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Economic and Environmental Resolutions of Coal in Cement Industry

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Abstract

According to the latest statistics, the main reason of the increase of fog and haze in China lies in the increased air pollution emission caused by enlarged energy demand of the whole society every year. The pollution mainly comes from thermoelectric emissions, heavy chemical industry enterprises, automobile exhaust, residential heating in winter, living (cooking, hot water), urban construction and demolition, etc.. One main reason is industrial pollution, and the pollution caused by coal-use accounts for more than 65% of the total industrial pollution. This paper aims at the useful skills of industrial coal to enable enterprises to use coal more economically and more environmentally friendly, so that enterprises can save costs, duly fulfill their social responsibilities to environmental cause and achieve economic and environmental benefits.

Key words: Clean energy; Calorific value of coal; Denitration; Desulfurization

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INTRODUCTION

Today, green economy and circular economy have become an important goal of the new century. Promoting the development of clean energy and green energy is an important part of economic development. After nearly three decades of reform and opening up, China's economic growth rate has let the world wonder. China's economic development has been implemented mainly in heavy industry, and in order to pursue the production quantity and scale, heavy industry enterprises mostly took a productive method of low energy costs which did not use energy completely and had no supporting decontamination facilities. Coal is the largest variety of industrial energy use, and its proper use has a decisive significance to economic and environmental pollution. In addition to a large amount of smoke and dust produced during coal combustion, the combustion process also forms carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen oxides, organic compounds, soot and other harmful substances. This paper analyzes the selection of industrial coal, desulfurization, denitration (remove nitrogen oxides) and other aspects, trying to find solutions to enable industrial enterprises to ultimately achieve economic and environmental benefits in terms of coal use.

1. ANALYSIS ON COAL TYPES AND SELECTION

(a) Classification of industrial coal. According to the degree of evolution of coal, the international society classifies coal into lignite, bituminous coal and anthracite. In terms of bituminous coal, according to the volatile of more than 10% to 20%, more than 20% to 28%, more than 28% to 37% and more than 37% it can be classified into low, medium, medium high, and high volatile bituminous coal. Anthracite has low volatile, high fixed carbon, heavy specific gravity, pure coal can have a real specific gravity up to 1.90, high ignition point and no smoke when burned. But no matter what is the type, their main industrial components: Moisture Mad/%, ash Aad/%, volatile Vad /%, total sulfur SO_3/%, and net calorific value as dried air basis Qnet, ad. Based on the national standard, different grades of coal are converted into standard coal consumption for a comparison (standard coal refers to per kilogram net calorific value as received basis of 29.27 megajoules (MJ) (equivalent to the 7,000 kcal/kg of coal).

(b) Economic and environmental relations to coal selection. According to an industrial enterprise's use of one million tons of standard coal (7,000 kcal/kg) as the following table.

Table 1
Different Calorific Value of Coal Consumption

Calorific value	Chemical analysis	Converted to standard coal	Converted to material coal	Sulfide
7,000 kcal/kg			1 million ton	1 ton
6,500 kcal/kg	Reference data: SO_3 content 1%	1 million ton	1.08 million ton	1.08 ton
5,000 kcal/kg			1.27 million ton	1.27 ton

(c) According to the table, when using high calorific value coals, under the premise of the equivalent content of SO_3 sulfide has been significantly reduced. This is the positive significance to environmental protection.

(d) As an enterprise economic analysis, the cost of coal transportation will not change with the calorific value, if coal freight is 220 yuan/ton; 6,500 cal coal's unit price is 420 yuan/ton; 5,000 cal coal's unit price is 330 yuan/ton, so the actual purchasing cost is:

(6,500 kcal/kg value coal) 1.08 million tons * (420 yuan +220 yuan) = 691.2 million yuan,

(5,000 kcal/kg value coal) 1.27 million tons * (330 yuan +220 yuan) = 698.5 million yuan.

