A Review on Indian Coal Power Plants and it's Impacts

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***Abstract*—This paper presents an over view of Indian coal fired power generation, classification of coals, properties of coal, growth in thermal power plant according to five years plan of India and growth in coal consumption capacity for power generation and its emission impacts on environment. It also describes the emission measurement process, controlling of coal, resources of coal and different approaches to reduce emissions of thermal power plant and finally the merits and demerits of coal fired power plants.**

Keywords—coal; emission; mesarement; impacts; merits and demerits;

1. INTRODUCTION

As per recent data India remains the 5th largest consumer of electricity in the world. Coal is the primary fuel for electricity generation in countries like India, China and across world, the coal and nuclear usage is continuously increasing to meet the energy demands of the country. Nuclear power plants will produce less emission but disposal of ash content and cost of the fuel are the main issues. Therefore, Coal fired power plants occupies more than 65% of the power demand. Indian coal contains a high ash content of around 30-40 percent with average calorific value of 4000 kcal/kg and average sulphur content of 0.35 percent. Power generation projects, which require not only huge capital investment but also various natural resources like, fossil fuels and water, suitable site, transportation and engineering technology. Thus make considerable impacts on the environment and generate remarkable stress in the local eco-system. From the below figure we may recognize more than half of the power generation capacity by the coal burned plants, these coal fired plants produce green house gases like Carbon dioxide (CO_2), Sulphur dioxide (SO_2) and Nitric oxide (NO) that creates global warming. Pollution from coal plants resulted in 85,000-115,000 premature deaths in 2011-2012. [1-6]

Table 1.Growth of installed capacity in thermal power since 6th Plan

Plan/Year	Thermal			
	Coal	Gas	Diesel	Total
End of 6th Plan	26310.83	541.50	177.37	27029.70
End of 7th Plan	41237.48	2343.00	165.09	43745.57
End of 8th Plan	54154.48	6561.90	293.9	61010.28
End of 9th Plan	62130.88	11163.10	1134.83	74428.81
End of 10th Plan	71121.38	13691.71	1201.75	86014.84
End of 11th Plan	112022.38	18381.05	1199.75	13603.18
End of Feb '14	140723.39	21381.85	4172.69	163304.99

Table 2.All India yearly Coal Consumption for Power Generation (Utilities)

Year	Coal consumption in million tones
2004-05	278.00
2005-06	281.00
2006-07	302.00
2007-08	330.00
2008-09	355.00
2009-10	367.00
2010-11	387.00
2011-12	417.56
2012-13	454.60

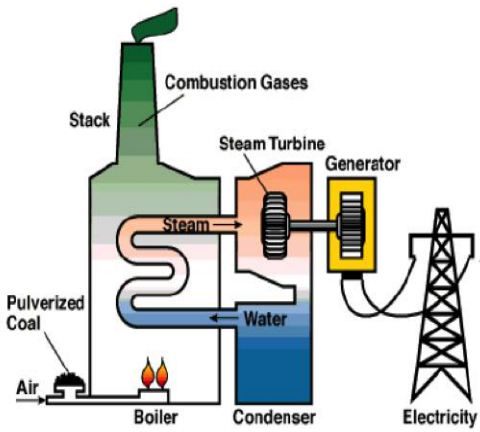
A comparative changes have been done in thermal power stations from 6th Indian five year plan up to end as on 28-02-2014.The usage of coal in million tonnes is also increase as shown in above table[5].

2. COAL CONTROL AND COAL RESOURCES

The Ministry of Coal effectively finds out all matters that are relating to the production, storage, supply, distribution and sale price of coal. The Ministry of coal is including Coal India Limited (CIL), Singareni Colliery Company Limited (SCCL), and Neyveli Lignite Corporation (NLC). India has an estimated 22,400 square kilometres (sq. km) of potential coal bearing area. Most of the major coal deposits are Gondwana coals in the eastern and south eastern parts of India; the Tertiary coals are located in Assam and other north eastern states, as well as Jammu and Kashmir. Indian coal is primarily bituminous and sub-bituminous; there are nearly 36 gigatons (GT) of lignite resources in Tamil Nadu, Gujarat, Rajasthan, Jammu and Kashmir (Ministry of Coal, 2006a).

