



# Parametric Study on Production and Utilisation of Fly Ash in India

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**Abstract:** In India the generation of electricity mainly depend upon coal based power plant and would remain predominantly by coal based stations in the near future. The Indian coal is of low grade having high ash content of the order of 30 - 45% generating large quantity of fly ash at coal/lignite based thermal power stations in the country. After China, India is the second most country consumes large amounts of cement, which produces over 184 millions tones of fly ash per year with half of its in used. The management of fly ash has thus been a matter of concern in view of requirement of large area of land for its disposal because of its potential of causing pollution of air and water. Present paper has given an overview of production of Indian fly ash and utilisation of its discussed.

**Keywords:** Fly Ash, Coal, Production, Utilization

## 1. Introduction

FLY Ash is a by-product of burning pulverized coal to generate electric power [1]. During the combustion of powdered coal in modern thermal power plants, as coal passes through high-temperature zone in the furnace the volatile matter and carbon are burned off while most of the mineral impurities such as clays, quartz, and feldspar melt at the high temperature. The fused matter is quickly transported to low-temperature zones where it solidifies as spherical particles of glass. Some of the minerals agglomerate forming the bottom ash, but most of the fine particles fly ash is subsequently removed are called fly ash [2]. This ash is subsequently removed from the gas by cyclone separation, electrostatic precipitation, and bag house filtration.

Coal/Lignite based Thermal Power Generation has been the backbone of power capacity addition in the country. Presently in India the installed thermal power capacity of coal is 1,67,707 MW, which produces large quantity of ash. Safe disposal of fly ash is a growing problem in India, with rising fly ash production more efforts must be put on higher consumption of fly ash. In India about 145 major coal-based thermal power stations are producing over 184 million tons fly ash per year [3]. More than

80,000 acres of land is buried under the ash ponds [4]. Fly ash generation is expected to increase to 300 million tons per annum by 2017 and 900 million tons per annum by 2031-32 [5]. If not handled properly management of fly ash shall require huge land area for dumping and it will be an environmental threat for coming generations. As there are many creative usages of fly ash so need to be increase the utilisation for better tomorrow.

## 2. Physical and Chemical Properties of Fly Ash

Fly ash is a coal combustion residue shows a different variation in their physical and chemical Properties depending on the conditions of combustion, nature of parent coal type of emission control devices, handling and storage methods. Fly ash particles are spherical (which is more important from the water requirement point of view) and have a very high fineness, low bulk density, light texture and high specific surface. The high specific surface of the fly ash means that the material is readily available for reaction with calcium hydroxide [6].

## 3. Coal Demand and Coal Ash Production

Indian coal is of low grade with ash content of the order of 30-45 % in comparison to imported coals which have low ash content of the order of 10-15%.

**Table 1.** Projected coal demand in Million Ton (Source India Energy Book, 2012)

Sectors	2005-06	2006-07	2011-12	2016-17	2021-22	2026-27	2031-32
Electricity (A)	310	341	539	836	1040	1340	1659
Iron & Steel	43	43	69	104	112	120	150
Cement	20	25	32	50	95	125	140
Other	53	51	91	135	143	158	272
Non Electrical (b)	116	119	192	289	350	403	562
Total (A) + (B)	426	460	731	1125	1390	1743	2221

In India a major 145 Coal/Lignite based thermal power plant is setup for providing electric power to

rapidly growing industrial as well as agriculture sectors [3]. In India the total coal demand, has been

forecasted increase 730 Million tons in 2010-11 to 2000 Million tons in 2031-32 of this approx. 75% of this coal would go thermal power plant [7]. The table below will present the projected coal demand (Million Tons).

The above table no. 1 shows that the coal demand in the coming year, there will be more chances for increasing the generation of fly ash in future. At present the consumption rate of fly ash is 55.69% per annum [3]. So need to be increase the consumption rate of fly ash to maintain production-consumption balance. Further the table no. 2 given below shows the production and utilisation of fly-ash for the year 2014-15 in India.

