Light Metals 2011 *Edited by: Stephen J. Lindsay*
TMS (The Minerals, Metals & Materials Society), 2011

STUDY ON THE ENERGY-SAVING TECHNOLOGY OF CHINESE SHAFT CALCINERS

Guanghui LANG, Chongai BAO, Shoulei GAO, Ronald Lee Logan, Yan Li
Sunstone Development Ltd, Beijing 100029, China

Keywords: Shaft Calciner, Energy-saving, Integrated Technology, Carbon Burning Loss

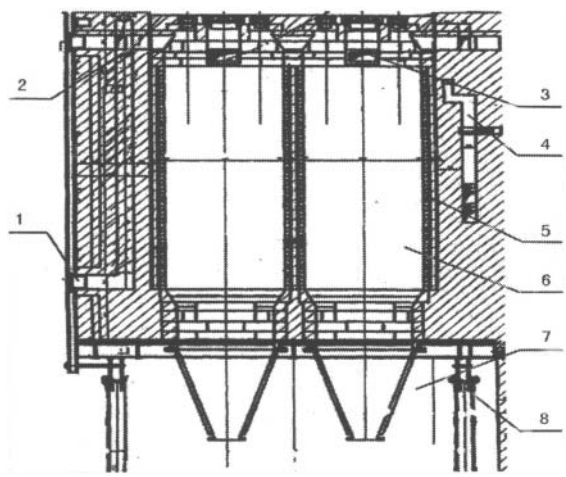
Abstract

Shaft calcining technology is widely used in China for the calcination of green petroleum coke. It has the advantages of lower energy consumption and lower carbon burning loss compared to the rotary kilns. In this paper, a method of further reducing carbon burning loss using integrated technology is discussed.

Introduction

Rational utilization of resources is a basic state policy for China. During the production of carbon materials, calcination of GPC (Green petroleum coke) is a very important process, which is to heat up the GPC to a high temperature. When calcined, moisture and VCM (Volatile Combustion Matter) are removed from coke, crystal-lattice grows, real density increases, bulk shrinks, and mechanical strength enhanced. And, the performance of electrical conductivity, thermal conductivity, thermal shock resistance and oxidation resistance are all improved simultaneously.[1] Currently, more than half of the Chinese carbon plants use vertical shaft calciners as main method for petroleum coke calcination, and the current production capacity is about 3,500Kt/a.

Vertical shaft calciner is an indirect heating calciner where GPC and flues are separated. The VCM from GPC when heated burns in the flue and heats up GPC inside the shaft. So it's somewhat a self-support system. Once it starts, you don't have to input fuels to maintain the calcining process. Fig. 1 is a cross sectional view of vertical shaft calciner.

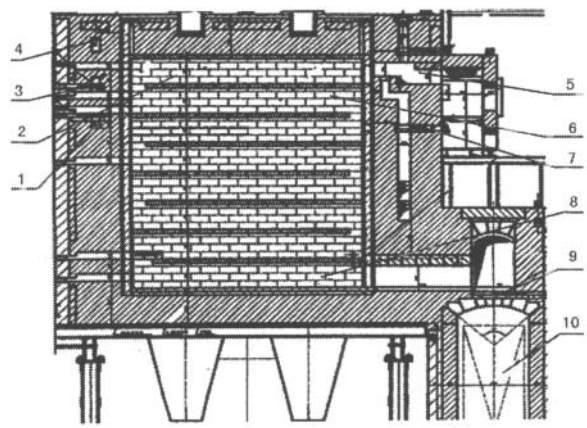


1 - Air Tunnel; 2 - VCM Collecting Tunnel; 3 -Escaping Rim; 4 – Vertical Air Tunnel; 5 - Shaft Wall; 6 - Calcining Pot; 7 - Cooling Sleeves; 8 – Calciner Support

Fig.1 Cross sectional view of vertical shaft calciner

When calcining, VCM discharged from the calcining pot is mixed with the air from the preheating air tunnel and burns in the first level flue. This process generates high temperature exhaust gas, which flows to the second level flue, then the third, and finally the last flue by the draft from exhausting system. After the exhaust gas passed through the last flue, it arrives at the heat accumulator room, where heat exchange happens between cold air and hot exhaust gas through bricks. The cold air can be heated up to 400-600℃, and then it goes to the first level flue to help VCM burning.

The connection of level 1 to 8 flue are 'Z' type from the top to the end, and the green cokes are heated indirectly by the flue on both sides of the calciner. High temperature exhaust gas coming out from the last flue goes into a boiler to recycle the heat through the main flue. Fig. 2 shows the 8 flues of calciner.[2]



1 – Air Damper; 2 - First Flue; 3 - VCM Damper; 4 – VCM Vertical Tunnel; 5 - Temporary Drying Furnace Device; 6 - Second Flue; 7 - Preheated Air Damper; 8 – Last Flue; 9 – Exhaust Gas Damper; 10 - Boiler

Fig.2 Eight flues of the calciner

Energy available for us in the world is less day by day. Energy saving technology has been one of the most important fields to develop in. The advantage of shaft calciner – less carbon burnt loss and high quality calcining process – has made it very popular in carbon industry all over the world. In year 2008 and 2009, this technology was introduced to Brazil and Middle East countries.

