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Situation analysis and countermeasures of China's fly ash pollution prevention and control

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Abstract

Coal, as the main energy resource of China, results in huge amount of fly ash and increasing public attention. Fly ash has become China's single bigger source of solid industrial waste currently. Toxins in fly ash not only pollute the local soil, air and water, but also cause harm to the health of people through the food chain. The Chinese government attaches great importance to the environmental pollution, and has established a series of comprehensive utilization incentives and pollution prevention measures for fly ash. In this paper, the status of fly ash generation, storage, and comprehensive utilization in China has been described, and some suggestions and countermeasures are given.

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1. Introduction

Fly ash, as the larger amount of industrial solid waste in China currently, is a fine solid particles of ash that are carried into the air when coal is combusted. China's rapid economic growth leads to the quickly increasing demand for electrical energy. Coal, as the main fuel resource of coal-fired power plants, results in increasing problems with the disposal of fly ash. Fly ash will take up a large amount of stored land and will become a grave threat to the environment and public health if it is not dealt with appropriately. Fly ash is easy to generate dust and cause large area serious air pollution in windy weather [1]. Nearby rivers would be blocked if stored fly ash lets out, and the harmful heavy metals contained, such as lead, cadmium, arsenic and mercury, would present a threat to the environment and human health. The Chinese government attaches great importance to the fly ash pollution, has introduced a series comprehensive utilization incentives and pollution prevention standards and technical specifications. This paper is a brief

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introduction of the status of fly ash generation, storage, and comprehensive utilization in China, and some suggestions and countermeasures are provided.

2. 2. The sources and generation of fly ash

China, as one of few countries which coal is the main energy source, is the biggest coal mining and consumption country in the world. China meets more than 75 percent of its energy demands through coal and has consumed more than 3 billion tons coal in 2010. Half of all coal consumption is burnt to produce electricity, and a large amount of fly ash is an inevitable consequence [1, 2, 3] (Fig. 1). Coal-fired power plants and urban central heating boiler are the main source of fly ash, where coal-fired power plants produce about 90 percent (calculated based on coal consumption data in 2008). There are three major reasons for the huge amount of fly ash: (a) Very large scale of coal-fired units, (b) Coal combustion produces a lot of fly ash, (c) Very high coal consumption rate for unit power generation.

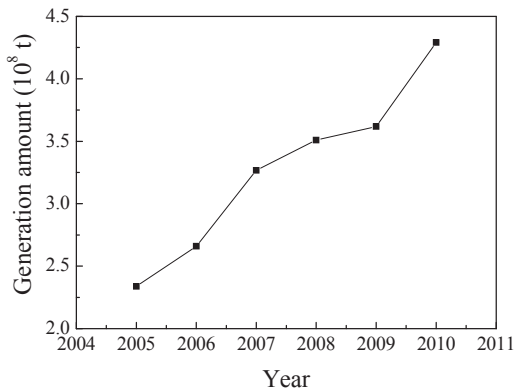


Fig. 1 Fly ash production over the years in China

The chemical composition of fly ash is extremely complex in China and varies greatly with coal source and combustion conditions. The fly ash commonly consist of SiO_2 , Al_2O_3 , Fe_2O_3 , CaO , MgO , Na_2O , K_2O , SiO_2 and trace concentrations of heavy metals like lead, cadmium, arsenic and mercury.

The particles fineness of fly ash ranged from 0.5 to 300 μm and changes with pulverized coal fineness, combustion conditions and dusting method. Typically, particles greater than 80 μm is about 23 percent, particles ranged from 45 to 80 μm is about 24 percent, and particles less than 45 μm is about 49 percent. Moreover, the fly ash packing density is also changed in different coal-fired power plants and varied from 700 to 1000 kg/m^3 [4].

According to the discharged way, fly ash has been divided into dry ash and wet ash in China. The dry ash is collected by dirt catcher whose moisture content less than 1 percent, while wet ash is collected by dirt catcher fly ash and discharged by hydraulic system. At present, wet ash accounts for 90 percent of all fly ash is in China, while its comprehensive utilization rate is much lower than that of dry ash for its poor activity and thicker particles.

3. 2. Storage status of fly ash

According to "Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste", industrial solid wastes can be divided into general industrial solid wastes and industrial hazardous wastes, and general industrial solid can further be divided into class I and class II though environmental influences. Fly ash belongs to the class II. Currently, the fly ash cannot be comprehensive utilized temporarily will be stockpiled in China, and the "Standard for Pollution Control on the Storage and Disposal Site for General Industrial Solid Wastes" (GB 18599-2001) is the most relevant mandatory standards for fly ash disposal site. The standard gives specific demand on choice of location and measures to prevent wind dispersal, leakage and run-off. Although there are other 20 national standards or industry standards, they are almost voluntary standards and only encourage enterprises to adopt on an optional basis. Therefore, the effectiveness of these standards is limited and cannot have a strong constraint on coal-fired power plants.

