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Comparison Between Coal Fired and Biomass Fired Power Plant

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Abstract—This paper addresses the importance of biomass fired electricity generation plant compare to coal fired electricity generation and advantages over the coal fired power plant. The various methods of electricity generation from coal fired power plant and various technologies of conversion of biomass in to electricity. Biomass (rice husk) as a fuel is less harmful for climate as compare to coal because it less emission sulphur oxcides, nitro oxides, carbon di oxides, carbon mono oxides etc. Major advantage is it is agriculture waste and it will not be end.

Keywords:— Biomass, coal, gasification, combustion, analysis.

1. INTRODUCTION

The present environment pollution crisis world over is attracting the attention of all the concerned. The liberation of green house gases from various means is contributing to make the scenario further intuition grimmer. The environmental hazards due to these gases need to be arrested and develop alternative means the use of the fossil fuels (coal) to meet the projected power demand over the next 25 years of 300000 MW of new generating capacity has its one limitation. They produce harmful green house gases such as SO_x, NO_x, CO, CO_2, and some toxic maters such as mercury, Pb etc. So the need of clean energy is very important for our environment.

The role of non conventional sources of energy has already appreciated and MNES is promoting it in right in earnest to harness this renewable energy sources. India being an agriculture country, biomass as a source of electricity has considerable importance in general and use of rice husk as a fuel in electricity generation. Biomass is beginning to look promisssing in the view of new emerging technologies. Even though all of the renewable energy sources have a niche market, biomass has been playing a key role in the renewable energy sector. The modern bio energy has received comparatively little fiscal and financial incentives unlike its counterpart, namely the solar photovoltaic s. However, for reasons like the cost effectiveness and availability factor, biomass based technologies are becoming popular as they have edge over other renewable and non renewable (coal).

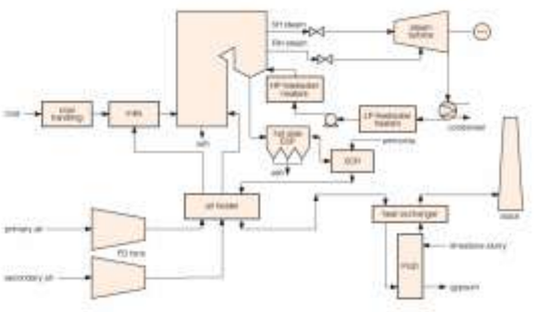
2. METHODOLOGY

The comparison between coal fired power plant and biomass fired power plant can be done on the bases of detailed study of overall operation in the plant. In the detail study, we can find various types of process power generation and which type of process and technology used in plant. Complete fuel (coal) analysis on the bases of proximate analysis and ultimate analysis and find the emission of SO_x, NO_x, CO_2, CO, Carbon, Hydrogen, Moisture, Mineral maters(ash) and analysis of flue gases to find the combustion efficiency in furnace. This process is done on the plant based of biomass fuel(Rice Husk) and compare both of the plants. The different types of coal fired power plants are discussed below. In this paper, the comparison of a coal fired power plant(pulverized coal fired) and biomass (rice husk) fired power plant (combustion in dedicated power and CHP plant (direct combustion in furnace)) and find some analysis :-

2.1. Pulverized Coal

A simplified diagram of a pulverized coal (PC) power plant is shown in Figure

In a PC plant, finely ground coal is fed into a boiler with air where it is combusted, releasing the coal's chemical energy in the form of heat. The heat is used to produce steam from the water running through tubes in the boiler walls. The high temperature, high pressure steam is then passed through a steam turbine that is connected to a generator to produce electricity. After the steam passes through the turbine, it is cooled and condensed back to liquid before it runs back into the tubes of the boiler walls where the cycle starts over. Many different types of coal may be used in a PC system, but the complexity and cost increases for systems designed to burn multiple types of coal



2.2. Supercritical Pulverized Coals

Although pulverized coal plants have been around for some time, there have been considerable recent advances in materials and technologies. Supercritical pulverized coal (SCPC) plants are essentially the same as conventional pulverized coal plants, but they can operate at much higher temperatures and pressures by using the advanced materials and technologies. Operating at higher temperatures makes it possible to have higher efficiencies. Since less coal is used to produce a given amount of electrical energy, SCPC plants generally have lower emissions of most pollutants than PC units

2.3. Circulating Fluidized Bed

In a circulating fluidized bed (CFB), crushed coal and limestone or dolomite (for SO2 capture) are fed into a bed of ash and coal particles, and then made highly mobile by a high velocity stream of preheated air. The air is fed into the combustor at two levels to control combustion and minimize NO_x formation. The combustion chamber is lined with water to produce steam. Particles and combustion products travel up through the combustor and on to a cyclone where the solids are separated from the gases and sent back to the combustor for further oxidation. Hot gases are passed through heat exchangers to produce more steam to drive a steam turbine.