3. COAL FIRED POWER PLANT

3.1 Coal Power



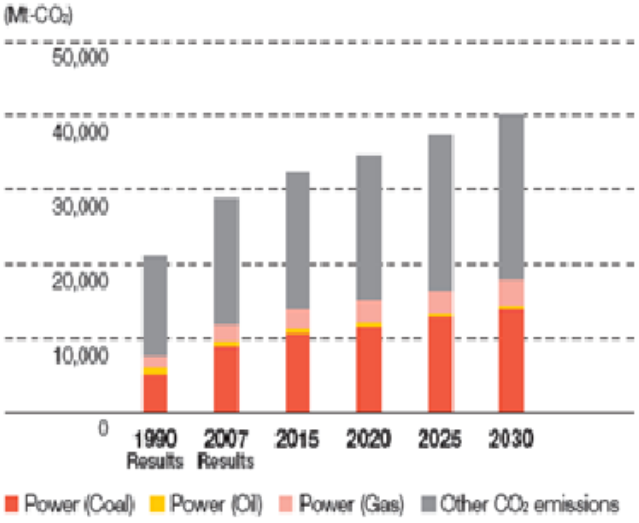
The current power sector in India is dominated by coal-based generation and remains largely under government control. India's generation of electricity using coal began as early as 1899, with the 1 MW Emambaugh Lane power station in Calcutta. Just after India's independence, there were 65 projects, nearly all in the private sector. These projects generated electricity using coal-fired steam generators for public supply with an installed capacity of 1 GW, which accounted for 60% of total capacity (CWPC, 1951; Planning Commission, 1952).

Hussain Sagar Thermal Power Station is the historic thermal power plant that was located in Hyderabad, Andhra Pradesh on the banks of Hussain Saga in 1920. The 4,620MW Mundra Thermal Power Station located in the Kutch district of Gujarat is currently the largest operating thermal power plant in India. It is a coal-fired power plant owned and operated by Adani Power. Presently more than 85 thermal power plants are operating in India. In thermal power plant coal is used as a fuel for producing steam, and then steam runs the turbine that intern coupled with generator that produces electricity. Due to burning process of coal emission are produced.

Major emission from thermal power stations are fly-ash, carbon ash, smoke, dust and irritating vapours like carbon dioxide(CO_2), Sulphur dioxide(SO_2)and nitrogen oxide(NOx). Emissions are creating hazards to human and environment when exceeds particular limit.

Fine dust particles normally spread over 15 to 25 Kms from the Thermal Power station. These pollutants cause respiratory and related nourishment to human beings and animal kingdom. Because of deposition of SPM on the plants, photosynthesis process of plants is affected very badly. These particles penetrate inside the plants through leaves & branches thereby creating imbalance of minerals & micro and major nutrients in the plants. All these affect the plant growth very badly. Due to this no big industrial zone is developed within 20 Kms radius of the source and the habitations too are facing severe problems. Spreading & deposition of SPM on soil disturbs the contents of minerals, micro and major nutrients. Continuous and long term deposition of SPM causes the fertile and forest land to be unproductive for plants & farming.

Due to continuous & long lasting emission of carbon dioxide (CO2), sulfur dioxide (SO2), and nitric oxide (NO) which are the principal pollutants coal based plants, surrounding structures, buildings, monuments of historic importance & metallic structures too are affected very badly due to corrosive (Acid rain) reactions. Well known example of this is the victimized Tajmahal of Agra which is being deteriorated due to these toxic gases. It is also worth to note that very high amount of carbon dioxide (CO2) emission (0.9-0.95 kg/kwh) from thermal power plants contribute to global warming leading to climate change. The world Estimated Energy-derived CO_2 Emissions Volume by Emissions Source is shown in figure.



4. COAL CLASSIFICATION

Coal is classified into three major types viz., lignite, bituminous and anthracite. However there is no clear differentiation between them and further we can classified coal as semi-anthracite, semi-bituminous, and sub-bituminous. Anthracite is the oldest coal from geological perspective having higher calorific value. It is in the form of hard with lower volatile contents and negligible amount of moisture contents. Lignite is the youngest coal from geological perspective. It is in the form of soft and mainly contains volatile matter and moisture content with low fixed carbon. Classification of coal on the basis of calorific value is shown in the table normally D, E and F coal grades are available to Indian Industry

Table 3.Typical proximate analysis of various coals (in percentage).

Parameter	Indian coal	Indonesian coal	South African coal
Moisture	5.98	9.43	8.5
Ash	38.63	13.99	17
Volatile matter	20.70	29.79	23.28
Fixed carbon	34.69	46.79	51.22

Table 4.The gradation of Indian coal based on its calorific value is as follows:

Grade	Calorific Value Range (in k Cal/kg)
A	Exceeding 6200
B	5600-6200
C	4940-5600
D	4200-4940
E	3360-4200
F	2400-3360
G	1300-2400

5. PROPERTIES OF COAL

The properties of coal are broadly classified as [1].

