

## Design and Study on Coal Slime Drying System with the Low Concentration Coal Bed Methane Regenerative Oxidation

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**Keywords:** low concentration coal bed methane, regenerative oxidation, coal slime drying, thermodynamic calculation

**Abstract:** In order to solve the industrial application difficulty of coal slime in coal mine, and the pollutants exceeding the standard exists in the coal furnace in the current coal slime drying system, by using low concentration coal bed methane (CBM) regenerative oxidation reactor instead of coal furnace to produce the high temperature flue gas and combining with slime drying system, a low concentration coal bed methane regenerative oxidation slime drying system which is applied to coal slime drying is formed. The technical principle of low concentration CBM regenerative oxidation and the technological process of a whole coal slime drying system are introduced. Taking the scale of a single regenerative oxidation reactor which processing capacity is 100,000m<sup>3</sup>/h as an example, the thermal calculation of the whole coal slime drying system was carried out. The results show that the system can dry coal slime 39t/h and has a large-scale effect.

### 1. Introduction

In recent years, the situation of atmospheric pollution in China is grim, and regional atmospheric environmental problems have become increasingly prominent [1,2]. The CBM also known as coal mine gas which is mainly composed of methane. Its calorific value is comparable to that of conventional natural gas. It is a clean, efficient and high-quality energy source that has risen in recent 20 years. Making comprehensive use of CBM can save energy resources, reduce environmental pollution and promote the coal mine safety production, which also can play multiple role in adjusting the energy structure [3]. As a mainstream technology of low concentration CBM utilization, the regenerative oxidation technology has made great progress in scientific research since the 11th Five-Year Plan, and has successfully realized the industrial application of coal mine shaft heating and mine district heating.

The coal slime is a by-product of coal washing in coal preparation plant. It has many disadvantages such as high water content, high viscosity, high water holding capacity and low calorific value. It is difficult to realize industrial application. How to make clean and efficient use of inferior coal slime with low grade, poor direct combustion rate and serious environmental pollution has become a practical problem to be solved urgently. Usually, when mixing coal slime as fuel, the coal slime should be dried first for avoid bringing too much water into the burner. The dried coal slime which moisture content decreases and its calorific value can also be greatly improved when together with other raw coal enters the burner to burn.

The coal slime drying not only has obvious economic benefits, and also has great social benefits, especially for environmental protection. The technology of coal slime drying in our country is mainly divided into high temperature flue gas drying technology and low temperature steam drying technology. At present, high temperature flue gas drying technology which uses high temperature flue gas to dry coal slime in rotary cylinder dryer is mostly used [4].

Therefore, using low concentration CBM regenerative oxidation reactor as high-temperature flue gas heat source, the low concentration CBM regenerative oxidation coal slime drying system used

in coal mine slime drying has become an innovative application, and has broad application prospects. At present, there are few related research applications and few related academic reports.

## 2. Regenerative oxidation technology

Taking the two-bed type regenerative oxidation reactor as an example, there are two combustion chambers, one as the inlet and the other as the outlet of mixed gas [5]. After the reactor is heat-actuated, the low concentration CBM which concentration of methane is between 0.2% and 1.2% and at the ambient temperature flow from the low temperature side (e.g., chamber 1) into the regenerative chamber, then heated, oxidized and released thermal energy. The released energy during methane oxidation is recovered by ceramic as the gas moves to the outlet side of the chamber. This process is often referred to as the upper half cycle of the circulating operation, at this time, the chamber 1 in the exothermic stage and the chamber 2 in the storage stage. Then the direction of flow should be switched and the reverse process to carry on, the system should be self-balance operational with the continuous transformation between two chambers at high temperature and low temperature. When the methane concentration is higher than that of self-balance operational (about 0.3%), some high temperature flue gas can be extracted for thermal energy utilization, thus generating economic benefits.

