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# An Innovative Approach of Pulverized Coal Combustion By Plasma Technology In India

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**Abstract:**
The plasma technology is one of the most promising technology which is emerging in this new era. In India most of the power and electricity is generated from the thermal power plants and coal is the main solid fuel which is used in this process. This paper focuses on the study and approach of pulverized coal combustion by the use of plasma fuel system(PFS) to increase the efficiency of the flame inside the boiler in thermal power plant and reduce harmful emissions from of all types coal (peat, bituminous, anthracite and their mixture etc.).

***Keywords*** **—** Coal, thermal power, plasma, plasma fuel system**.**

## I. INTRODUCTION

Due to the rapid growth of human population there is growing demand of thermal power and electricity in most of the countries all over the world and India is not an exception. More than 62% of the India's electricity demand is met through the countries vast coal reserves [1].

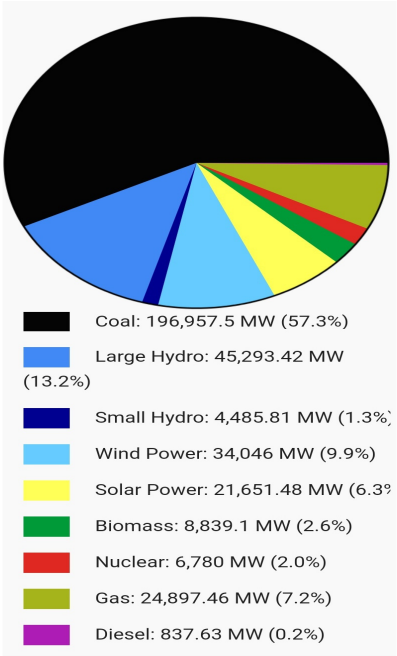


Fig. 1 Installed capacity by source in India

Mostly bituminous and lignite are widely used as commercial coal in thermal power plants due to their huge availability in all parts of the country. The problem arises as India's coal is of low caloric value and high ash content and the carbon content is also low. Due to this reason India imports a large amount of coal from other countries. India is now the third largest importer of coal in the world [2]. To overcome these issues the plasma treatment of coal can be done in a plasma fuel system where the coal will be preheated and combusted before entering the main chamber of the boiler in thermal power plant. In this way the efficiency of the combustion of coal can be increased and generation of electricity will be maximum.

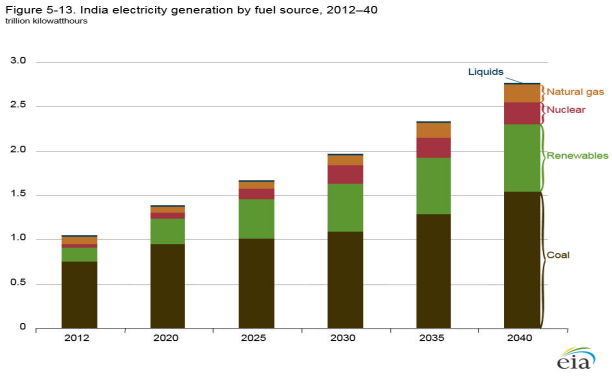


Fig. 2 India's electricity generation from 2012 -2040

## II. PLASMA TREATMENT OF COAL COMBUSTION

The plasma fuel system is based on the thermochemical fuel conversion for combustion and gasification of a low grade coal used in the thermal power plant. The core part of plasma fuel system is arc linear plasmatron which consists of copper

water cooled electrodes through which the plasma air flame is blown [3]. In this process a part of the pulverized fuel (PF) is separated from the main PF flow and is fed into a special chamber with plasmatron which undergoes activation by the plasma arc. The air plasma flame generates extreme temperature enriched with radical and it heats the air-coal mixture. The volatile components from the coal are extracted and the coal gets partially gasified. This active mixture can ignite the main pulverized fuel supplied into the furnace which helps in the stabilization of the PF flame and eliminates the necessity of additional high reactive fuel [4].

