Fly Ash from Thermal Power Plants – Waste Management and Overview

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Abstract— Energy requirements for the developing countries in particular are met from coal -based thermal power plants. The disposal of the increasing amounts of solid waste from coal -fired thermal power plants is becoming a serious concern to the environmentalists. Coal ash, 80% of which is very fine in nature and is thus known as fly ash is collected by electrostatic precipitators in stacks. In India, nearly 90 mt of fly ash is generated per annum at present and is largely responsible for environ-mental pollution. In developed countries like Germany, 80% of the fly ash generated is being utilized, whereas in India only 3% is being consumed. This article attempts to highlight the manage-ment of fly ash to make use of this solid waste, in order to save our environment.

Key words: Fly ash, Solid Waste, Electrostatic Precipitators, Energy Saving, Fly Ash Utilization

I. Introduction

COAL-based thermal power plants have been a major source of power generation in India, where 75% of the total power obtained is from coal-based thermal power plants. The coal reserve of India is about 200 billion ton-nes (bt) and its annual production reaches 250 million tonnes (mt) approximately. About 70% of this is used in the power sector. In India, unlike in most of the deve-loped countries, ash content in the coal used for power generation is 30–40%. High ash coal means more wear and tear of the plant and machinery, low thermal effi-ciency of the boiler, slogging, choking and scaling of the furnace and most serious of them all, generation of a large amount of fly ash. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China, in that order. Fly ash is defined in Cement and Concrete Terminology (ACI Committee 116) as the 'finely divided residue resulting from the combustion of ground or powdered coal, which is trans-ported from the fire box through the boiler by flue gases'. Fly ash is fine glass powder, the particles of which are generally spherical in shape and range in size from 0.5 to 100 μm. Fly ash is classified into two types according to the type of coal used. Anthracite and bituminous coal produces fly ash classified as class F. Class C fly ash is produced by burning lignite or sub-bituminous coal. Class C fly ash has self-cementing properties. The esti-mated thermal power generation, coal consumption and ash generation in India is given in Tables 1 and 2.

II. Effluent and Disposal

Disposal and management of fly ash is a major problem in coal-fired thermal power plants. Fly ash emissions from a variety of coal combustion units show a wide range of composition. All elements below atomic number 92 are present in coal ash. A 500 MW thermal power plant releases 200 mt SO_2, 70 t NO_2 and 500 t fly ash approximately every day. Particulate matter (PM) consid-ered as a source of air pollution constitutes fly ash. The fine particles of fly ash reach the pulmonary region of the lungs and remain there for long periods of time; they behave like cumulative poisons. The submicron particles enter deeper into the lungs and are deposited on the alveolar walls where the metals could be transferred to the blood plasma across the cell membrane (Figure 1). The residual particles being silica (40–73%) cause silico-sis. All the heavy metals (Ni, Cd, Sb, As, Cr, Pb, etc.) generally found in fly ash are toxic in nature (Figure 2). Table 3 provides a list of diseases caused due to the pres-ence of these toxic metals.

Fly ash can be disposed-off in a dry or wet state. Studies show that wet disposal of this waste does not protect the environment from migration of metal into the soil[1]. Heavy metals cannot be degraded biologically into harm-less products like other organic waste. Studies also show that coal ash satisfies the criteria for landfill disposal, ac-cording to the Environmental Agency of Japan[2]. Accord-ing to the hazardous waste management and handling rule of 1989, fly ash is considered as non-hazardous. With the present practice of fly-ash disposal in ash ponds (gener-ally in the form of slurry), the total land required for ash disposal would be about 82,200 ha by the year 2020 at an estimated 0.6 ha per MW. Fly ash can be treated as a by-product rather than waste[3].

Year	Thermal power generation (mW)	Coal consumption (mt)	Ash generation (mt)
1995	54,000	200	75
2000	70,000	250	90
2010	98,000	300	110
2020	137,000	350	140

Table 1: Thermal power generation, coal consumption and ash generation in India

Power station	Location	District	State	Region	Installed capacity (MW)
Badarpur TPP	Badarpur	New Delhi	NCT Delhi	Northern	705
Singrauli TPP	Shaktinagar	Sonebhadra	Uttar Pradesh	Northern	2000
Rihand TPP	Rihand nagar	Sonebhadra	Uttar Pradesh	Northern	2000
Feroz Gandhi Unchahar	Unchahar	Raebarelii	Uttar Pradesh	Northern	1050
Tanda TPP	Vidyutnagar	Ambedaknagar	Uttar Pradesh	Northern	440
Korba STPP	Jamani palli	Korba	Chhattisgarh	Western	2100
Sipat TPP	Sipat	Bilaspur	Chhattisgarh	Western	1000
Vindhyachal STPS	Vidhya nagar	Sidhi	Uttar Pradesh	Northern	3260
Ramagundam STPS	Jyothi nagar	Karimnagar	Andhra Pradesh	Southern	2600