**Table 2.** Generation and utilisation of fly-ash in India 2014-15 (Source: Central Electricity Authority annual Report 2014-15)

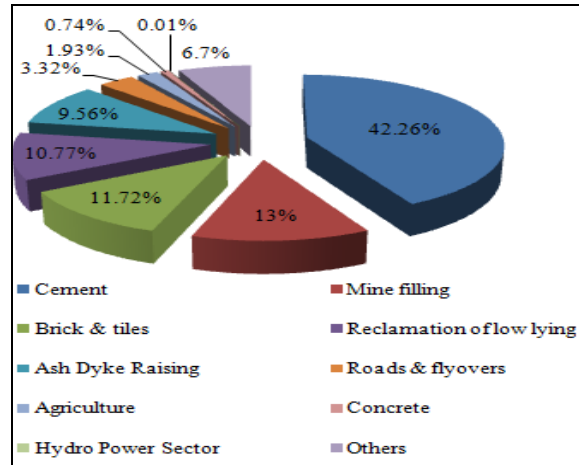
2014-2015	
No. of Major coal/Lignite based thermal power station in India	145
Installed Capacity	18915.80 Mega Watt
Total Ash generated	184.1435 Million Tons
Total Ash utilized	102.5433 Million Tons
<b>Percentage Utilization</b>	<b>55.69%</b>

**(i). Modes of Fly Ash Utilisation in India**

Fly ash generation is expected to increase up to 900 million tons per annum by 2031-32 [5]. The large amount of fly-ash produced if not utilised properly will be hazardous to Environment. The data on fly ash utilization received from Thermal Power Stations/Power utilities for the year 2014-15 has been analyzed to ascertain the modes in which fly ash was utilized and the quantity utilized in each mode. The modes in which fly ash were utilized during the year 2014-15 along with utilization in each mode are given in Table-3.

**Table 3.** Fly-ash utilization during the year (2015) (Sources: CEA annual report 2014-2015)

Sl. No.	Modes of utilisation	Million-Ton	Percentage (%)
1	Cement	43.3300	42.26
2	Mine filling	13.3311	13.00
3	Brick & tiles	12.0216	11.72
4	Reclamation of low lying area	11.0398	10.77
5	Ash Dyke Raising	9.8025	9.56
6	Roads & flyovers	3.4086	3.32
7	Agriculture	1.9748	1.93
8	Concrete	0.7606	0.74
9	Hydro Power Sector	0.0054	0.01
10	Others	6.8690	6.70
<b>Total</b>		<b>102.5433</b>	<b>100.00</b>



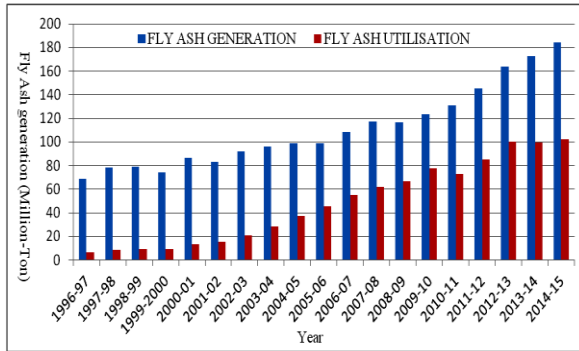
**Figure 1.** Indian modes of fly ash utilisation in percentage

The above pie diagram (Figure 1) shows that different modes of fly ash utilisation during the year 2014-15 in India, the maximum utilization of fly ash to the extent of 42.26 % of total fly ash utilized was in the Cement sector, followed by 13.00 % in mine filling, 11.72 % in making bricks & tiles, 10.77 % in reclamation of low lying area, 9.56 % in ash dyke raising, 3.32 % in roads & embankments, 1.93 % in Agriculture, 0.74 % in Concrete, 0.01 % in Hydro Power Sector & 6.70 % in Others etc.

Thermal power producers have again missed the 100% fly ash utilisation target set by environment ministry. According to Ministry of Environment and forest (MoEF) notification after 3<sup>rd</sup> November 2009, the utilisation of fly ash should be 100% after four year from date of commission i.e. at 2013, but at present utilisation of fly ash is 56%, that means still 44% fly ash is unused, will be create more environmental problems.

**(ii). Progressive Fly Ash Generation and Utilisation during the Period from 1996-97 to 2014-15**

Central Electricity Authority has been monitoring since 1996-1997 the fly ash generation and its utilization at coal/lignite based thermal power stations in the country. Based on data of fly ash generation and utilization received from Thermal Power Stations/Power Utilities since 1996-97, the progressive fly ash generation and its utilization for the period from 1996-97 to 2014-15 is given in below graph (figure 2), which shows that at present the total production of fly ash is 184.14 million tons (MT) but utilisation is only 102.54 MT that means 82 MT fly ash (44.31%) still unused. The graph also shows that quantities of fly ash generation during 2012-13, 2013-14 and 2014-15 have been 163.56, 172.87 and 184.14 million tonnes respectively, indicating there in gradual increase in fly ash generation but utilization during the said three years are 100.37, 99.62 and 102.54 million tonnes, indicating slight variation.