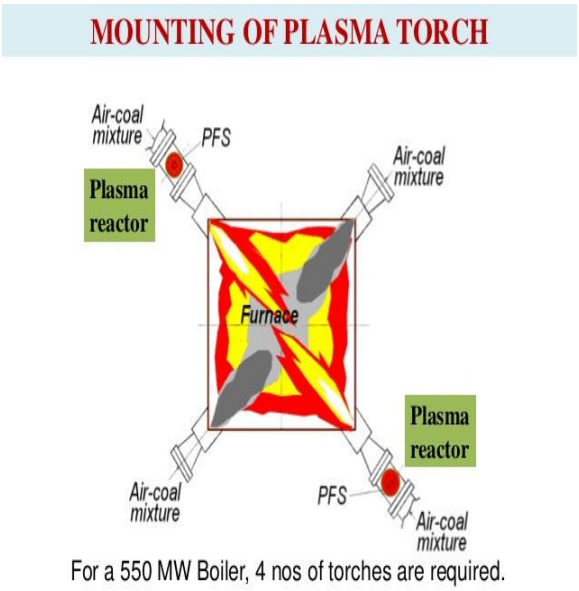


Fig. 3 Combustion of air-coal mixture in boiler

Messerle et al. demonstrated the processes of coal combustion by the plasma assisted one complex of two software codes (PLASMA-COAL and CINAR ICE). These codes applications allowed in investigating the processes of coal plasma assisted combustion. Plasma activation of coal combustion increases efficiency of its incineration, decreasing unburned carbon concentration and nitrogen oxide formation which in turn increases economy indexes of thermal power plant. Power consumption for PFS does not exceed 2% from heat Capacity of the reequipped pulverized-coal burner. The maximum temperature reached by the flames is 1600 degree Celsius and furnace characteristics was improved due to the 34% reduction of nitrogen oxide emission [3-4].

Karpenko et al. demonstrated that this technology is based on plasma thermo-chemical preparation of coal for burning and allows substituting of fuel oil or gas by coal. The plasma flame temperature can reach from 4000-6000 degree Celsius. The operation was done with a 200KW plasmatron power and the air coal mixture temperature raised about 362k. The total amount of coal consumption was about 6000kg/h and it was seen that all the volatile substances inside the coal got extracted after the process [5].

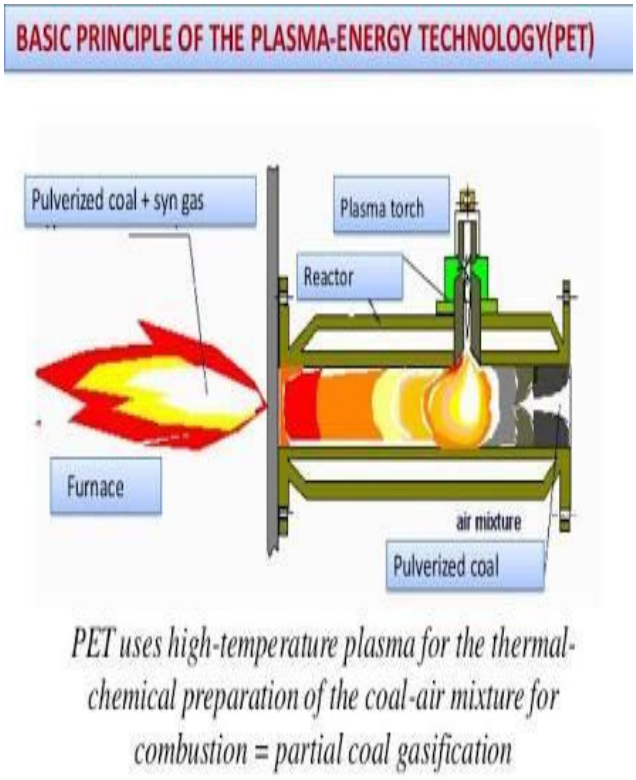


Fig. 4 A typical design of plasma fuel system and furnace

Askarova et al. studied that the plasma activation promotes more effective and environment friendly low rank coal combustion. This technology is tested successfully on 27 pulverized coal boiler for productivity of steam ranging from 75 to 670 t/h in 16 thermal power plant located in 7 countries (Russia, Kazhakathan, Koria, Ukrain, Slokovia, Mongolia and China). Two fluid dynamics kinetic model has been used and numerical simulation of the experimental data was done proving the reliability and efficiency of this technology [6].

Karpenko et al. demonstrated that more than 90 plasma ignition system were installed and tested in countries like Russia, Korea, Ukraine, Slokovia, Kazhakathan, Serbia, Mongolia on 30 boilers having a steam capacity of 75-670 t/h which are equipped with different pulverised fuel system. The study also shows a comparative characteristics between the existing and new technology [7].

| Existing technology | Plasma technology |
|---|---|
| Fuel oil consumed 5.1*10^6 t/y | Fuel oil consumed is 0 |
| Capital investment in TPP is 100 % | Capital investment in TPP is 3-5% |
| Operating cost 100% | Operating cost 28-30% |
| Electrical consumption is 3-5% | Electrical consumption 0.5-1% |

Table 1.Comparative study of existing and plasma technology operated in Russia and other countries.

