# Briquette Boiler & FO Boiler Comparative Analysis in terms of Energy Efficiency

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**Abstract - Boiler is a typically complex system which is multi-input, multi-output, nonlinear as well as non-self-balanced, and boiler combustion of power station is complex physical and chemical process. The efficiency of a boiler system is important in several ways. Thus this work will provide the performance comparison of Briquette Boiler & Furnace Boiler of process industry and the ways to improve its efficiency. The company is using a basic rankine cycle with an open system. The source of raw water for boiler is pumped from the bore wells provided by HSIIDC to the reserve pond for further internal and external treatments. For analysis and improvement, three approaches are used and analyzed by MATLAB Tool.**

**Keywords- *Briquette Boiler, Furnace Oil Boiler, Boiler Efficiency, Process Industry etc.***

## I. INTRODUCTION

A boiler is defined as "**A** closed vessel in which water or other liquid is heated, steam or vapor is generated, steam is superheated, or any combination thereof, under pressure or vacuum, for use external to itself, by the direct application of energy from the combustion of fuels, from electricity or nuclear energy". Boilers are considered to be as the key part in any generation station as it is the place where the fuel is used for producing the needed amount of heat. A boiler is an enclosed vessel that provides a means for combustion heat to be transferred to convert water into steam. A boiler is a complex integration of evaporator, re-heater, super heater, economizer, air pre heater along with various auxiliaries such as pulverizer, fans, etc. The purpose of the performance test of boiler is to determine actual performance and efficiency of the boiler and compare it with design values. It is an indicator for tracking day to day and season to season variation in boiler efficiency and energy efficiency improvements to control unit heat rate. Basically Boiler efficiency can be tested by the following methods:

*The Direct Method*

Where the energy gain of the working fluid (water and steam) is compared with the energy content of the fuel. This is also known as „input-output method" due to the fact that it needs only the useful output (steam) and the heat input (fuel) for evaluating the efficiency.

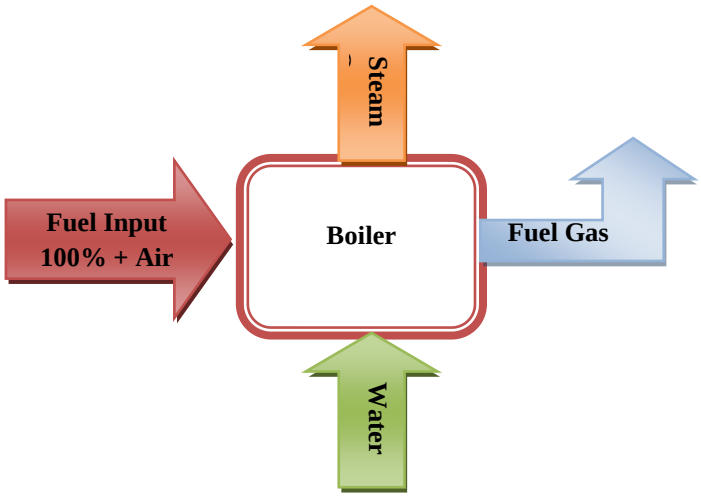


Fig 1: Direct Method for Boiler Efficiency

*The Indirect Method*

Where the efficiency is the difference between the losses and the energy input. The efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The efficiency can be arrived at, by subtracting the various heat losses from 100. An important advantage of this method is that the errors in measurement do not make significant change in efficiency

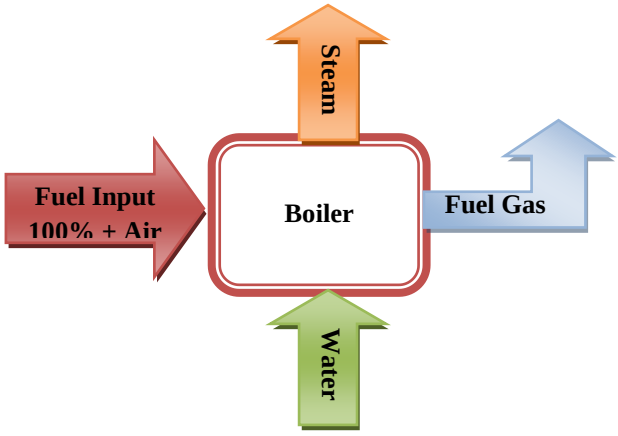


Fig 2: Indirect Method for Boiler Efficiency

From survey, Boiler is a typically complex system which is non-self-balanced, and boiler combustion of power station is complex physical and chemical process. In survey, it was found that Energy consumption at soy milk cooking was the greatest one in tofu production. This experimental study aimed to investigate the fuel consumption and energy efficiency at soymilk cooking process using a mini boiler and using a gas stove. From the survey, authors reported that the natural gas boiler has significantly lower CO2 emission than an equivalent coal or oil fired boiler. Therefore how to improve the combustion efficiency of boiler has always been an important issue in this field. This research result indicated that the natural gas boiler had a relatively high energy sustainability index compared to other fossil fuel boilers. Authors reported about the experiments study on effect of operating and design parameters on the gasification/combustion process of waste biomass in fixed bed downdraft reactors. The major challenges from survey are how to improve boiler efficiency and also energy efficiency of system.