CFB technology is generally used with low heat content coals. Since the thermodynamic cycle is the same as for pulverized coal plants, efficiencies are in the same range as the pulverized coal plants. As with the pulverized coal plants, this configuration may be pressurized to increase efficiency, but the gains come at increased capital and operating costs.

2.4. Integrated Gasification Combined Cycle

Integrated gasification combined cycle (IGCC) generation differs considerably from the combustion technologies described previously. In this type of configuration the carbon in the coal chemically reacts with steam at high temperatures to produce a combustible gas, which is primarily a mixture of hydrogen (H_2) and carbon monoxide (CO). Methane (CH_4) may also be present. The gas may be cleaned up pre-combustion and used in a gas turbine to drive a generator, thereby producing electricity. The post-combustion gases exiting the turbine are still at a high temperature and may be used to produce steam, which in turn can be used to produce more electricity. The use of both a combustion turbine and a steam turbine is referred to as a combined cycle process and is more efficient than a simple steam cycle.

The ability to clean gases pre-combustion is an important aspect of IGCC systems. This allows for NO_x and SO_2 controls that are less expensive than post-combustion controls.

Also, since the CO_2 is relatively concentrated in the exhaust stream, it is much simpler and less costly to capture CO2.

3. BIOMASS POWER SCENARIO

India has a biomass availability of 150 million MT per annum which gives us a potential to install 16,000MW of biomass based power plants. But only 600MW is installed and another 600MW is under implementation. To realise this huge potential we need an investment of Rs.1, 00,000 crore.

Some reasons for lack of investments in Biomass sector are:

- It costs around Rs.6cr/MW for a Biomass plant whereas a thermal plant requires only about Rs.4.5cr/ MW.
- Availability of Biomass fuel with high calorific value (> 4000kcal/kg)

3.1 Biomass Cultivation

- Low productivity of 5 T/Hectare
- Biomass cultivation over 11 million Hectares of wasteland can generate a total of 12 million direct and indirect jobs and a revenue of over Rs. 20,000 crore.
- Oil content of Jatropha seeds should be increased from 33% to 50%

3.2 Biomass Power Sector

The key drivers for Biomass energy in India are the following:

- The demand-supply gap, especially as population increases
- A large untapped potential
- Concern for the environment
- The need to strengthen India’s energy security
- Pressure on high-emission industry sectors from their shareholders
- A viable solution for rural electrification

3.3 Advancements in Biomass Energy Technologies

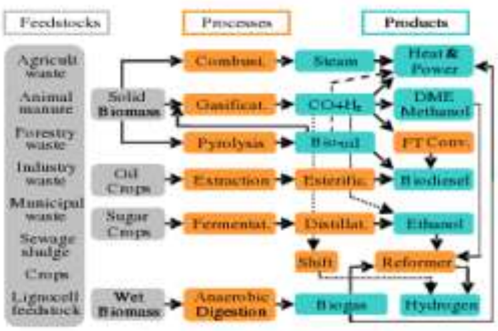
Technological advancement in biomass energy is derived from two spheres - biomass energy production practices and energy conversion technologies. A rich experience of managing commercial energy plantations in varied climatic conditions has emerged during the past two decades. Improvements in soil preparation, planting, cultivation methods, species matching, bio-genetics and pest, disease and fire control have led to enhanced yields.

Development of improved harvesting and post harvesting technologies has also contributed to reduction in production cost of biomass energy. Technological advancements in biomass energy conversion comes from three sources - enhanced efficiency of biomass energy conversion technologies, improved fuel processing technologies and enhanced efficiency of end-use technologies. Versatility of modern biomass technologies to use variety of biomass feedstock has enhanced the supply potential. Small economic size and co-firing with other fuels has also opened up additional application.

For electricity generation, two most competitive technologies are direct combustion and gasification. Typical plant sizes at present range from 0.1 to 50 MW. Co-generation applications are very efficient and economical. Fluidized bed combustion (FBC) is efficient and flexible in accepting varied types of fuels. Gasifiers first convert solid biomass into gaseous fuels which is then used through a steam cycle or directly through gas turbine/ engine.

Gas turbines are commercially available in sizes ranging from 20 to 50 MW. Technology development indicates that a 40 MW combined cycle gasification plant with efficiency of 42 percent is feasible at a capital cost of 1.7 million US dollars with electricity generation costs of 4 cents/ KWh.

4. CONVERSION TECHNOLOGIES



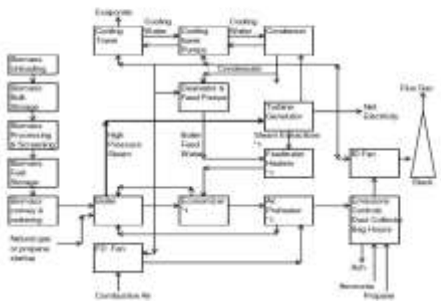
Biomass Conversion Paths

4.1. Co-Firing

Biomass co-firing in modern, large- scale coal power plants is efficient, cost-effective and requires moderate additional investment. In general, combustion efficiency of biomass can be 10 percentage points lower than for coal at the same installation, but co-firing efficiency in large-scale coal plants (35%-45%) is higher than the efficiency of biomass-dedicated plants. In the case of co-combustion of up to 5%-10% of biomass (in energy terms) only minor changes in the handling equipment are needed and the boiler is not noticeably de-aerated.