Simhadri STPS	Simhadri	Visakhapatnam	Andhra Pradesh	Southern	1000
Farakka STPS	Nagarun	Mushidabad	West Bengal	Eastern	1600
Kahalgaon STPS	Kahalgaon	Bhagalpur	Bihar	Eastern	2340
Talcher STPS	Kaniha	Angul	Orissa	Eastern	3000
Talcher TPP	Talcher	Angul	Orissa	Eastern	460

Table 2: Details of NTPC power plants in India

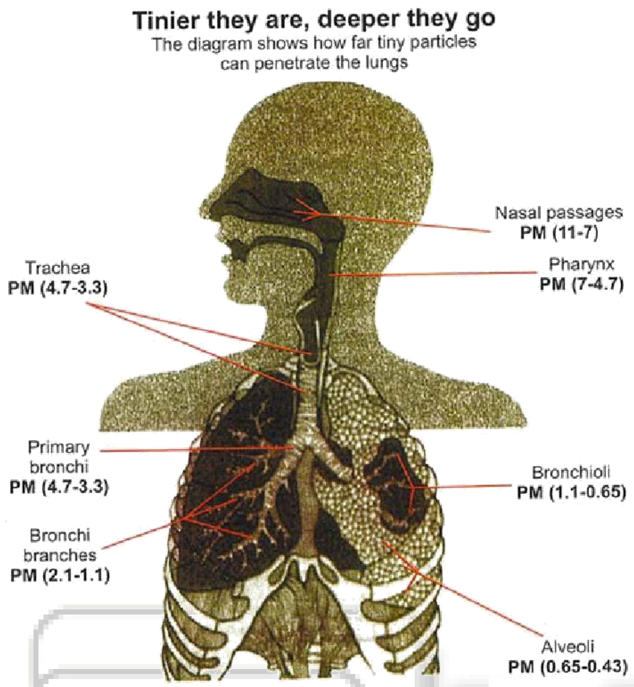

Fig. 1: Penetration of tiny particles into the lungs

III. FLY ASH UTILIZATION

The ash generated from volcanoes was used extensively in the construction of Roman structures. The colosseum (constructed in AD 100) is a classic example of durability achieved using volcanic ash (Figure 3). Fly ash is gener-ated in artificial volcanoes (coal-fired). Volcanic ash acts just like fly ash obtained from coal-fired thermal power plants.

During the last 30 years, extensive research has been carried out to utilize the fly ash in various sectors, as this is not considered as hazardous waste[4,5]. Broadly, fly ash utilization programmes can be viewed from two angles, i.e. mitigating environmental effects and addressing disposal problems (low value–high volume utilization).

Following are some of the potential areas of use of fly ash.

IV. FLY ASH BRICKS

The Central Fuel Research Institute, Dhanbad has deve-loped a technology for the utilization of fly ash for the manufacture of building bricks. Fly ash bricks have a number of advantages over the conventional burnt clay bricks. Unglazed tiles for use on footpaths can also be made from it. Awareness among the public is required and the Government has to provide special incentives for this purpose.

V. FLY ASH IN MANUFACTURE OF CEMENT

Fly ash is suitable for use as pozzolana. In the presence of moisture, it reacts chemically with calcium hydroxide at room temperature to form compounds possessing cementitious properties. Fly ash has a high amount of silica and alumina in reactive form. These reactive elements complement the hydration chemistry of cement. On hydration, cement produces C–S–H gel and free lime, i.e. $Ca(OH)_2$. The C–S–H gel binds the aggregates together and strengthens the concrete. Water, sulphates and CO_2 present in the environment attack the free lime causing deterioration of the concrete. A cement technolo-gists observed that the reactive elements present in fly ash convert the problematic free lime into durable con-crete. The difference between fly ash and portland cement becomes apparent under a microscope. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. This property make fly ash a desirable admixture for concrete.