There are 2386 coal-fired power plants in China by the end of 2010 [1], including 1642 independent coal-fired power plants and 744 corporate-owned power plants. The number of fly ash disposal sites is related to the installed capacity of coal-fired power plants and initial planning of disposal sites. According to the preliminary statistics, a coal-fired power plant will have more than one disposal site, and there should be more one thousands of disposal sites in China now. The stockpiled fly ash has exceeded 1 billion tons and mainly distributed among the provinces which rich in coal and less developed, such as Shanxi, Inner Mongolia autonomous region, Jilin, Guizhou and Yunnan.

Moreover, the lacking of regulatory resources and weak implementation in China also leads to the exaggeration of fly ash comprehensive utilization ratio, and the choice of location and measures to prevent wind dispersal, leakage and run-off were cannot completely prevented at the majority of the fly ash disposal sites [5].

Although the purpose of constructing disposal sites is protecting environment, the measures taken cannot completely prevent wind dispersal, leakage and run-off at lots of disposal sites [5] and still lead to some inevitable problems [6, 7]. Including:

(a) Taking up a large amount of land. According to statistics [8], every tons of fly ash occupy 0.27 to 0.33 hectares of land, and all fly ash disposal sites in China will occupy 3.33 to 41.7 thousand hectares land by the end of 2010.

(b) Being easy to cause environmental pollution when disposal sites are poorly managed [9, 10, 11, 12]. Dry ash is easy to raise dust and pollute air at windy weather, especially to the residents living in the outlet of disposal site. The hazardous heavy metals, such as lead, cadmium, arsenic and mercury, will be leached during fly ash is long piled up and soaked in alkaline water, the longer of time the greater of concentration. The leachate will pollute surrounding surface water, groundwater and cultivated land. Surrounding rivers will be silted when fly ash discharged, which will be harmful to human body and living beings.

At present, fly ash raising dust and disposal sites leachate infiltration or excretion during storage has become the major environmental issues in China. A report "The true cost of coal: an investigation into coal ash in China" [13] released by Greenpeace China has aroused great concern of Chinese government and the public on fly ash disposal sites pollution in 2010.

4. 3. Comprehensive utilization of fly ash

China has established the guideline "based on usage" clearly for fly ash and introduced a series of preferential measures, such as funding or tax breaks for projects using fly ash. The fly ash comprehensive utilization amount is increased gradually in the past few years, and has exceeded 300 million tons in 2010 [1]. At present, the Chinese National Development and Reform Commission and relevant departments are revising the "Management Measures for Comprehensive Utilization of Fly Ash", which is jointly

promulgated by the former State Economic and Trade Commission and other five ministries in 1994. According to the “Management Measures for Comprehensive Utilization of Fly Ash (exposure draft)” published recently, National Development and Reform Commission takes charged in the organization, coordination, supervision and inspection of fly ash comprehensive utilization in China, and the relevant departments under the state council provide assistances within their own mandates. The draft identifies a new principle “who produce, who govern, who use, who benefit” to achieve the target of comprehensive utilization rate 70 percent proposed by “Major Industrial Solid Waste Comprehensive Utilization ‘Twelfth Five Years’ Planning” in 2015.

At present, there are six major ways for fly ash comprehensive utilization in China [14, 15, 16, 17], including: (a) Building materials production, including cement, fly ash bricks, fly ash ceramic and fly ash blocks; (b) Building works, including produces concrete, mortar, etc.; (c) Roads construction, including the embankment, pavement base and pavement; (d) Backfill, including the structure backfill, construction backfill, filling in low-lying area and wasteland, filling with mines, coal mining subsidence area, building materials factory to take pits, tidal marsh, etc.; (e) Agriculture field application, including soil improvement, compound fertilizers production and land reclamation; (f) Recycling useful raw materials, including hollow microsphere, Al_2O_3 , Fe_2O_3 , SiO_2 , carbon granules, etc. Fig. 2 gives a map of fly ash comprehensive utilization rate in different provinces, autonomous regions or municipalities directly under the central government in 2010 [1].

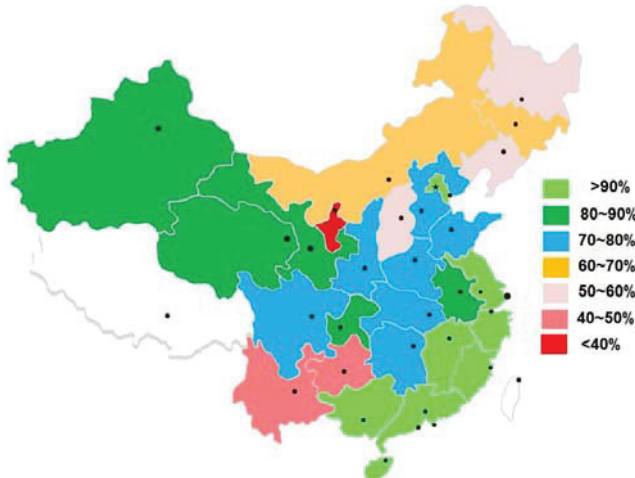


Fig. 2 The fly ash comprehensive utilization rate of different provinces, autonomous regions or municipalities directly under the central government in 2010