The advantage of energy-saving

Now, there are three kinds of mainly used calcining equipment (rotary kiln, vertical shaft calciner and rotary hearth

calciner).[3] A comparison of these three calcining equipment is shown in Table 1.

Table 1 calcining equipment comparison

Item	Rotary Kiln	Shaft Calciner	Rotary Hearth
Technology Features	Direct Heating	Indirect Heating	Direct Heating
Product Quality	Fine	Good	Good
Productivity	6-12t/h	80-100kg/h (per Shaft)	13-21t/h
Carbon Loss	7-10%	3-4%	7-8%
Energy Consumption	High	Low	Low
Recycle Heat	Yes	Yes	Yes
Environment Protection	Good	Good	Good
Material Adaptability	Wide	Common	Wide
Investment	Low	High	High
Operation Cost	High	Low	High
Automatic Level	High	Low	High

We can see from table 1 that the advantages of vertical shaft calciner are less carbon burnt loss, less operation and maintenance cost, energy-saving and so on. It corresponds with the tendency of using resources in sustainable development way. Fig. 3 is the flow chart of energy circulation in calcining.

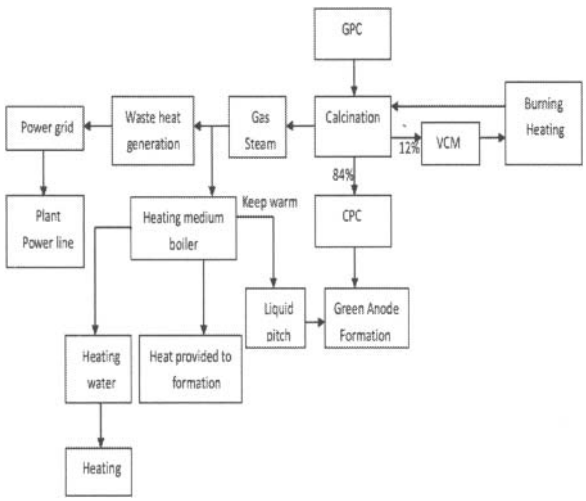


Fig.3 Flow chart of energy circulation in calcining

There are 10 to 12 percent of VCM in GPC, which must be discharged during calcining. With these VCM, we don't have to input additional fuel. And, the GPC are heat treated under an air isolated condition, which allows low carbon burnt loss.

Escaping VCM enter into the flue and burn. The heat produced is used for GPC calcination, and high temperature exhaust gas of 800-1000℃can be used to generate electrical power, which can satisfy 80 percent electrical energy of the whole plant. Or, through a boiler, it can be used in Green Mill or daily lives. The energy balance diagram of heating and cooling zone of the shaft is shown in Fig.4 and Fig.5.

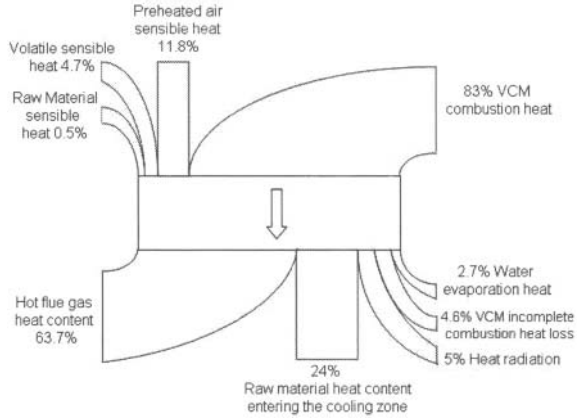


Fig.4 The heating zone energy balance diagram

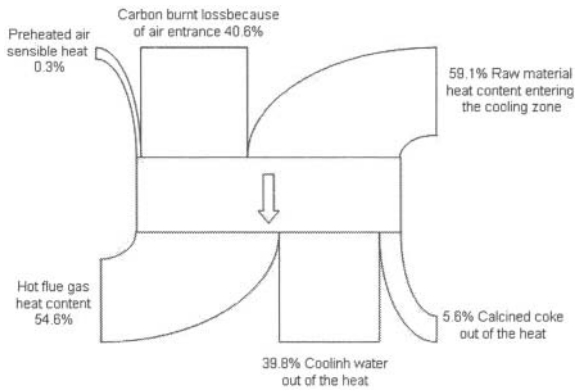


Fig.5 The cooling zone energy balance diagram

From figure 4 we can tell that 83.1% of heat income in calcinations zone is from VCM, and the hot flue exhaust gas takes away 63.7% of heat. The proportion of the heat produced by carbon burnt loss and carried by the cooling water respectively is 40.6% and 39.8% in Figure 5. Therefore, reducing carbon burnt loss has the advantage of increasing product recovery efficiency and decreasing the quantity of the cooling water for the shaft.