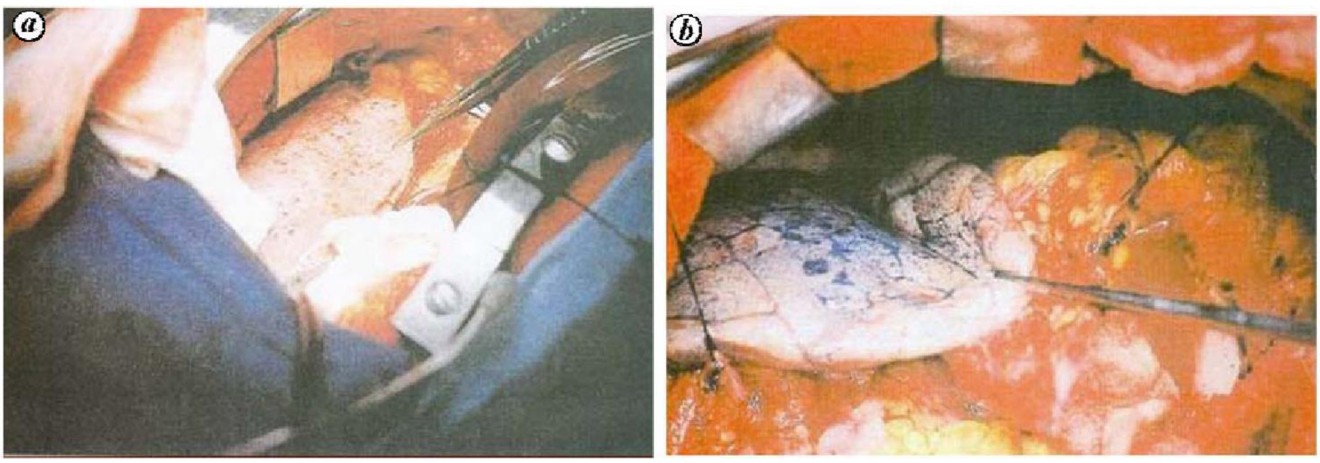

Fig. 2: *a)* Clean lungs of a patient from Himachal Pradesh b) Dirty lungs of a patient from New Delhi

Fig. 3: The Roman colosseum

Metal	Content (ppm)	Diseases
Nickel (Ni)	77.6	Respiratory problem, lung cancer
Cadmium (Cd)	3.4	Anaemia, hepatic disorder
Antimony (Sb)	4.5	Gastroenteritis
Arsenic (As)	43.4	Skin cancer, dermatitis
Chromium (Cr)	136	Cancer
Lead (Pb)	56	Anaemia

Table 3: Diseases due to the presence of heavy metals in fly ash

VI. FLY ASH IN DISTEMPER

Distemper manufactured with fly ash as a replacement for white cement has been used in several buildings in Neyveli, Tamil Nadu, in the interior surfaces and the per-formance is satisfactory. The cost of production will only be 50% that of commercial distemper.

VII. FLY ASH-BASED CERAMICS

The National Metallurgical Laboratory, Jamshedpur has developed a process to produce ceramics from fly ash having superior resistance to abrasion.

A. Fly ash as fertilizer

Fly ash provides the uptake of vital nutrients/minerals (Ca, Mg, Fe, Zn, Mo, S and Se) by crops and vegetation, and can be considered as a potential growth improver. It serves as a good fertilizer.

B. Fly ash in road construction

The use of fly ash in large quantities making the road base and surfacing can result in low value–high volume utilization.

VIII. CONCLUSION

It has been recognized worldwide that the utilization of an enormous amount of fossil fuels has created various adverse effects on the environment, including acid rain and global warming. An increase in the average global temperature of approximately 0.56 K has been measured over the past century (global warming). Gases with three or more atoms that have higher heat capacities than those of O_2 and N_2 cause the greenhouse effect. Carbon dioxide (CO_2) is a main greenhouse gas associated with global climate change. The disposal, management and proper utilization of waste products has become a concern for the scientists and environmentalists. Proper management of solid-waste fly ash from thermal power plants is nec-essary to safeguard our environment. Because of high cost involved in road transportation for the dumping of fly ash, it is advisable to explore all its possible applica-tions. The Pradhan Mantri Gramya Sadak Yojana would be a successful and economically viable project with the utilization of fly ash in road construction in remote and rural areas. Every village in India will have concrete roads and large amounts of fly ash can be consumed in this process. Concentrated efforts are needed to utilize fly ash in the manufacture of building bricks, cement and ceramics, and mitigate the unemployment problem as well.