However, although the comprehensive utilization amount of fly ash increases gradually in recent years, the utilization rate maintains at about 67 percent [4, 15]. There are two main reasons: (I) Fly ash production amount is very huge and growth rapidly in China; (II) Comprehensive utilization depends on the needs of urban construction greatly and constraints by the transport radius significantly. All these make the fly ash comprehensive utilization presents the phenomenon "three excess three lack": (a) Comprehensive utilization products are concentrated in building materials field and are popular goods of dependable quality and low value-added, which results in the phenomenon of larger amount of fly ash utilized while its products are value-added; (b) comprehensive utilization in eastern China is better than western China, and the market demand in eastern China is more larger, some area even supply falls short

of demand; (c) Although there are many fly ash comprehensive utilization products in China, the technical level of products is still low, which results in the phenomenon of many product while low technical level.

Moreover, some comprehensive utilization process inevitably triggers notable pollution [4]. Such as, hazardous heavy metals contained in the fly ash will pollute agricultural soil, water and living beings, dry fly ash is easy to cause dust pollution during transport, while wet fly ash with excessive moisture is easy to flow out and pollute environment.

Although the ultimate purpose of fly ash comprehensive utilization is protects environment and achieve sustainable development, secondary pollution is still cannot effectively avoid [18]. There are two reasons: (I) Lacking of sound legal regulations. Although Chinese government has issued a series of specialized administrative regulations, administrative rules or normative documents on fly ash, the specialized environmental governance requirements are still lacked. The rules and regulations introduced are almost those aimed at promoting fly ash comprehensive utilization, which result in the absence of environmental protection laws and government regulation when fly ash turns out to be a variety of products, such as concrete, fly ash bricks, embankment, dam, etc.; (II) There is a lack of environmental monitoring standards and pollution prevention standards for products made from fly ash or crops cultivated in fly ash improved soil, the current standards only focus on fly ash.

5. 4. Recommendations

5.1. 4.1 Promoting fly ash comprehensive utilization vigorously

Comprehensive utilization is the best way to prevent fly ash pollution [4, 19] and many attempts should be made in China. A recommended option is developing and promoting technologies which can consume larger fly ash, and upgrading existing technology and expanding new application fields through scientific and technical innovation. Other alternatives include developing fly ash comprehensive utilization echelon technologies positively, extracting and making the most of the fly ash by economical and mature methods, and adding value of products as much as possible.

Both preferential policies and punitive measures should be introduced to improve the activeness of enterprises. Firstly, funding or tax breaks for projects using fly ash should be put into practice as soon as possible, especially to the larger enterprises and larger projects; Secondly, some government's subsidies should be for poured out for projects to encourage use of fly ash instead of natural resources, especially to the development and application of new technologies and facilities; Thirdly, enterprises who discharge exceeds the limits set by the national or local standards or discharge fly ash outside the designated areas should be severely punished by central and local governments; Finally, levying new project's "three simultaneous" margins, ecological environment compensation or resources loss tax.

5.2. 4.2 Improving fly ash management system

Strengthening fly ash comprehensive utilization management and establishing the new management system adapted to the new situation as soon as possible. On the one hand, promulgating new "Management Measures for Comprehensive Utilization of Fly Ash" quickly, developing pollution control standards and technical specifications, and updating technical standards for new products; On the other hand, developing circular economy to improve the control of fly ash pollution by the combined effect of laws and regulations, government management, public awareness, market conditions and technological advances.

Some measures must be taken out to prevent the pollution caused by the toxic trace elements presented in products made from the fly ash. Such as, biological monitoring the agricultural soil, water and living

beings which might be polluted; conducting environmental impact assessment for soil-groundwater-crop system to make sure that quantity of products used cannot lead to secondary pollution; constructing closed cylinder silos and corresponding facilities for dry ash, and selecting a reasonable moisture content to be sure moisture content of wet ash neither too little to wind dispersal nor too much to run-off or handling difficult.

5.3. 4.3 Strengthening management of disposal sites

First of all, the location selection, design and construction of new fly ash disposal sites must conform to “Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste” and “Standard for Pollution Control on the Storage and Disposal Site for General Industrial Solid Wastes” and other related laws and regulations and standards specifications. Moreover, the disposal sites must equip with necessary facilities to prevent wind dispersal, leakage and run-off [20].

Secondly, fly ash disposal sites must take necessary measures to restrain the re-entrainment of dust during normal operation [10, 21, 22, 23]. For example, rational planning and partition running the disposal sites to minimize the working face during storage process, setting up sprinkler system to keep ash surface humid and increase cohesion between particles, layered paving and compacting fly ash during normal operation timely, sprinkling water to the temporary rolling face timely, making sure the rolled hard shell layer cannot be destroyed by disturbance, growing grass on the layered compaction permanent slope body, reclaiming land when stockpiling height raises to the designed elevation, planting trees around the disposal sites to restrain dust re-entrainment.

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