4.2. Combustion in Dedicated Power and CHP Plants

Biomass can be burned to produce electricity and Combined Heat – and – Power (CHP) via a steam turbine in dedicated power plants. The typical size of these plants is ten times smaller (from 1 to100 MW) than coal-fired plants because of the scarce availability of local feedstock and the high transportation cost. A few large-scale such plants are in operation. The small size roughly doubles the investment cost per kW and results in lower electrical efficiency compared to coal plants. Plant efficiency is around 30% depending on plant size. This technology is used to dispose of large amounts of residues and wastes (rice husk). Using high -quality wood chips in modern CHP plants with maximum steam temperature of540° C, electrical efficiency can reach 33%-34% (LHV), and up to 40% if operated in electricity-only mode. Fossil energy consumed for bio-power production using forestry and agriculture products can be as low as 2%-5% of the final energy produced.



4.3. Gasification

The essence of gasification process is the conversion of solid carbon fuels in to carbon monoxide by thermo chemical process. Splitting of the gasifier into strictly separated zone is not realistic, but nevertheless conceptually essential. Gasification stages occur at the same time in different parts of the gasifier.

Drying:- biomass fuel consists of moisture ranging from 5 to 35%. At the temp. above 100°C, the water is removed and convert in to steam.

Pyrolysis:- it is the thermal decomposition of the biomass fuels in the absence of oxygen. Pyrolysis involves release of three kinds of products: solid, liquid, and gases. The ratio of products and influenced by the chemical composition of biomass fuels and the operating conditions.

Oxidation: introduced air in the oxidation zone contains, besides oxygen and water vapours, inert gases such as nitrogen and argon. These inert gases considered to be non-reactive with fuel constituents. The oxidation takes place at the teme. Of 700-2000° C. heterogeneous reaction takes place between oxygen in the air and solid carbonized fuel, producing carbon monoxide.

Reduction: in reduction zone, a no. of high temp. chemical reactions take place in the absence of oxygen. The principle reaction that takes place in reduction is mentioned below.

Boudouard reaction

$CO2+C=2CO-172.6\{MJ/kmol\}$

Water gas reaction

$C+H2O=CO+H2 -131.4\{MJ/kmol\}$

Water shift reaction

$CO2+H2=CO+H2O+41.2\{MJ/kmol\}$

Methane production reaction

$C+2H2=CH4 +75\{MJ/kmol\}$

If complete gasification takes place, all the carbon is burned or reduced to carbon monoxide, a combustible gas and some other mineral matters is vaporized. The remains are ash and some char (unburned carbon). This combustible gas is known as syn gas. This gas is produce heat in combustion and this heat is used in steam generation. This steam is used in electricity generation.

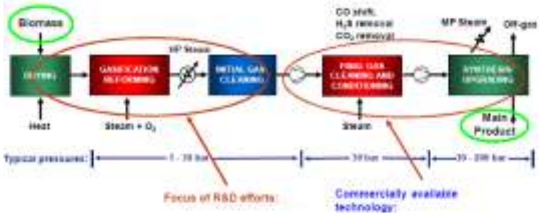


Figure: Conversion of biomass-derived synthesis gas

5. TEST AND ANALYSIS

Ultimate analysis of Indian coal

parameters	Moisture	Mineral Matter (1.1 x Ash)	Carbon	hydrogen	oxygen	sulphur	nitrogen
Indian coal %	5.98	38.63	41.11	2.76	9.89	0.41	1.22

Calorific value 4000 kcal/kg

Cost Rs1200/ton to Rs1600/ton

Ultimate analysis of biomass

Type Carbon Hydrogen Oxygen Nitrogen Sulphur Ash

Rice husks 38.83% 4.75% 35.59% 0.52% 0.05% 20.26%

Calorific value	3100kcal/kg
Moisture content	5-12%

Cost Rs 1500/ton

1 ton of Rice paddy produces 220 kg Rice Husk

1 ton Rice Husk is equivalent to 410- 570 kWh electricity

6. ADVANTAGES

1. Eco friendly electricity generation.
2. Producing cheap electricity.
3. Improving efficiency by co-firing with other fuels.

4. It is renewable energy source because biomass will not be end.
5. Biomass is easily available as compare to coal.
6. easy to handling of fuel.

7. CONCLUSION

Biomass is the environment friendly as compare to coal. The emissions from the biomass based power plant are much lesser then as compare to coal fired power plant. The cost of biomass power is also much less then the coal fired power. These plants are much economies the area where rice mill or production of rice and sugar are very large because the scrap of rice mill (rice husk) and scrap of sugar mill (bagaas) is the primary fuel of these power plant.

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