This paper presents classification of Boilers in section II. Section III describes the proposed system. Section IV presents the results of system. Then conclusion is presented in Section V.

## II. CLASSIFICATION OF BOILERS

### *A. Briquette Type Boiler*

A briquette (or briquette) type of boiler is a boiler where we use briquette for combustion. Briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire.

#### *1. Coal Briquette*

Coal briquettes have long been produced as a means of using up 'small coal', the finely broken coal inevitably produced during the mining process. Otherwise this is difficult to burn as it is both hard to arrange adequate airflow through a fire of these small pieces, also it tended to be drawn up and out of the chimney by the draught, giving visible black smoke. This involved blending a mixture of coals from different grades and colliery sources:

- Bituminous coal, 25%
- Steam coal, 45%
- Dry steam coal, 22%
- Pitch, 8%

#### *2. Biomass Briquette*

Biomass briquettes are made from agricultural waste and are a replacement for fossil fuels such as oil or coal, and can be used to heat boilers in manufacturing plants, and also have applications in developing countries. Biomass briquettes are a technically renewable source of energy and produce less carbon emissions than traditional coal briquettes. A number of companies in India have switched from furnace oil to biomass briquettes to save costs on boiler fuels. The use of biomass briquettes is predominant in the southern parts of India, where coal and furnace oil are being replaced by biomass briquettes. Biomass briquettes also provide more calorific value/kg and save around 30-40 percent of boiler fuel costs. Moisture content of a briquette can be as low as 4%, whereas green firewood may be as high as 65%.

Table 1: Briquette Fuel Parameters

| Parameter | Value |
|---|---|
| Briquette density, t/m³ | 1.0-1.2 |
| Heat content, MJ/kg | 19.3-20.5 |
| Ash content, % | 0.5-1.5 |

## III. DESCRIPTION OF PROPOSED WORK

Boiler is a typically complex system which is multi-input, multi-output, nonlinear as well as non-self-balanced, and boiler combustion of power station is complex physical and chemical process. In survey, authors reported that the natural gas boiler has significantly lower CO2 emission than an equivalent coal or oil fired boiler. Therefore how to improve the combustion efficiency of natural gas boiler has always been an important issue in this field. The efficiency of a boiler system is important in several ways. The constantly rising cost of fuel used means that by increasing the efficiency by several percent, substantial savings can be made on a yearly basis. By maximizing the amount of energy extracted from the fuel, not only does the fuel usage decrease and thereby reduce cost but it also has a significant effect on the emissions from the system. Thus this work provides the performance comparison of Briquette Boiler & Furnace Boiler of Coca-Cola Plant and the ways to improve its efficiency. The main objective of this thesis is to study performance analysis of Briquette & FO Boiler of Process Industry in SAHA.

The facility is located at HSIIDC, Industrial Growth centre, SAHA in the state of Haryana, India. The location is well connected by rail, road and air transport. The plant is about 15 km from the Ambala Railway station, about 50 km from the Chandigarh Airport and about 15 km from Interstate Bus Terminal, Ambala. Their manufacturing facility is located at HSIDC Industrial Area in Haryana which has a lush Green Environment, free from pollution and has good quality of water. The Plant has five manufacturing lines like PET- 720 BPM (Carbonated Product Filling), PET-600 BPM (Carbonated and Non Carbonated Products), CAN-966 BPM (Carbonated and Non Carbonated Products), Returnable Glass Bottles (Carbonated Products) & PET Line (Packaged Drinking Water). The Manufacturing facility is capable of producing different types of carbonated & non carbonated products in different flavor & pack size as well Packaging drinking water in different size .The KBPL plant is the franchise of Coca-cola company in this area. It is largest plant in terms of production and automation facility in India in Coca-cola system. The plant has two Boilers one is Briquette Boiler and other is FO Boiler. The Briquette Boiler has a capacity of producing 4 kg output with 1 Kg input Briquette and FO Boiler has a capacity of 10.5 kg output with 1 Litre of Furnace Oil. For

producing output in Briquette Boiler, labour cost is also considered because it requires at least 4 persons at a time. The briquette boiler efficiency will be improved by use of auto-feeder system.