**Figure 2.** Fly-ash generation and its utilisation in Million Ton for the period from 1996-97 to 2014-15 (Source: CEA, Annual Report 2015)

**Table 4.** State wise fly ash generation and utilisation (Source: CEA Report 2015)

Sl. No	Name of state	Numbers of Thermal power stations	Installed Capacity (MW)	Fly Ash Generation (Million tonne)	Fly Ash Utilization (Million tonne)	Percentage Utilisation %
1	Andhra Pradesh	6	7610	13.80	7.870	57.01
2	Bihar	4	4100	6.22	1.752	28.20
3	Chhattisgarh	15	12740	21.92	8.60	39.24
4	Delhi	2	840	0.94	1.07	114.75
5	Gujarat	11	15212	7.83	5.92	75.48
6	Haryana	5	5987.80	6.62	4.35	65.86
7	Jharkhand	7	5307.50	6.88	7.09	103.22
8	Karnataka	4	4780	8.46	2.20	26
9	Madhya Pradesh	7	10280	13.84	5.44	39.34
10	Maharashtra	19	18336	18.63	11.12	59.73
11	Odisha	5	5188	10.02	4.91	49
12	Punjab	3	2640	2.67	2.26	84.92
13	Rajasthan	7	6640	8.07	6.50	80.52
14	Tamilnadu	12	9150	7.67	5.63	73.20
15	Talanganana	5	2832	7.13	2.20	31
16	Uttar Pradesh	16	14804	24.37	10.78	44.30
17	West Bengal	17	12468	19.08	14.80	77.52
<b>Grand Total</b>		<b>145</b>	<b>138915.80</b>	<b>184.15</b>	<b>102.53</b>	<b>55.69</b>

#### (iv). Indian Utilisation of Fly Ash in Cement Industry

The Indian cement industry is the second largest market after china accounting for about 8% of the total global production. Manufacturing of cement is most important sector and it take king share in utilisation of fly ash in India [8]. Many previous studies showed that fly ash as a pozzolanic material, is effective for improving the various properties of concrete. Owing to its pozzolanic properties fly-ash is used as a replacement for some of the Portland cement content of concrete. The current utilization of fly-ash in cement industry is 42.26% [3]. The industry has a current installed capacity of more than 380 million ton per annum with cement production about 272 million ton per annum and operates at 75-80 per cent utilisation [9].

It is expected that the cement industry will continue to increase their annual cement output in coming years and the country's cement production will grow at a

#### (iii). State Wise Fly Ash Generation and Utilisation

The state wise status of fly ash generation & utilization in India based on data in below table 4. shows that seven states namely Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Uttar Pradesh and West Bengal have generated more than 10 million-ton of fly ash with Uttar Pradesh as the maximum of 24.3755 million ton during the Year 2014-15. In the Year 2014-15, Union territory of Delhi and state of Jharkhand has achieved fly ash utilization level of more than 100 % and the States of Gujarat, Punjab, Rajasthan, and West Bengal achieved the fly ash utilization level of more than 75 %.

compound annual growth rate (CAGR) of more than 14% during 2013-14 to 2015-16 [10].

**Table 5.** Expected Fly-ash absorption in cement (MTPA) (Source: WBCSD/CSI/LOW Carbon technology road map for Indian cement industry)

Sl No.	Year	Expected Fly-ash absorption in Indian Cement Industry ( million tons per annum)
1	2015	52.65
2	2020	73.01
3	2025	94.63
4	2030	120.50
5	2035	143.72
6	2040	158.02
7	2045	167.74
8	2050	177.54

#### (v). Attempts for Fly Ash Utilisation In India

In India at least for next 25 years coal would continue to remain as major source of energy, it is expected to

increase fly ash generation. The FA, which is a resource material, if not handled properly, may cause environmental challenges. Fly Ash Utilisation Programme (FAUP), Ministry of Power (MOP) and Ministry of Environment & Forests (MOEF), wherein Department of Science & Technology is the nodal agency and Technology Information, Forecasting and Assessment Council (TIFAC) is the implementing agency. Fly ash utilisation program has been undertaking various attempts for the technology development, creating awareness, facilitating multiplier effects, policy interventions etc. in the area of safe management & gainful utilisation of fly ash [11]. (Figure 3) shows some fly ash mission project site undertaken by fly ash utilisation program. At present FA utilization in India has reached to the level of about 56% [3]. The policy guidelines in India encourage the use of at least 25% ash in clay bricks manufactured within a radius of 100 km from coal and lignite based [12]. There is a need to use 100% utilisation of fly ash to protect from environmental threat for coming generation.