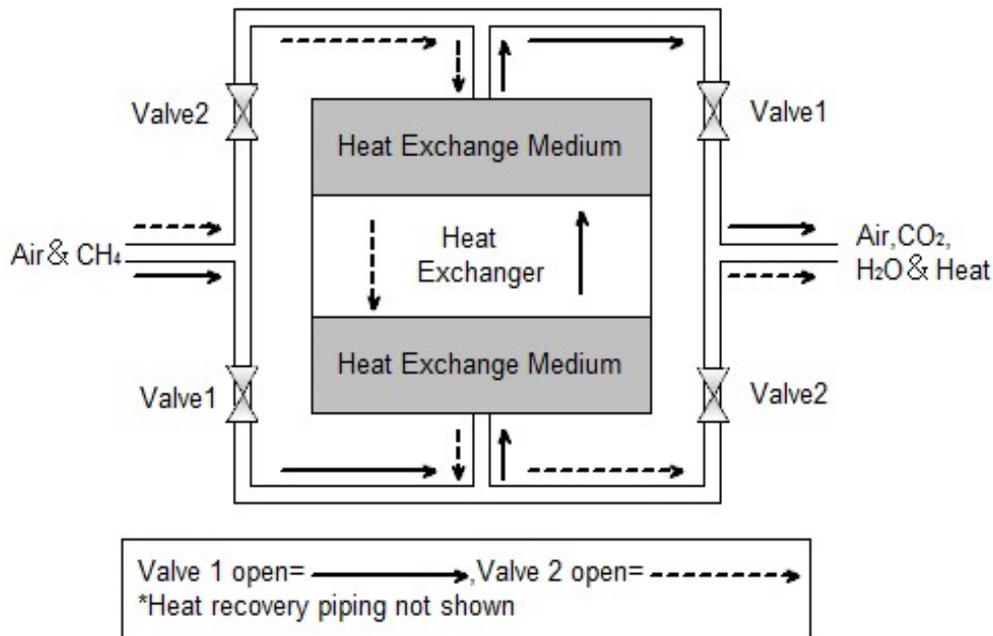


Fig.1 Schematic of two-bed type regenerative oxidation reactor

At present, great progress has been made in the research of low concentration CBM regenerative oxidation utilization technology, which gradually forms single-bed, two-bed, five-bed and other structural types. Its methane oxidation rate and operation stability are gradually improved, laying a good foundation for industrial application. In the form of back-end thermal energy utilization, steam turbine generation, coal mine shaft heating and building heating are gradually developed.

## 3. Coal slime drying technology of high temperature flue gas

The slime drying system of high temperature flue gas is mainly composed of heat source equipment, charging machine, belt conveyor, rotary drum dryer, transmission mechanism, discharge bin, dust catcher and electronic control system [6]. The process flow chart is shown in Fig.2.

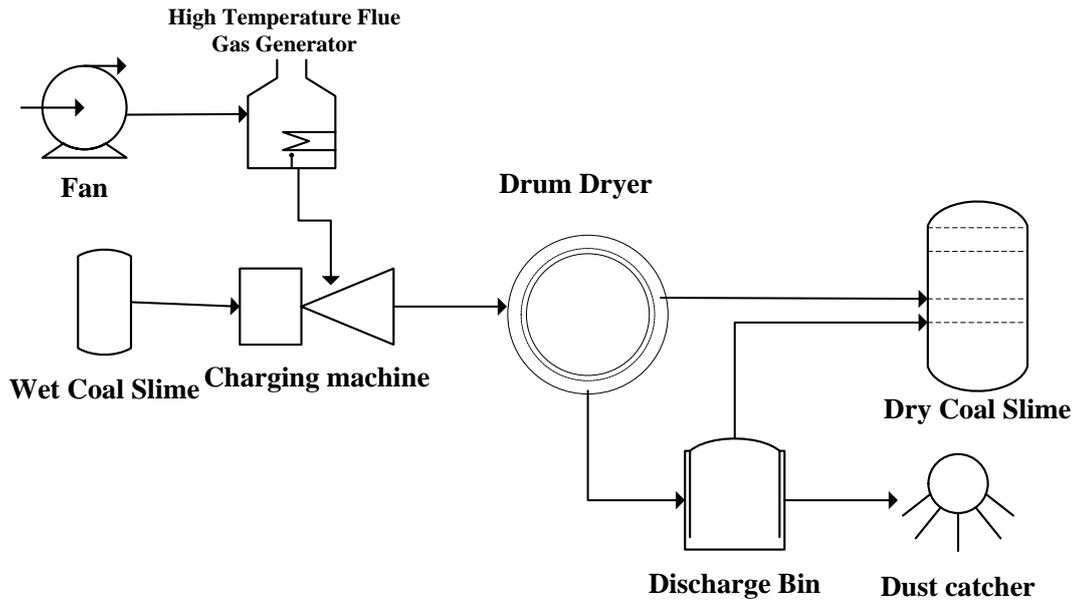


Fig.2 Process flow chart of high temperature flue gas coal slime drying technology

The wet slime is conveyed from the charging machine to the inner part of the cylinder of the rotary drum dryer. Meanwhile, high temperature flue gas enters the inner part of the cylinder. Coal slime is fully heat and mass transfer under the direct contact of high temperature flue gas, a large amount of water is evaporated, and the dried coal slime is discharged through the discharger to complete the whole drying process. Dust-laden gas is purified by dust catcher and exhausted by induced draft fan. The dried product is conveyed to the finished product yard by conveyor.

