A STUDY ON FLUIDIZED BED COMBUSTION SYSTEM IN COAL BASED CENTRAL HEAT PLANTS

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ABSTRACT:

Fluidized Bed Combustion (FBC) technology involves burning sulfur-containing fuel particles suspended in an air stream. Industries and other sectors are more dependable on energy to run their machines. To equalize the economic growth as well as environment protection by decreasing the use of unsustainable energy resource which play a crucial role in the emission of greenhouse gases and other pollutant product which are majorly responsible for the global warming and climate change. In India, most of energy comes from coal thermal power plant as it has abundant amount of coal and it is cheaper for industries to produce electricity from it. However, it is also an important source of harmful gases such as CO_{2},, NOx et. The atmospheric scheme is considered feasible at present, although not without risk, but doubt is expressed concerning the pressurized scheme as a consequence of the early stage of development. Although FBC boilers are economically competitive with conventional coal fired boilers and offer greater fuel flexibility, FBC boilers firing coal are not competitive with oil or gas in the current energy market.

Keywords: *Fluidized Bed Combustor, Power Plants, Coal Power*

INTRODUCTION:

FBC involves burning sulfur-containing fuel particles suspended in an air stream, which causes them to behave like a fluid. The bed of particles is normally only about 10 percent fuel; the remainder is inert materials and sorbent (dolomite or limestone), which is used to capture up to 90 percent of the sulfur. This sorbent is continually injected into the bed while a gravity drain system withdraws spent material and ash particles. Combustion also occurs at relatively low temperatures (14(X) to 15(X) 'F), which maximizes sulfur capture. This low bed temperature also reduces NOx emission while minimizing clinker (a hard mass of fused furnace refuse) formation. Fly ash and spent sorbent are removed from the stack gas by particulate collectors. This technology is very insensitive to the fuel quality, allowing solids with a widely varying calorific value to be burned. Typically, FBC Technology is applied in new plants, but recent developments of a shallow bed FBC system by Wormer Engineering. Inc. has shown that it may also be used as a retrofit technology. The steam produced by FBC ranges from low-pressure process steam to superheated high-pressure steam. FBC has also been applied to cogeneration where high-pressure steam drives turbines to generate electricity. Low pressure steam from the steam turbines is then used for process applications.

Types of Fluidized Bed Combustion Boilers:

- Atmospheric classic Fluidised Bed Combustion System (AFBC)
- Atmospheric circulating (fast) Fluidised Bed Combustion system (CFBC)
- Pressurised Fluidised Bed Combustion System (PFBC)

COAL TECHNOLOGY:

Fluidized Bed Combustion (FBC) uses fine coal particles suspended in air. Solid coal behaves as a fluid at high pressures and allows rapid transfer of heat which increases the efficiency of the burning process because the movement of coal carries a steady supply of hot particles to the surface. The heat is take out and consume in a conventional power generation cycle. It operates at inferior temperatures than the Pulverized Fuel (PF) process, and hence, reduces NOx release in the atmosphere.

Major performance features of the circulating bed system are as follows:

- Sulphur present in the fuel is retained in the circulating solids in the form of calcium sulphate and removed in solid form. The use of limestone or dolomite sorbents allows a higher sulphur retention rate, and limestone requirements have been demonstrated to be substantially less than with bubbling bed combustor.
- The combustion air is supplied at 1.5 to 2 psig rather than 3–5 psig as required by bubbling bed combustors.
- It has high combustion efficiency.
- It has a better turndown ratio than bubbling bed systems

LITERATURE REVIEW:

Toni Pikkarainenet. al. [3] get the worst sulphur capture in oxygen combustion was measured in direct sulphur capture conditions, where high CO2 partial pressure in low temperature prevents the calcinations of CaCO3. Therefore the design of the furnace heat transfer and temperature levels has significant effect on in-furnace sulphur capture in CFB combustor, especially in oxygen combustion conditions. At comparable conditions in oxygen combustion the feed gas oxygen content or oxygen staging (to primary and secondary feed gases) had no remarkable effect on SO2 capture or emissions of nitrogen oxides.

G. Hofbaueraet. al. [4] Experiments for oxy-fuel combustion of bituminous coal in a circulating fluidized bed were carried out. A mixture of oxygen and re circulated flue gases was used as the fluidizing agent. No constraints regarding the stability of the facility and the combustion process could be found.

PichetNinduangdeeet. al. [5] conducted an experimental investigation in which he successfully test the burning oil palm shells at fuel feed rates of 45 kg/h and 30 kg/h, while ranging excess air from 20% to 80% for fixed combustor load and concluded that operating conditions (fuel feed rate and excess air) have effects on the behavior of major gaseous pollutants (CO, CxHy and NO) inside the combustor, as well as on its emissions and combustion efficiency; at the rated combustion load, high (about 99%) combustion efficiency can be achieved when burning oil palm shells at excess air of 60% ensuring acceptable levels of CO and NO emissions from the combustor; no bed agglomeration occur in the combustor when using dolomite as the bed material, as has been shown by 30-h combustion testing; compared to original dolomite, the reused bed material shows a decrease of mean diameter size in the course of the time; fine powder formed during dolomite calcination adhere to the large particles of the bed material.