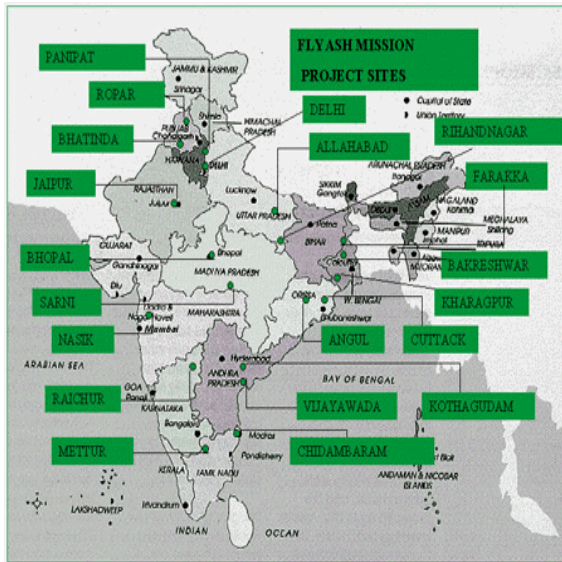


Figure 3. Fly ash mission project site (Source: <http://www.tifac.org.in>)

#### 4. Result and Discussion

The major sources of power generation in India through coal based thermal power plants, resulting in coming year a huge quantity of fly ash will be generated, and hence need to be more utilisation of fly ash is an important concern to protect the environment. According to planning commission 2014, Fly ash generation is expected to increase to 300 million tons per annum by 2017 which is approximately double than the quantity produce now so there is a need to be consume more quantity of fly ash to safeguard the cleaner environment. As per CEA report 2015, The highest level of fly ash utilization of about 62.6% was achieved in the year 2009-10 and it is, however, 55.69 % in the year 2014-15. The utilization is behind the target, it would

require a lot of efforts to achieve the target of 100% utilization of fly ash as stipulated in Ministry of Environment and Forest Notification of 3<sup>rd</sup> November, 2009. The utilization of fly ash is not commensurate with fly ash generation and that is why there percentage decrease. The stipulations of notification of 2009 and recently proposed amendment should be effectively implemented. For 100% fly ash utilisation level a few strategies need to be adopted which are given below:

- Thermal Power Stations have to ensure the utilization of fly ash and fly ash based building products within the thermal power station for the development of infrastructure like construction of buildings & roads, reclamation of low lying areas, the raising of ash dyke etc.
- Thermal Power Stations have to explore and promote all possible modes of fly ash utilisation at their respective thermal power station for increasing the fly ash utilisation in the country in line with ministry of environment and forest notification of 3<sup>rd</sup> November, 2009.
- Use of fly ash in the construction of embankments for laying railway lines has also significant potential for large scale utilisation of fly ash. There are safety concerns in use of fly ash in the construction of railway embankments having passenger traffic. There is a need to address these concerns by carrying out necessary studies by organizations like RDSO, a research organization under the Ministry of Railways.
- Further increase in utilization of fly-ash in other sector such as cement, roads and embankment, agriculture, mine filling, reclamation in low lying area would definitely fulfil the more and more utilisation of Indian fly-ash.

#### 5. Conclusion and Future Enhancement

Current paper gives brief idea on present status of fly ash generation at major coal/lignite based thermal power stations and its utilisation in the India. Present study will be useful to all the stakeholders involved in fly ash management for planning the utilisation of fly ash in the India. Fly ash being an environmental pollutant, yet is an important raw material for different applications. Efficient utilisation of fly ash in different sectors can be a great help for the development of new technologies. Many researchers have shown that fly ash can be effectively used in cement and concrete due to its pozzolanic properties. Thus need to be using more fly ash than current in cement and concrete sector to achieve the target of 100% utilisation of fly ash in India.

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