Taking the cement industry for example, changes in the ash content of coal lead to changes in coal ash incorporated into the clinker, and cause changes in the chemical composition and rate of the clinker, thus affect the clinker's strength. By comparing the data it can be found that each 1% change in coal ash causes about 0.008 change in clinker KH, showing the impact of changes of coal quality to clinker quality. Pulverized coal's calorific value directly affects the flame temperature, and affects the kiln burning temperature. Low calorific value leads to difficulties in kiln burning temperature rise, leads to increase of heat consumption and large decrease in output. Calorific value directly affects the inner temperature of kiln, thereby further affects the generation of C_3S. In order to maintain kiln's temperature at 1,450℃, it requires coal to have a higher calorific value. Coal's grindability directly affects the operation of coal mill and firing condition of pulverized coal.

At the same time, before being used there is a processing of coals. In the cement industry if processing raw coals into 8% residue on sieve, the power cost of the processing is 30kwh/ton (the percentage of quality of the residue sieved by a 80 um square hole sieve in the total quality, generally used to control product fineness), equivalent to 18 yuan/ton depending on electricity charge of 6 yuan/ton, thus the processing cost of coal is:

(6,500 kcal/kg value coal) 1.08 million tons * 18 yuan / ton = 19.44 million yuan,

(5,000kcal/kg value coal) 1.27 million tons * 18 yuan / ton = 22.86 million yuan.

From the above we can find that the use of cheap coals leads to 10.72 million yuan rises in cost (7.3 million yuan increasse in purchasing cost, and 3.42 million yuan increases in processing), and harmful gas emission also rises. In addition, low calorific value coal also causes a dramatic increase in the use amount, and leads to an increase in coal grinding and power cost. In order to save costs, enterprises usually tend to choose low-calorific value coals, but from the realistic point of view, cheapness will eventually lead to more expenditure and more pollution. With the scientific and technological progress and enhancement of strength of enterprises technical teams, they began to realize this principle. In recent years, the Chinese government has continued to increase environmental protection efforts, which further reduced the demand for coals. The Government's goal is that by 2020 the proportion of coal in primary energy consumption will reduce from the current 66% to 62%. Reasonably chooses the control target of pulverized coals. If a coal is finer, the surface area is larger, burning speed is faster, and incomplete combustion loss is smaller. Coal ash level has a great impact on calorific value and burning speed. If coals have more varieties, the quality fluctuations are larger. For high ash coals, we should use less primary air and decrease coal fineness to accelerate combustion and reduce incomplete combustion, which can increase the heating intensity of burning zone and increase production. In short, the demand for cheap coals will slowly decrease.

2. INDUSTRIAL ENTERPRISES' DESULFURIZATION MEASURES IN COAL COMBUSTION PROCESS

(a) The distribution pattern of China's coal resources is shown as poor in the south, rich in the north, less in the east and more in the west, and high sulfur coals are mainly distributed in the southeast region with relatively smaller coal reserves, especially in southern China where the proportion of high sulfur coals is more concentrated. The earliest formation of high sulfur coal resources was mainly in the late Carboniferous – early Permian (northern China) and the late Permian (Southern China). During the two periods of the formation of coal reserves accounts for 25% and 8% respectively of the country's total coal resources. The formation of high sulfur coals was affected by the climate and ecological evolution which determined the composition of coal quality in the region. Such as in the regions in northwest China where coal resources are concentrated, due to land and sea changes and crust movements, sulfur content is generally from 1.5% to 4.8%. By modern mining technologies, we can properly reduce the sulfur content of high sulfur coals. Industrial enterprises can make use of flue gas desulphurization technology to remove over 95% SO_2 generated by coal firing. In today's world there are nearly more than 100 popular desulfurization technologies, but those can be adopted by industrial enterprises are less than 10, out of which the industrial enterprises in China use the desulphurization by wet processes the most, which has also been adopted by 95% enterprises in the US and 88% enterprises in Germany. After nearly 10 years of promotion of environmental protection, the wet desulphurization technology's coverage has grown from 10% to 85% now.

