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Recovering Waste-Heat and Water from Alumina Calciner Gas

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Abstract

There is lots of heat and water vapor in alumina calciner gas. Almost all alumina refineries exhaust the gas that is about 150 degree C directly. A method was provided to recover both sensible heat and latent heat at the same time using the patented equipment. The thermal balance was calculated. Hot water can be obtained, which can be used to wash aluminum hydroxide and residue. And the exhausted gas after recovering would be below 70 degree C.

Introduction

For getting product of alumina, calciner is used to calcine aluminum hydroxide, which includes gas suspension calciner, fluidization flash calciner and circulating fluidized bed calciner[1-2]. The temperature of exhaust gas from the calciner is about 140-190 degree C. There is more than 43% water vapor in the gas, so there are lots of sensible hear and latent heat in the gas. There is also a little alumina dust in the gas, which is about 25-100mg/Nm^3. The dust would pollute the atmosphere if it isn't recovered. Some alumina refineries use indirect heat exchangers to recover the heat of the gas and reduce the temperature of the exhaust gas to 120-130 degree C[3]. But this technology can only recover part of sensible heat. With advancement of calciner technology, the temperature of the exhaust gas becomes much lower and the sensible heat that can be recovered becomes much less. So, it is very important to recover waste heat and water from calciner gas for reducing energy consumption and the cost of alumina.

Amount of hot water is needed in alumina process, including aluminum hydroxide washing water and residue washing water. A patented technology was developed by our research team to recover both sensible heat and latent heat and most of alumina dust from the gas and get hot water.

1 The patent technology

1.1 Exhaust gas analysis

Normally, three kinds of fuel are used in calcining unit, which are natural gas, coal gas and heavy oil. The most convenient and economical fuel is coal gas in china. The components of exhaust gas of different fuel are in Table 1. It shows that water vapor is about 50%. The thermal distribution of the exhaust gas which is produced with coal gas is in Table 2. It shows that the heat of water vapor is 90.58% in total and the latent heat is about 80%. In the exhaust gas of calciner most heat belongs to water vapor and most water vapor heat is latent heat. So recovering the latent heat of the water vapor is much significant.

Table 1 Components of exhaust gas of the different fuel

(mol/mol %)

	CO_2	SO_2	H_2O	N_2	O_2	Total
Heavy oil	6.0	0.03	**46.5**	44.1	3.34	100.0
Nature gas	4.91	0.01	**53.93**	40.18	1.0	100.0
Coal gas	8.88	0.03	**47.04**	43.02	1.04	100.0

Table 2 Thermal distribution of the gas of coal gas calciner

	CO_2	SO_2	O_2	N_2	H_2O	Total
Flow(Nm^3/t-AO)	167.4	0.5	19.6	810.8	**886.6**	1884.9
Components (%)	8.88	0.03	1.04	43.02	**47.04**	100.0
Heat (MJ/t-AO)	43.79	0.14	3.91	157.87	**1978.0**	2183.7
Heat (%)	2.01	0.01	0.18	7.23	**90.58**	100

	Sensible heat	Latent Heat	Total
(%)	19.21	80.79	100

1.2 The use of heated water and resource of cool water

The water that is used to wash residue and aluminum hydroxide should be heated in alumina refinery. The washing water is composed of fresh water, circulating water of the refinery, return water of residue storage yard and unqualified condensate of digestion and evaporation units normally. The water with low temperature of the washing water could be preheated by calciner gas.

The heated water by calciner gas could preheat spent liquor before evaporation circularly with an indirect heat-exchanger.

The heated water by calciner gas could heat demineralized water of power plant circularly with an indirect heat-

exchanger.

The heated water could be used for heating in winter.

1.3 The patent technology

The cool water is pumped into the top of the direct heat-exchanger and the hot gas is blown into the bottom of it. The temperature of water could be about 80 degree C and the temperature of exhaust gas could be reduced to 60-70 degree C after recovering heat. The hot water would be pumped from the bottom of the heat-exchanger to users. The cool gas would be exhausted to atmosphere with less dust. The recovered alumina dust would be discharged and send to aluminum hydroxide washing unit discontinuously. The Figure 1 is process flow drawing of recovering waste heat and water from calciner gas.