Jan Skvarilet. al. [6] conducted an experimental measurement (i.e. combustion flue gas temperature and concentration of O2, CO2, CO, and NOX) at different points in the full-scale biomass-fired bubbling fluidized bed boiler. Results of the constructed profiles from the furnace indicate the intermediate stage of thermo chemical reactions and show that the thermo chemical reactions peak at the center of the furnace and combustion intensity decrease towards the wall. Furthermore, increased levels of CO concentration close to the wall have been found in the vicinity of port SHE.

Pankaj Kalitaet. al. [7] conducted experiments at four different percentages blending of biomass such as 2.5 %, 7.5 %, 15 % and 20 % in sand with two different weight composition ratios and at a superficial velocity of 5 m/s. Operating pressure is varied from 1 to 5 bar in a step of 2 bar. He have conclude that the suspension density increases with the increases in operating pressures and the axial heat transfer coefficient increases with an increase in operating pressure at all the % blending with the radial heat transfer coefficient decreases from the wall (about 480 W/m2-K) to the core (93 W/m2-K) of the riser in all the operating conditions.

METHODOLOGY:

Capability of FBC Technologies:

Combustion Efficiency/Boiler Efficiency:

Combustion efficiencies (carbon utilization) for AFBC boilers range lron 701 to 99.5 percent. The loss in combustion efficiency arises from incomplete combustion of fixed carbon (char) and volatiles. Higher efficiencies are attained through modifications of the system. This increases both the cormplcxut of the system and the cost. Table I summarizes the measured combustion efficiencies front commercial boilers and demonstration units.

Combustion Efficiencies of AFBC Boilers

FBC Boiler Design	Type of Fuel	Combustion Efficiency N. %
BFBC with over bed feeding	bituminous high fines	85.98
BFBC with over bed feeding ash recycle	bituminous - high fines	94-95
FBC	bituminous lignite/subbituminous	97-99.5
Multi bed pneumatic under bed feed	coal, peal wood chips	98

Fuel Flexibility:

FBC boiler systems as noted have a large degree of fuel flexibility. FBC boilers can be designed to bum almost any fuel with reasonable efficiency. However, problems due to heat transfer restrictions can arise when switching fuels. The moisture, volatiles content, and reactivity of fuels play an important role in the heat release and temperature distribution within the boiler. When the fuel is switched, the heat release may no longer correspond to the designed heat transfer surfaces.

Boiler Efficiencies for FBC Boilers and Conventional Boilers

FBC Boiler Design	Boiler Efficiency, %
High efficiency CFBC	**89.45**
Low efficiency CFBC	**85.66**
Bubbling Red	**83.49**
Stoker	**87.14**
Pulvenzed coal	**89.19**

Emission Characteristics:

FBC boilers remove the sulfur dioxide by adding sorbent (limestone or dolomite) directly to the bed.

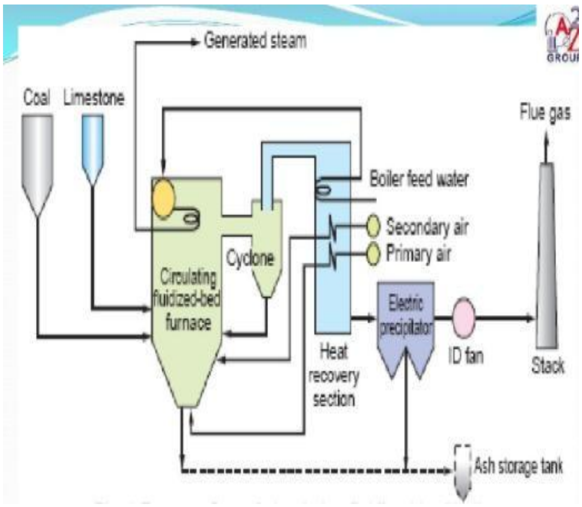


Fig1: Process flow of bed boilers

RESULTS AND DISCUSSIONS:

The following information offers several reasons for choosing an FBC boiler over the alternatives of stoker and pulverized systems

• Lower power requirements for fuel preparation than for PC boilers. "

• Wide range of fuel variations:

a) +/- 5-10 percent pulverized firing

b) +/- 10-15 percent stoker firing

c) +/- 25-30 percent AFBC. "

* Better ability to handle a wide range of fuels:

a) Moisture 0 to 80 percent

b) Ash 0 to 90 percent

c) Heat values from 5X) to 15.0 (0 Btu/Ib)

* Easy disposal of solid waste products (by landfill). The wet scrubbers required in conventional boiler systems create capital- and labor-intensive water management and maintenance problems. Surveys of existing power plant data indicate wet scrubber reliability (ratio of time system operated to time system was called on to operate) to be approximately 81 to 83 percent. "