Figure 3: Furnace Oil Boiler

Biomass briquettes are made from agricultural waste and are a replacement for fossil fuels such as oil or coal, and can be used to heat boilers in manufacturing plants, and also have applications in developing countries. A fire-tube boiler is a type of boiler in which hot gases pass from a fire through one or (many) more tubes running through a sealed container of water. The heat of the gases is transferred through the walls of the tubes by thermal conduction, heating the water and ultimately creating steam.

Table 2: Specifications of FO Boiler

| Make | Shellmax |
|---|---|
| **Standard Rating** | 10.54 kg/cm$^2$ |
| **Speed** | 2900 rpm |
| **Motor Connection (starting)** | DOL |
| **Fuel Pump Type** | Gear |
| **Discharge Pressure** | 25 kg/cm$^2$ |
| **Fuel Pump Speed** | 1450 rpm |
| **Voltage** | 415 V, 50 Hz |

Table 3: Specifications of Briquette Boiler

| Make | Himani Briquette |
|---|---|
| **Standard Rating** | 10.54 kg/cm$^2$ |
| **Capacity** | 500-10000 kg/hr |
| **Fuel Suitability** | Biomass Briquette |
| **Fuel Firing** | Manual/Mechanized Feeding System |
| **Voltage** | 415 V, 50 Hz |

*Boiler Efficiency*

To get the most out of the boiler system it is necessary to implement a complete maintenance/efficiency plan to maintain every aspect of efficiency. Basically, boiler efficiency represents the difference between energy input and energy output. Boiler efficiency describes the fraction of fuel energy that is converted into useful steam energy. In this work, efficiency comes down to properly evaluating the performance of the boiler and the performance of the burner. There are three terms that influence boiler efficiency; Combustion Efficiency and Fuel-to-Steam Efficiency and Thermal Efficiency.

Combustion efficiency is an indication of the burner's ability to burn fuel and the ability of the boiler to absorb the heat generated. The amount of unburned fuel and excess air in the exhaust gas are used to assess a burner's combustion efficiency. Burners performing with extremely low levels of unburned fuel while operating at low excess air levels are considered efficient. In other words, combustion efficiency is measured by dividing the usable heat produced by the fuel input in MJ/h content. This calculation is based on the actual heat available produced by the system after heat loss up the stack and other heat losses which do not provide usable heat. To determine Boiler Efficiency, there are two methods that are typically utilized but generally prefer Direct Method (Input-Output Method) to calculate. It needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency. This efficiency can be evaluated using the formula:

$$Boiler\ Efficiency = \frac{Heat\ Output}{Heat\ Input} * 100$$

## IV. RESULTS & DISCUSSION

Boiler is a complex system, whose combustion efficiency is of great significance for sustainable development of energy and economy. Boiler is a typically complex system which is multi-input, multi-output, nonlinear as well as non-self-balanced, and boiler combustion of power station is complex physical and chemical process. In survey, authors reported that the natural gas boiler has significantly lower CO2 emission than an equivalent coal or oil fired boiler. Therefore how to improve the combustion efficiency of natural gas boiler has always been an important issue in this field. The efficiency of a boiler system is important in several ways. The constantly rising cost of fuel used means that by increasing the efficiency by several percent, substantial savings can be made on a yearly basis. By maximizing the amount of energy extracted from the fuel, not only does the fuel usage decrease and thereby reduce cost but it also has a significant effect on the emissions from the system. Thus this work provides the performance comparison of Briquette Boiler & Furnace Boiler of Coca-Cola Plant and the ways to improve its efficiency. The main objective of this work is to study performance analysis of Briquette & FO Boiler of Process Industry and performance analysis of Briquette Boiler & Furnace Oil Boiler in terms of Boiler Efficiency & cost efficiency.

*Procedure of Finding Boiler Efficiency*

*Direct Method Procedure*

- Measure steam flow via kg over a set period, e.g. one hour. Use steam integrator readings, if available, and correct for calibration pressure. Alternatively, use the feed water integrator, if available, which will in most cases not require a correction for pressure.
- Measure the flow of fuel over the same period. Use the gas or oil integrator, or determine the mass of solid fuel used.
- Convert steam flow, feed water flow and fuel flow to identical energy units, e.g. Btu/lb. or kJ/kg.
- Calculate the efficiency using the following equation: Efficiency = 100 x (steam energy – feed water energy) ÷ fuel energy.