5.1. Chemical Properties

i. Proximate Analysis

ii. Ultimate Analysis

Coal comes in four main types; lignite (brown coal), bituminous (black coal), anthracite and graphite. Each type of coal has different moisture and volatile contents.

i. Proximate Analysis

Determinations of moisture, volatile-matter, ash and fixed carbon content of coal. Moisture is mainly due to groundwater and expose to moist air. Volatile matter in coal refers to the components of coal, except for moisture, which are liberated at high temperature in the absence of air. Ash content of coal is the non-combustible residue left after coal is burnt. Fixed Carbon: The fixed carbon content of the coal is the carbon found in the material which is left after volatile materials are driven off.

ii. Ultimate Analysis

Determination of total carbon, hydrogen, nitrogen, oxygen and sulphur percentages in coal comprises its ultimate analysis.

5. 2. Physical properties

The physical properties of coal determine the Specific Gravity, Densities Angle of Repose, Specific Heat, Porosity, Surface area and Heat of Wetting.

5.3. Thermal properties

When a sample of powdered coal is heated out of contact with air, it loses occluded gases consisting of methane, ethane, nitrogen, carbon dioxide etc at temperatures below 100˚C.

5.4. Plastic properties

When coal is heated, it passes through a transient stage which is called as plastic state (caking). If a particular coal does not pass through a plastic state, it is called sintered mass(non-coking).Plastic properties of coal is determined by caking index test, free swelling test, GKLT, Plastometer.

6. A METHOD OF ESTIMATING EMISSIONS

In this approach, the total amount of CO_2 generated during the life of a power plant is calculated by adding the CO_2 generated during construction and decommissioning to the CO_2 generated from burning fossil fuels and from operation and maintenance (O&M) of the plant. The CO_2 generated during the construction of a power plant is calculated by multiplying the primary energy investment in each component of the plant by the average CO_2 production per unit of primary energy used by the U. S. Energy infrastructure. The CO_2 production per unit of primary fossil energy for coal, oil, and natural gas is calculated from the carbon content and the stoichio metric equations of combustion for each of the fossil fuels. Carbon dioxide production from coal, oil, and natural gas has been calculated by several sources, including the U.S. Department of Energy (DOE). the results of these calculations agree within 10%. One reason for this discrepancy is the difference in assumptions about the carbon content in fossil fuels and the coal chemistry.

7. METHODS OF REDUCING EMISSIONS

There are several methods are available to reduce emission from thermal plant. Out of that effective methods as follows.

1. Fuels are used with low emission potential.
2. Increase the efficiency of existing system with new technologies.
3. Integration of wind/solar systems.
4. Modify the existing power dispatch strategies

In the first process the fuels are used should be less emission usually these are classified in to solid, liquid and gaseous. Normally in thermal power plant coal is a major fuel expect in some situation oil and gas are used. Peat, lignite, bituminous, semi-bituminous, semi-anthracite and anthracite

are classification coal classes depending on their heat output and produces varying limit of emission. The ash content and emission can be reduced by pre-treating process.

The existing plant efficiency can be increased in second process, here the efficiency of heating process, boiler, turbine and generator can be increased it reduces the drastically change in emission production.

In third approach integration with renewable sources like solar, wind power is done. The only requirement of this approach is the sufficient natural resources like solar radiation, minimum wind speed is present at vicinity of thermal power plant.

In fourth approach modifying existing power dispatch strategy with suitable constraints are included. Optimal output of generator will be obtained with minimum fuel cost, low emission and less transmission loss.

8. IMPACTS OF COAL FIRED POWER PLANTS

8.1. Impact on water

For coal fired power plant huge amount of water is needed for producing steam, cooling and cleaning process. The water requirement for a coal-based power plant is about 0.005-0.18 m3/kwh. Leach of stored water from used water storage pond, which may contains heavy metals like Boron (B), Arsenic (As) and Mercury (Hg). There is a possible chances mix with natural water sources like river, pond and cannel this causes harmful to the fisheries and other aquatic biota in water body. It is unsuitable for domestic use and underground water gets polluted.