#### 4. Coal slime drying system with the low concentration CBM regenerative oxidation

The drying system of low concentration CBM regenerative oxidation is mainly composed of mixing system, regenerative oxidation reactor, slime heating system and monitoring system. The process flow is as follows: after coal mine gas extraction passes through fire arrester and explosion-proof device of pumping station, it is connected with pipeline of conveying and mixing system, and mixed with air in mixing device to form raw gas with a methane concentration of about 1.2%, which is transported to regenerative oxidation reactor under the action of main fan. The regenerative oxidation reactor periodically adjusts the opening and closing of the intake and outlet valves, so that each bed can switch periodically between the regenerative and exothermic processes. After the system enters a stable operation state, the high-temperature flue gas is extracted into the slime dryer to dry wet slime.

#### 5. System Thermodynamic Calculation

Taking the scale of a single regenerative oxidation reactor which processing capacity is  $100,000\text{m}^3/\text{h}$  as an example, the thermal calculation of the coal slime drying system was carried out. The high temperature flue gas produced by the low concentration CBM regenerative oxidation reactor with a capacity of  $100,000\text{m}^3/\text{h}$  is converted into the working parameters of the standard condition:  $25,000\text{Nm}^3/\text{h}$ ,  $800\text{ }^\circ\text{C}$ .

(1) Heat Released by  $25\ 000\text{Nm}^3$  Flue Gas

Enthalpy calculation of flue gas under standard condition refers to the following parameters. Enthalpy of hot air at  $800\text{ }^\circ\text{C}$  is  $h_1$ . Enthalpy of hot air at  $105\text{ }^\circ\text{C}$  is  $h_2$ . The heat released by the hot flue gas from  $800$  to  $105\text{ }^\circ\text{C}$  is as follows.

$$Q_0 = 25000 \times (h_1 - h_2) \quad (1)$$

Considering the heat loss, if the heat utilization rate is calculated at 80%, the heat released:

$$Q = Q_0 * 80\% = 19940000 \text{ KJ} \quad (2)$$

### (2) Heat Consumption in Drying Process of Ton Coal

Heat required for evaporation of one ton water is  $Q_1$ . One ton coal slime is dried from 30% to 15% moisture, and the evaporated water is divided into:

$$1 \text{ t/h} - \frac{1 \text{ t/h} \times (1 - 30\%)}{1 - 15\%} = 0.176 \text{ t/h} \quad (3)$$

The amount of heat consumed by evaporating water in drying one ton coal is that

$$Q_2 = 0.176 \times Q_1 = 441830.4 \text{ KJ} \quad (4)$$

The temperature of one ton coal slime before drying is 25 °C and the discharging temperature of the product is 75 °C. The heat absorbed during the heating process of each ton of coal slime required is  $Q_3 = 65000 \text{ kJ}$ . The total heat requirement for each ton of wet coal slime during the whole drying process is as follows:

$$Q_4 = Q_2 + Q_3 = 506830.4 \text{ KJ} \quad (5)$$

### (3) Capacity calculation of drying

$$M = Q / Q_4 \approx 39 \text{ t/h} \quad (6)$$

## 6. Conclusion

(1) The technology of low concentration CBM regenerative oxidation and the technological process of coal slime drying system which formed by this technology combined with coal slime drying system are introduced. High temperature flue gas produced by low concentration CBM regenerative oxidation reactor used instead of traditional coal furnace in coal slime drying, this will promote the clean and efficient utilization of coal slime.

(2) Taking the scale of a single regenerative oxidation reactor which processing capacity is 100,000 m<sup>3</sup>/h as an example, the thermal calculation of the whole coal slime drying system was carried out. The results show that the system can dry coal slime 39 t/h.

## Acknowledgements

This study was financially supported by the National Science and Technology Major Project of China (N0.2016ZX05045-006).

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