In this work, it presented a comparative study of performance analysis of Briquette Boiler & Furnace Boiler used in the plant in terms of efficiency. The existing boiler is a horizontal fire-tube boiler fuelled with furnace oil. Fuel shift from present oil firing to solid fuel becomes inevitable owing to the rise in fuel cost. In view of this, the fuel system of the boiler has been changed from furnace oil to briquettes.

Table 4: Performance Analysis of Briquette & FO Boiler In terms of Boiler Efficiency

| Date | Briquette Boiler | | FO Boiler | |
|---|---|---|---|---|
| | Briquette Consumption (Kg/ Hr) | Steam Produced (Kg/Hr) | FO Consumption (Ltr/Hr) | Steam Produced (Kg/Hr) |
| **01-08-19** | 857 | 1149 | 153 | 1640 |
| **02-08-19** | 857 | 1142 | 147 | 1356 |
| **03-08-19** | 838 | 1142 | 153 | 1542 |
| **04-08-19** | 856 | 1150 | 156 | 1650 |
| **05-08-19** | 906 | 1125 | 162 | 1587 |
| **06-08-19** | 825 | 1156 | 153 | 1650 |
| **07-08-19** | 850 | 1150 | 150 | 1650 |
| **Average (kg Per Hr)** | 855 | | 153 | |
| **Average (kg Per day)** | 20520 | | 3672 | |

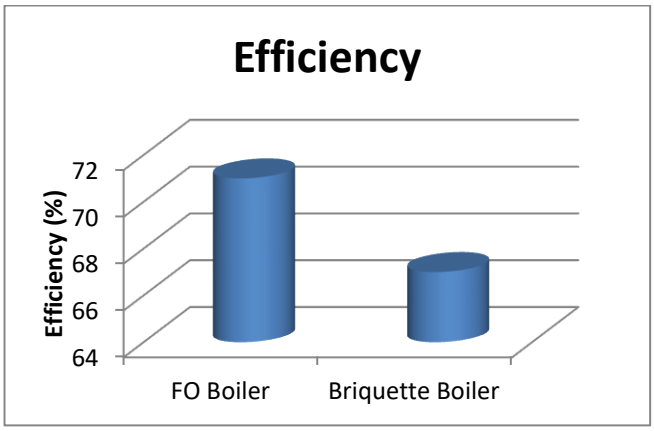


Figure 4: Efficiency Comparison of FO & Briquette Boiler

With the conversion of fuel system of the boiler from furnace oil to briquettes the company has yielded a savings of 26000 with a consumption of 1000 liter of furnace oil equivalent to 2100 kg of briquettes daily. The saving potential with fuel conversion is illustrated in the following Table 2. It considers 21 hours running time in a day. The Briquette & Furnace Oil Boilers cost is Rs. 5.30 and Rs. 43/ltr respectively. So, by the use of Briquette Boiler, it can be economical also. Superheated steam generated from boiler is used to run steam turbine for heat process in the plant. The exhaust steam from turbine is then condensed and later discharged and mixed with waste water from the plant operation to the effluent treatment. For analysis and improvement, three approaches are used and analyzed by MATLAB Tool. These approaches are by increasing pressure, by increasing temperature and by increasing both parameters.

Table 5: Performance Analysis of Briquette & FO Boiler In terms of Cost Efficiency

| FO Boiler | | Briquette Boiler | | |
|---|---|---|---|---|
| Daily FO Consumption (liter/Day) | Cost per Day (Rs.) | Equivalent Briquette Consumption (kg/Day) | Cost per Day (Rs.) | Savings (Rs/day) |
| 3672 | 157896 | 20520 | 108756 | 49140 |

Table 6: Performance Comparison of Efficiency by Various Approaches using MATLAB

| Method | Quality | Boiler Efficiency | Plant Efficiency |
|---|---|---|---|
| **By Increasing Pressure** | 0.834 | 0.68 | 0.36 |
| **By Increasing Temperature** | 0.99 | 0.78 | 0.34 |
| **Both** | 0.935 | 0.84 | 0.41 |

## V. CONCLUSION

This work presents a work on performance comparison of Briquette & FO Boiler in terms of Boiler Efficiency. The main objective of this work is to study the performance of Briquette Boiler & FO boiler in terms of their efficiency. This study will be conducted in Coca-cola Plant. One of their plant is currently working with low efficiency and performance of its boiler and turbine, as compare to the rated capacity. Currently, the company is using a basic rankine cycle with an open system. The source of raw water for boiler is pumped from the bore wells provided by HSIIDC SAHA to the reserve pond for further internal and external treatments. For analysis and improvement, three approaches are used and analyzed by MATLAB Tool.

In Future, it can be investigated using auto feeder setup for improving briquette Boiler efficiency and also for reducing cost.

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