8.2. Impacts on Noise

The coal fired power plants consists of several conveyors, electric drives, boiler and steam turbine and steam exhaust system with high pressure, here exposure of employees to high noise levels that is greater than audible range. Due to noise employ cannot concentrate and some time feels Headache, loss in hearing capacity. For coal transportation heavy vehicles are used that may creates noise in local environment.

8.3. Impact on land

The land requirement per mega watt of installed capacity for coal is 0.1-4.7 hectare. If it is near to coal mines the coal transportation is easier. The land was used to dispose ash from the coal based plants. Therefore more area of land is required for coal based thermal power plant. Due to this processes of ash dispose, the natural properties soil gets changes.

8.4. Biological & thermal impact

The effect on biological environment can be divided into two parts, viz., the effect on flora and the effect on fauna. Effect on flora is due to two main reasons, land acquisition and due to flue gas emissions. Land acquisition leads to loss of habitat of many species.

The waste-water released by thermal power plant is at higher temperature (40-50^{o}C) when this discharged water mix with local water body can harm the local aquatic biota. It reduces the oxygen content by the water source that's leads to effect on local water family.

8.5. Socio-economic impact

The effect of power plants on the socio-economic environment is based on three parameters, viz. Resettlement and Rehabilitation (R & R), effect on local civic services and work related hazards to employees of the power plants. The development of civic amenities due to the setting up of any power project is directly proportional to the size of the project. The same has been observed to be the highest for the coal based plants followed by the natural gas based plant and lastly the hydroelectric plant. The coal based plant has the highest number of accidents due to hazardous working conditions [4].

9. MERITS & DEMERITS OF THERMAL POWER PLANT

9.1. Merits of thermal power plant

1.Fuel used is cheaper comparing nuclear
2.Smaller space is required compared to hydro power plant
3.Economical in initial cost compared to hydro plants and running costs are less compared to gas plants or diesel plants
4.Thermal plants can be placed near load centers unlike hydro and nuclear plants. Hence transmission of power losses can be minimized
5.Thermal plants are able to respond to the load demand more effectively and supports the performance of the electrical grid
Steam plants can withstand for overload for certain extent

9.2. Demerits of thermal power plant

1.Higher maintenance and operational costs
2.Pollution of the atmosphere
3.Huge requirement of water
4.Handling of coal and disposal of ash is quite difficult and requires large area
5.Gestation period (period for commissioning of plant) takes long time
6.Efficiency of thermal plant is quite less (30-35%)
7.Operational cost of thermal plant is more costlier compared to hydro and nuclear plant

10. DISCUSSION

More than half of the power demand is from coal fired power plants. These types of plant requires huge amount water, land, transportation, technology etc.., but due to coal burnt higher emissions are produced comparing nuclear power plant, due this emission a considerable changes has been made in local temperature, global temperature, animal kingdom, and on environment. Population growth is also one of the reasons for increase of emission.

Indian coal contains higher percentage of ash content with lower calorific value. The operating efficiency of the existing coal fired power plant is usually less

comparing United States coal fired power plants. Number of emission controlling methods is available by evaluating effectiveness of the method we can implement to the emission reduction process.

11. CONCLUSIONS

As the power demand increases by the society it should be met by energy sources with less emission and cheaper in price. Several technologies are available to mitigate the emission process each have their own limitations. It should be noted that several policies are implemented to modify the output of emissions and its impacts on nature. Therefore several studies have to be made on fuel cost minimization, emission minimization. With combined (co-generation) generation and electrostatic precipitator technology the value of emission output can be reduced at minimum level.

This paper describes the different types of coals with their properties and its emission impacts on the environment system. And various approaches available to mitigate emission levels finally with related merits and demerits of coal fired power plants.

12. REFERENCES

[1]. Anudhyan mishra., "assessment of coal quality of some indian coals" national institute of technology rourkela - 769008 in 2009.

[2]. Coal Kills; An Assessment of Death and Disease caused by India's Dirtiest Energy Source, Conservation Action Trust.

[3] "A Resource and Technology Assessment of Coal Utilization in India" , Ananth P. Chikkatur, Kennedy School of Government, Harvard University, Cambridge, MA October 2008.

[4] "Effects of thermal power plant on environment" by W. K. Pokale scientific reviews & chemical communication.

[5]. "Government Of India Executive Summary Power Sector February-2014" Ministry of Power Central Electricity Authority New Delhi.

[6]. "Increasing the Efficiency of Existing Coal- Fired Power Plants" Richard J. Campbell Specialist in Energy Policy December 20, 2013

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