Boilers For Firing Renewable Fuels

S SRIDHARAN
Avant-Garde Engineers and Consultants (P) Ltd.,

About the author:

Shri S Sridharan, graduated in Mechanical Engg. in the year 1960 from the University of Mysore. After a brief stint with the Central Water & Power Commission, he joined BHEL in 1962 and was trained in the field of boiler design. After occupying various positions in the design department of BHEL, he retired from the Magneto Hydro Dynamics Advanced Research Wing of BHEL as General Manager in 1989.

Presently, he is a Senior Consultant with Avant-Garde Engineers and Consultants (P) Ltd, Chennai. Shri S Sridharan represented as an active member in many committees of the Govt. of India in the fields of Coal Utilisations and selection of boiler technologies for future in India. He has contributed numerous papers in National and International Forums / Journals in the fields of Power Engineering and Energy Conservation.

Introduction

India is one of the fast developing countries with ample prospects for improving specific percapita energy consumption. It is a known fact that all forms of energy used by humanity are derived from Sun. The incidence of solar energy on the planet earth is estimated to be 182 x 106 MW. Less than a thousandth of this energy is being retained. The solar energy manifests itself in the form of wind, hydel, low temperature thermal as well as light energy for absorption by living beings. The light energy is being converted into usable form by the photo synthesis process. Bio-mass which is a renewable fuel is a direct result of photosynthesis conversion. The biomass fuels are therefore not contributing to the global carbon di-oxide level, while they can produce useful electrical energy through combustion.

Renewable Nature of Bio-Mass

Many forms of plant life are known to grow without human effort. The forest and grass lands come under this category. The typical global annual bio-mass production without human endeavour (tones per hectare) are given below

a) Topical Forests 10 to 35
b) Temperate Forests 6 to 25
c) Savannah 2 to 20
d) Grass Land 2 to 15

In addition, the cultivated lands would yield about 1 to 10 tones of bio-waste per hectare after the harvest of usable crops. The annual organic residue of such waste products (rice husk, coconut shell etc.,) in India is as follows

Type of organic residue Qty	**Available per annum (106 Tons)**
Straws of various cereals and pulses	225.50
Bagasse	31.00
Rice Husk	10.00
Ground nut shell	11.10
Cotton stalk	2.00
Oil talk	4.50
Others	69.90
Total	350.00

Most of these bio-masses have been analysed. The combustion characteristics of these bio-masses are shown in **Table**

Thermochemical Characteristics of Bio-Mass

The fuel characteristics of various bio-masses shown in table indicate the following

1. All of them are high in moisture content
2. Most of them are low in ash content.
3. All of them are high in of volatile matter content
4. Most of the bio-mass ashes have low ash fusion temperature

In addition to the above, the sizes of these bio-masses, as available at the growing field also are widely different. While rice husk is available in size range of 4 mm and below, all other bio-masses are in the form of fairly long sticks or broad leaves. These bio-masses will have to be reduced in sizes before being used in boiler. Thus, the properties of all these bio-masses have an influence on the design of boilers.

The most efficient method of using bio-mass would be for power generation purposes. The bio-mass boilers would produce steam which will be fed to steam turbine producing electrical power. The steam turbines work on the Rankine Thermo Dynamic Cycle. Rankine Cycle gives better efficiencies with the increase in pressure and temperature of the steam fed to the turbine. The turbine designs have their own special features which make certain steam temperature regimes attractive with certain specific steam pressure regimes. These ranges of steam pressure and their corresponding ranges of steam temperature are given in Table

Preferred pressure temperature combinations at inlet to steam turbines

Steam Inlet Pressure (ATA)	**Preferred steam inlet temperature (Deg C)**
32	435
41	455
62	485
86	510/538
103 and above	538/635

It should always be desirable to go in for as high a steam pressure and temperature as possible. However, going in for higher steam temperature for certain specific pressure values have limitations with regard to boilers firing bio-mass fuels.

With higher steam temperatures and pressures, it becomes necessary that greater percentage of total heat of steam generation be given in the super heater. It then becomes necessary that the flue gasses leaving the furnace must have higher and higher temperatures, in order to cater to this higher percentage of super heat requirements. The recommended temperature of flue gases leaving the furnace for various super heat temperature requirements are given in Table – 3

Recommended Flue Gas Temperatures at Furnace Outlet for Achieving Various Superheat Steam Temperature

Super Heat Steam Temperature (Deg. C)	**Required flue gas furnace outlet temperature (Deg C)**
Upto 380°C	Above 600°C
380 to 420°C	Above 650°C
420 to 480°C	Above 700°C
480 to 520°C	Above 750°C
520 to 540°C	Above 980°C

It becomes evident from the Table - 3 that the ash fusion characteristics of the bio-mass fuel will have a definite influence on the allowable flue gas temperature on furnace outlet. The flue gas temperatures at furnace outlets should be 100°C less than the ash fusion temperature. This feature imposes restriction on the super heat temperature that can be achieved in a boiler with a given bio-mass fuel. Most of the bio-mass fuels are therefore not amenable for super heat temperature of 515°C and above. They are also non-amenable for adoption with re-heat cycles.

The higher moisture content in the biomass fuels lead to higher moisture content in the flue gas evolved. The non-luminous radiation characteristics of flue gas are greatly influenced by the quantity of water content in them. Flue gasses with high water content give raise to higher non-luminous radiation. The bio-mass fuel fired boilers should take this into consideration while assessing the total heat transfer across various heating surfaces in such boilers.

The higher moisture content of flue gasses also lead to higher dew point of these flue gasses. The low temperature heating surfaces in biomass fired boilers are therefore susceptible to low temperature corrosion due to moisture. The design of air pre-heaters for biomass fired boilers should take this aspect into account.

The bulk density of most of the biomasses at entry into the boiler is very low. This leads to a predominantly entrained combustion of bio-masses. With the exception of rice-husk, almost all the other bio-masses are difficult to be adopted in atmospheric fluidised bed boilers.

The high moisture content in the fibrous nature of the biomass fuels, make it difficult for achieving continuous feed of such fuels from storage bunkers. The storage bunkers and fuel feed devices for biomass fuels should be of special design to achieve uninterrupted fuel flow.

Since fibrous fuels have a tendency to form stable arches in the storage bunkers, the storage bunkers for such fuels should have a "negative angle of rest" for the fuel when stored in the bunker. The bunker geometry as shown in figure 1 is special for such fuels and the fuel feed device should be enabled by specially designed fuel extractors from the storage bunker. By far the most important design aspect of biomass fired boilers would be the fuel storage, retrieval and fuel feeding system to the boiler.

The biomass is a promising fuel alternative for power generation. Since, the biomass is created by "Carbon fixation" the combustion of biomass is not disturbing the delicate "carbon di-oxide balance" of the atmosphere. The adoption of bio-mass as a fuel for power generation should therefore be encouraged.

Reference:

http://www.greenbusinesscentre.com/casestudy.asp