Given an example of 150000 ton/a pre-baked anodes production plant, it need to construct six sets of shaft calciners (28 shafts and 8 flues for each calciner), the output per shaft is 80-100kg/h, exhaust gas temperature around 850-900℃, gas flow about 10000Nm3/h, temperature of exhaust gas from boiler is 400℃. There is about 154×10^4Kcal/h heat by one shaft. Totally, the production and daily life need about 584×104Kcal/h. So the waste heat produced by one set of calciner can satisfy then, and other 5 sets of calciners can be used to generate electrical energy for the production and daily life of the whole plant. And, the temperature of hot gas from boiler is still about 400℃ high. There is potential to recycle them further to save more energy.

It's extremely important for a carbon plant to recycle the waste heat from calciner exhaust gas. It's high efficient, environment friendly, and economical. There is great potential for energy saving. In the recent years, heat recycling is widely applied in many Chinese carbon plants successfully. And, it will be introduced to more and more plants all over the world. So, how to improve the efficiency of heat recycling and decrease carbon burnt loss is a necessary step for energy saving.

The direction of improvement

Shaft calciner has very good sealing around the body. However, air may leak into it during discharging. Actually, this is the main cause of carbon burning.[4]

Air leaking from the discharging gate will react with the carbon material inside the shaft. It happens at the cooling zone, where carbon material temperature is about 300-500℃, and generate CO_2. CO_2 rise up, react with the carbon material and generate CO, which will burn in the flue finally. In this process, some carbon materials are burnt and generate additional greenhouse gas – CO_2. On the other hand, it brings additional heat to the cooling zone so that the cooling water quantity has to be increased also. It's a negative process which leads to more cost and less environment protection. So, if we cut off the access of air at the discharging spot, we can reduce the carbon burnt loss. And therefore, we can reduce our cost, save energy and protect the environment with less CO_2 emission.

According to the actual structure of the discharging unit, we find a effective way to cut off the air, sealing this unit by draft. As Fig 6 shows. We fix an air extraction pipe at the CPC (Calcined Petroleum Coke) discharging unit and connect it with a draft generator. A negative pressure of about -10-0 millimeter of water inside the discharging pipe can cut off the access of air to the carbon materials inside the shaft.

When 1000kg GPC are calcined, we can get about 750 kg CPC only. About 10% of moisture and 10-13% of VCM are lost or burnt. In the process of CPC discharging, there is air entering the calciner, which will burn about 3-4% of coke and generate additional heat. This additional heat needs about 40% more cooling water. However, if we seal the discharging unit with this technology, the air leaking in can be reduced about 70% and, carbon burnt loss reduced to 0.5-1% accordingly. We can save carbon burnt loss about 6000-7500 tons per year. That means 25,000 tons of CO_2 emission and 36,000 tons of circulation water per year can be saved also. This technology can realize our purpose of reducing carbon burnt loss and CO_2 emission.

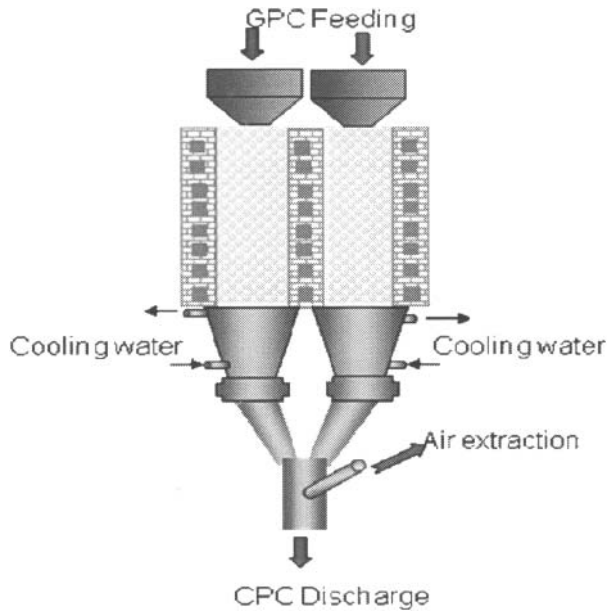


Fig. 6 The diagram of the draft sealing technology

Conclusion

(1) The Chinese vertical shaft calciners have big advantage in energy saving. They consume energy in a high efficient way with less carbon burnt loss and high CPC quality.

(2) The draft sealing technology at the discharging unit can reduce the carbon burnt loss, and therefore reduce the quantity of cooling water and CO_2 emission. This technology can improve the performance of calciners' energy consumption.

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