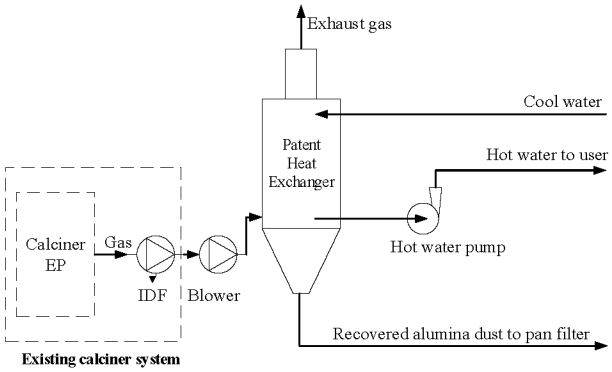

Figure 1 Process flow drawing of recovering waste heat and water from calciner gas

2 Calculation

2.1 Indirect heat exchanging process

Table 3 is the calculation of indirect heat exchanging process to recover heat from the calciner gas.

Table 3 Calculation of indirect heat exchanging process

No.	Items	Unit	Value
1	Temperature of cool water	℃	20
2	Temperature of the gas before heat exchanging	℃	150
3	Temperature of the gas after heat exchanging	℃	115
4	Temperature of hot water	℃	90
5	Mass of water heated	kg/t-AO	292
6	Recovered ratio of heat	%	4.1
7	Recovered ratio of water	%	0
8	Recovered heat	MJ/t-AO	89.97

Table 3 shows that indirect heat exchange process can only recover 89.97 MJ/t-AO, 4.1% heat of the calciner gas. The advantage of indirect heat exchange is the water can be heated to 95 degree C. The hot water can wash the residue or aluminum hydroxide directly.

2.2 Direct heat exchanging process

Table 4 is the calculation of our new technology. It shows that the recovered heat could be from 609.9 MJ/t-AO to 1321.7 MJ/t-AO, which depends on the mass of hot water needs. We can get about 80 degree C hot water under the conditions of recovering heat from calciner gas, which are the temperature of gas is 150 degree C, the fuel is coal gas.

Table 4 Calculation of direct heat exchanging process

No.	Items	Unit	Value		
1	Temperature of the gas before heat exchanging	℃	150	150	150
2	Temperature of the gas after heat exchanging	℃	60	70	75
3	Temperature of cool water	℃	20	20	20
4	Temperature of hot water	℃	80	80	80
5	Mass of heated water	t/t-AO	5.29	3.74	2.44
6	Mass of recovered water	kg/t-AO	504.75	335.0	190.3
7	Recovered heat	MJ/t-AO	1321.7	935.7	609.9
8	Recovered ratio of heat	%	60.5	42.9	27.9
9	Recovered ratio of water	%	70.8	47.0	26.7

2.3 Comparison of indirect and direct heat exchanging processes

As per the calculations, we can compare indirect and direct heat exchanging process.

(1) Indirect heat exchanging process can't recover the water of the calciner gas.

(2) Indirect heat exchanging process can only recover part of the sensible heat of the calciner gas. And direct heat exchanging process can recover both sensible and latent heat. The recovered heat of direct exchanging process is 6-20 times to indirect exchanging process.

(3) The temperature of the hot water that is prepared with indirect heat exchanging process can reach 95 degree C. And it can only be about 80 degree C with direct heat

exchanging process.

3 Application

A system of recovering waste-heat from alumina calciner gas, which included cool water tank, cool water pumps, hot water pumps, patent direct heat-exchanger, blower and control system, was built in an alumina refinery in henan province China.

The main equipment, the patent direct heat-exchanger, is φ5.2×29m. It is suitable for 1500 t/d calciner. The investment of the system is about 14,000,000 RMB. The payback period is 1.5-2 years.

The cool water is 20 degree C fresh water, and the hot water after recovering heat is used to wash aluminum hydroxide. And the recovered dust is sent to the pan filter.

The operation results are the temperature of hot water is 78-80 degree C and the temperature of exhaust gas is 65-68 degree C. The system can recover heat more than 450000GJ/a and water 180000t/a. Figure 2 is the patent direct heat-exchanger on site.

Figure 2 The patent heat-exchanger on site

Now we have developed larger equipment to be suitable for larger calciner.

4 Conclusions

(1) As per the components of the calciner gas, the direct heat exchanging process is more suitable for recovering waste-heat and water from alumina calciner.

(2) A patent technology was developed to recover sensible heat, latent heat and most of dust of the calciner gas. The energy consumption of alumina calcining is reduced and less dust is exhaust to atmosphere using this technology.

(3) About 80 degree C hot water can be gotten with the technology. It could wash residue and aluminum hydroxide after heated by vapor. It also can preheat the spent liquor of evaporation and be used to resident heating in winter.

(4) 609.9 MJ to 1321.7 MJ heat can be recovered per ton alumina as per the hot water needs.

(5) The investment of the system for 1500t/d calciner is about 14,000,000 RMB. The payback period is 1.5-2 years.

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