(b) Chemical desulfurization methods include alkali treatment, oxidation and solvent extraction method, etc.. These methods have their own characteristics, such as alkali treatment, oxidation, and solvent extraction method. With the development of science and technology, more efficient and more economical methods of desulfurization are constantly updated, such as the currently promoted principle of organic sulfur removal, desulfurization principle of microwave irradiation, desulfurization technology of high gradient magnetic separation, desulfurization method of electrostatic coal, and desulfurization method of selective flocculation, etc..

(c) The rapid development of desulfurization technology enables modern industrial enterprises to realize simple operation, fast desulfurization, good effect and low cost, and can remove more than 90% of total sulfur in coal, so that enterprises benefit.

(d) Efficiency analysis of desulfurization technologies: based on a 20 t/h coal-fired boiler with a flue gas desulphurization equipment, when the amount of flue gas emission per unit time and the amount of soot concentration per unit volume of flue gas are constant, if the annual running time is 300 days, when the sulfur content of coal is 1%, the sulfide emission is about 500t; when the sulfur content of coal is 2%, the sulfide emission is over 1,000 tons or more. Thus, atmospheric pollution has been greatly increased. When desulphurization facilities are adopted, if the sulfur content of coal is 1%, the desulfurization cost is about 80,000 yuan/year; and if the sulfur content of coal is 2%, the desulfurization cost is even up to 200 thousand yuan/year. Therefore, when amplifying to the country, the annual consumption cost and environmental protection cost will reach hundreds of millions yuan.

(e) The recycling efficiency of desulfurized residual materials. Desulfurized residual materials generally refer to the "industrial byproduct gypsum", namely the by-product or waste whose main component is calcium sulfate produced by the chemical reactions of desulfurization. In the cement industry, it can be used as cement retarder instead of natural gypsum, which has a great significance to environment protection, development of recycling economy and establishment of a conservation-oriented society. This is also the manifestation for enterprises to build a harmonious society and fulfill their social responsibilities. The use of desulfurized gypsum is in line with the national energy saving industrial policy, which creates good economy while reducing industrial waste pollution to the city. It is an innovation that cement production enterprises transform into environmental responsible enterprises.

3. INDUSTRIAL ENTERPRISES' DENITRATION (REMOVE NITROGEN OXIDES) IN COAL COMBUSTION PROCESS

3.1 The Current Environmental Problems of China's Industrial Enterprises

The "12th Five-Year Plan" clearly identified the constraint indicators of ammonia nitrogen (NH3) and nitrogen oxides (NO_x) in atmospheric emissions. According to the preliminary statistics in the first half of 2012, the total NH3 and NO_X emissions have not been significantly reduced. Through sampling analysis by industry experts, it is believed that the main reason is the too slow promotion of production reform and with the years of expansion of industrial enterprises in the construction, the reduced pollution is far less than the total annual increase in energy consumption, which caused increases in NO_X emissions every year. In 2013 the State implemented more strict environmental requirements, and cement plants began to massively promote and conduct denitration projects while accelerating the pace of eliminating backward production capacities. In 2014 the eight session of the NPC unanimously approved the amendment of the environmental law (GB4915-2004), and adjusted the NO_X emission limit for key areas from 800 mg/Nm³ to 350 mg/Nm³, and decreased particulate emission from the original 30 m/m³ to below 20 mg/m³. Even the latest dry-process clinker production lines are close to or higher than the limit value of 350 mg/Nm³. The new environmental protection law has been officially implemented on January 1, 2015. The NO_X emission of the new dry rotary kilns of below 2,500 t/d (inclusive) in early construction is generally up to about 1000 mg / Nm³, and the clinker dry process production lines of 2,500 t/d account for about 30% of the national cement production lines. Thus, if it's calculated by 2 kg/t NO_X clinker, the clinker unit emissions of the most new dry process cement kilns exceed the prescribed limit.