Yazicioglu et al. stated that plasma technology can be used in different sectors from waste gasification system to production of energy from coal etc. The study also shows the use of different plasma torches like dc arc plasma torches, radio frequency (RF) plasma torches and alternating current (AC) plasma torches. The general system efficiency which is to be calculated is defined as the ratio of the net generated electricity to the energy input of the system [8].
Bhanarkar et al. studied the amount of fly ash emitted from the electrostatic precipitator (ESP) inlet and outlet of a coal fired power plant operated at a power of 120MW and 210 MW. The efficiency of the ESPs was found to be 95.7% to 99.8%. The particle size distribution was same for all samples of ESP inlet from different boilers of thermal power plant [9].
Kanilo et al. studied about the coal ignition and combustion by means of a microwave plasma generator operated at 2.45 GHz frequency and power
4.5 KW. The result shows the reduction of volatile particles like CO, CH4, CO2, H2, NOx, SO2 etc. The degree of sulphur conversion is 21-24% and it is transferred into SO2 depending upon the combustion [10].

## III. ADVANTAGES

- Plasma ignition of coal eliminates the need for the use of any supplemental fuel.
- Plasma ignition of coal enables unit to operate at ~10% load with stable flame with a variety of coal qualities.
- Plasma ignition of coal improves boiler efficiency and decreases harmful NOx emissions
- Electrostatic precipitator can be put into service during start up and hence damage to ID fan Blades and Black Smoke can be avoided.
- After retrofitting we will get clean development mechanism benefits due to reduction in Greenhouse gas emissions.
- With Plasma guns, un-burnt carbon can be reduced from 1.4% to 1.0%
- Savings in Fuel oil pump house (FOPH) and boiler front maintenance costs.
- The initial capital cost is also low from the existing technology.
- Furnace characteristics increases.
- The generation of electricity increases to a maximum amount due to proper combustion of coal.
- The maintenance and operating cost of the plant decreases to a much lower level.
- The volatile materials present inside the coal gets removed.
- The slag which is generated after the complete combustion has no toxic level and can be further used by different industries as aggregates.

## IV. COST ESTIMATION

The cost of setting up a thermal power plant is 5 to 6 crore per MW. So the estimated cost of 10MW power plant is around 50 to 60 crore [11].
As per the CERC guidelines capital cost of Fuel oil pump house (FOPH) for a 2X500 MW plant = Rs 50 Cr**.** (0.05Cr/MW*). As per vendor information, capital cost for providing Plasma ignition and combustion system (PICS) for 2x500MW plant = Rs 13.8 Cr. Savings in capital cost = Rs 36 Cr [12].
The other costs which are included are cost of land, cost for the power evacuation, cost of machineries, cost of maintenance and operation, cost of getting various approvals like environmental clearances, coal linkage, cost of consultancy for the project etc.
In case if it is an addition to an existing power plant in the same premises then the cost of setup will be lower.

## V. ANALYSIS AND DISCUSSION

Coal is available all over India but as the quality of the coal is degrading day by day the combustion of these low graded coals is faced by most of the thermal power plants. The treatment of coal by plasma fuel system for the generation of power and electricity in India can be a big step in the path of development. Almost all types of volatile contents are removed and half amount of the coal is partially ignited through this process for complete combustion of the whole material. The slags generated lose their toxicity and efficiency of the furnace system is increased. This technology is still developing in most of the other countries and to set it up in a developing country like India proper planning and suitable land for infrastructure is needed. Trained technicians, engineers from different field and labours are also needed to maintain this type of advance technology.

## V. CONCLUSION

The use of Plasma technology in the thermal power plants for the combustion of pulverised coal can bring new possibilities in the generation of power and electricity to a much higher extent. The economy and financial status of the country will rise up eventually. As per the present scenario the

government of India is making plans and projects to develop the different power sectors located in various parts of the country. Initiative can be taken by the government or any private sector for the implementation of this plasma technology in different thermal power plants. Already many incentives are available for the development of this type of technology which can bring change in the future generation.

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