* Lower operating temperatures and better distribution, therefore there is:

a) Much improved NOx control

b) Minimal fouling and slagging potential

Table1: Fuel compositions of pilot scale CFB tests

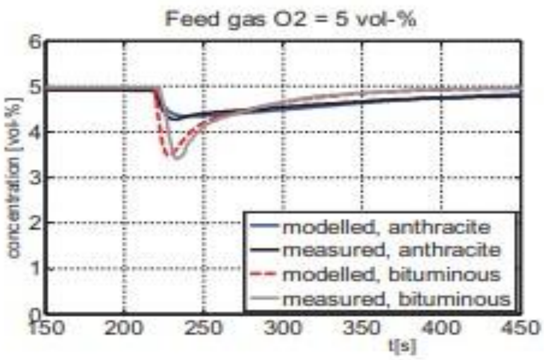
Analysis	Unit	Spanish anthracite	Spanish petroose	Polish bit coal
Moisture	w-%, wet	3.6	2.4	20.4
Ash (815°C)	w-%, dry	30.9	0.45	13.0
Volatiles	w-%, dry	8.0	10.1	35.9
Higher heating value	MJ/kg, dry	24.09	35.11	26.64
Lower heating value	MJ/kg, dry	23.60	34.37	25.70
Carbon	w-%, dry	62.8	87.9	65.6
Hydrogen	w-%, dry	2.3	3.5	4.4

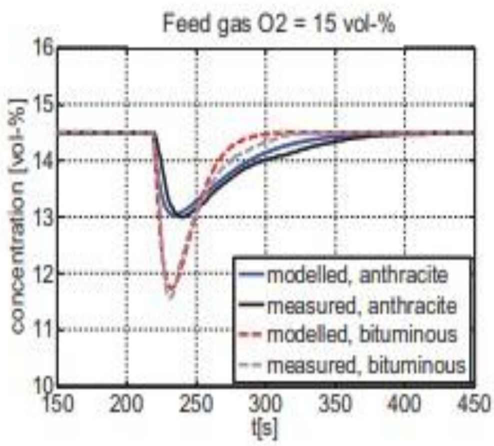
c) Thermally homogeneous combustion--lower potential for localized hot or cold spots

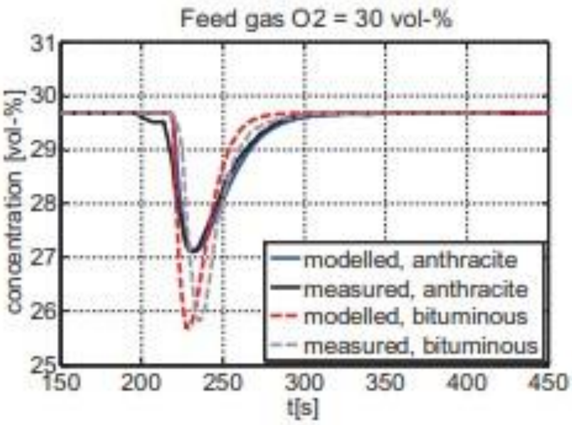
d) Prevented verification of the ash particles, causing them to the less abrasive than ash from stokers or PC fired units.

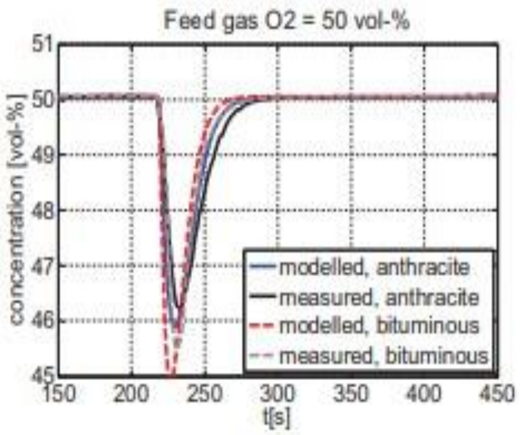
FBC technology is a practical option for both new and retrofit boilers at Army central heat plants. Boilers using this technology can be designed to bum various solid fuels and waste with reasonable efficiency. However, once the design is fixed, only a limited range of fuels can be burned without adversely affecting the boiler's performance. By using the high heat transfer rates available from in-bed tubes, the boilers can be designed smaller and still yield the same output. The lower operating temperatures and staged combustion of these boilers minimize slagging.

CFB technology is already used in India burning lignite and other low quality fuels. If SO2 emission regulations are introduced in the future, it is likely that this technology will be used more









CONCLUSION:

We have analyzed the importance of coal based power plants in countries like India where coal is cheap and easily available. Although coal based power plants are often liked to environmental issues but the use of fluid bed technology provides both process benefits as well as commercial benefits. Process benefits includes small amount of unburned components in residues and flue gas, low NOx production, wide range for calorific value and water content, wide range for superheating power due to low combustion temperature and high recirculation gas flow. Commercial benefits includes reduced space requirement, reduced cost for boiler plus combustion chamber, low fouling and corrosion risks, high availability and high electrical efficiency. Hence, it can be concluded that coal based thermal power plants can be effectively used with degrading the environment to some extent

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