3.2 The NO_X Emission of Cement Enterprise Clinker Production Lines Must Be Controlled by Coercive Measures to Avoid Direct Discharging

According to Chinese building material professionals' measured statistics in 2014 on the NOx emission of 10 domestic 1,500-5,000 t/d clinker dry process production lines, the lowest is 410 mg/Nm³, the highest is 1,020 m/Nm³, and the average is about 700 mg/Nm³. Therefore, the existing local regulations have made a mandatory target for coal purchases: be sure to adhere to the principles of source supply control, multiparty participation, integrated management and use process optimization. It firstly proposed that coal enterprises should start from the procurement step, and strictly control procurement, processing, storage, on-line use, total amount of emissions and other key aspects. The purchaser should purchase high quality of coals, promote and strengthen the management of coal cleaning. It also clearly proposed to restrict the sale of raw coal whose ash is higher than 16% and raw coal whose sulfur is more than 1%. Meanwhile, encourage enterprises to conduct supervision and management, for those leading and exemplary enterprises in consumption of clean energy, they can declare special funds of environmental protection and energy saving from the government.

Currently, the technologies used to control NO_X emission of cement kiln are flame cooling, low nitrogen burners, staged combustion, adding mineralizer, selective non-catalytic reduction technology and selective catalytic reduction technology. Flame cooling, low nitrogen burners, staged combustion, and adding mineralizer is the control technologies of combustion in kiln. After the adoption of these measures, NO_X emission level of cement kiln can be controlled to be 200-500 mg/Nm³. This technique is to inject reducer in cement kiln, which can generally reduce 30% to 50% of NO_X emission, and if optimize the injection mode of reducer the purification efficiency of NO_X can be increased to about 80%. The cement pollution control technology policy which will solicit public opinions proposed, "cement kilns' nitrogen oxide emission should be controlled based on the low nitrogen combustion technology (low nitrogen burners, staged combustion, etc.). Recently we should use the selective non-catalytic reduction technology to control emission concentration of nitrogen oxide to be below the 300 mg/Nm³; in the future we should use the composite technology of selective catalytic reduction to control emission concentration of nitrogen oxide to be below 200 mg/Nm³. We need to strictly control ammonia escape, and pay attention to the safety management of liquid ammonia and other reducers.

3.3 Economic Benefits

The implementation of reducing nitrogen oxide emission projects and NSP cement production line denitrification projects is not only important to reduce nitrogen oxide emissions and improve air quality, but also plays an exemplary role of carrying out denitration to industrial enterprises.

China is a big industrial country. Taking the cement industry for example, by 2014 China's cement production has been more than 1.9 billion t. When the projects on construction come into use, it will be significant to energy saving and emission reduction of the national cement industry. The NSP accounts for 85% of China's cement production capacity, and all need to install denitration equipment. According to 2014 cement output 1.9 billion t (clinker output 1.5 billion t), it is estimated that if it's applied in 60% of China's cement enterprises, based on a reduction of 55% emission of nitrogen oxide, NO_X emission will reduce 1.6 million t per year, namely the total national emissions will reduce by half compared to 2010.

CONCLUSION

Ministry of Industry and Information Technology has clearly stated in *The Guidance on Industrial Energy Conservation and Emission Reduction*: further clarify that production enterprises are the subject of energy saving and emission reduction, and give full play to the initiative of enterprises. Enterprises should strengthen management system construction of energy saving and emission reduction, establish energy management head, and clarify job responsibilities and target assessment requirements. Establish and improve new mechanisms and favorable policies of energy saving and emission reduction. Encourage professional energy saving service companies to provide industrial enterprises with energy audits, energy conservation engineering services, contract energy management, energy project financing and a series of other energy saving technology services. The environmental pollution has been fallen into a state of crisis. After a long-term of explorations and practices, China has formulated three basic environmental protection policies of "prevention first", "whoever causes pollution is responsible for its treatment" as well as the strengthening of environmental supervision and management. The starting point of these three basic policies is to be based on the specific condition of China, according to China's many years' of experience of environmental protection work, take environmental management as the core in order to achieve the purpose of economic, social and environmental coordinated developmental strategy.

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