determined in Comparative examples were achieved. Since the proportion of the anticaking agent was lower than that used in any of Comparative examples, the proportion of the pulverized baking soda, which is the constituent used for treating an acidic gas, was advantageously increased.

[0059] In Reference examples 1 and 3, where the content of carbon black or hydrophobic silica was small, the anticaking effect was poor, while the pressure loss was small.

[0060] In Reference examples 2 and 4, where the content of carbon black or hydrophobic silica was large, a markedly high anticaking effect was achieved, but the pressure loss was large.

[0061] Although the present invention has been described in detail with reference to particular embodiments, it is apparent to a person skilled in the art that various modifications can be made therein without departing from the spirit and scope of the present invention.

The present application is based on Japanese Patent Application No. 2015-228838 filed on November 24, 2015, which is incorporated herein by reference in its entirety.

Reference Signs List

- [0062] 1 CONTAINER
- 2 ACIDIC-GAS TREATING AGENT
- 3 LOAD

- 11 HEATER
- 13 VOLUMETRIC CHEMICAL FEEDER
- 15 BAG FILTER
- 17 COOLING TOWER
- 18 NEUTRALIZATION TOWER
- 19 INDUCED DRAFT FAN

CLAIMS

[Claim 1]

An acidic-gas treating agent consisting of a powder mixture of comprising sodium hydrogencarbonate and an anticaking agent that inhibits caking of sodium hydrogencarbonate, the anticaking agent being carbon black, or carbon black and hydrophobic silica.

[Claim 2]

The acidic-gas treating agent according to any one of Claim 1, wherein the carbon black has an average particle diameter of 0.1 to 10 μm .

[Claim 3]

The acidic-gas treating agent according to any one of Claim 1 or 2, wherein the sodium hydrogencarbonate has an average particle diameter of 5 to 30 μm .

[Claim 4]

The acidic-gas treating agent according to any one of Claims 1 to 3, wherein the content of the anticaking agent is 0.1% to 2.0% by weight.

[Claim 5]

An acidic-gas treating method comprising adding the acidic-gas treating agent according to any one of Claims 1 to 4 to an exhaust gas including an acidic gas.

[Claim 6]

An anticaking agent that inhibits caking of sodium

hydrogencarbonate, the anticaking agent comprising carbon black, or carbon black and hydrophobic silica.