Optimization on Biomass Boiler Operation and Maintenance

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Abstract : **- In done that, industrial project, they receive an economical stimulus from that organizations, which have a sustainable and environment-friendly energy system as an objective. When the optimization of a design, that design have main objective of simply to maximize the efficiency of production and to minimize the cost of production. When optimized the biomass fuel with the variables of Calorific value, Cost Savings, Efficiency. The biomass fuel materials used in this project was Rubber wood, Eucalyptus wood, mixed wood, Palm Shell with Fiber, Woodchips. Moisture content, Ash content and Calorific value are the most important quality parameters of the biomass fuel for a plant. The reasons for measuring the Moisture content, Ash content and Calorific value are the following such as For price determination, For control of the combustion. The industry will be interested in obtaining a method for measuring the above parameters of biomass fuels, quickly and reliably. So that moisture content has found with the help of IR Moisture Balance and Ash Content has found with Muffle Furnace and Calorific Value has get by Bomb Calorimeter. After economical analysis has done wiSSth the operational costs. That operational costs have two categories such as, fixed costs and variable cost. For the better examination and financial estimation of the possible project we assume that the operational costs are fixed, so there is no fluctuation on the feedstock, energy prices and all the parameters which can be considered as mutable during the examined times. When the three important parameters have calculated and figured with bar chart.**

Key Words : Biomass fuels, Moisture content, Ash Content, Calorific Value, Economical Analysis.

I. INTRODUCTION

Biomass fuels depending on the fuel characteristics and site requirements [1]. Biomass fuels are extremely variable in terms of heating value, moisture content[7], and other factors that affect combustion. Wood and most other biomass fuels are composed primarily of cellulose and moisture[3]. Heat from biomass is being promoted in an effort to reduce greenhouse gas emissions. In the full life cycle environmental and economic implications[4] of biomass heat are currently unknown and are therefore explored herein. The results indicate that heat from solid biomass can reduce global warming potential as well as depletion of fossil resources and the ozone layer by >90% compared to fossil fuels. And also we know the advanced type of boiler and boiler accessories. Electrostatic precipitator can help to reduce the emissions[6]. In this proposed study of optimization[2] on biomass boiler operation and maintenance for the working process of boiler in Thermax Group of Company and fuel characteristics, boiler efficiency were studied. For different types of biomass fuel and they have also different properties such as moisture content[5], fixed carbon, volatile matter, ash content, sulphur content.

1.1Biomass fuels

Biomass fuels is that they are considered sustainable and renewable. The reason for this is that when they are burnt in the biomass boiler, the release of carbon dioxide only amounts to the same level they absorbed as plants/trees while they were growing. For that one could argue that coal and gas are also renewable since they were once biological material. How-ever it is really a question of timescale. Coal might take millions of years to form, while biomass fuels can take just a couple of years. . When the biomass fuels have many types and they are Wood, Energy Crops, Agricultural Residues, Food Residues, Industrial Residues. But they used wood only, because they are considered sustainable and renewable and economical also. The wood has many types. They are Rubber Wood, Cashew Nut, Julio-flora Chips, Tamarind Shell, Mango Nuts, Palm Shell With Fiber, Veneer Chips, Casuarina, Silk Cotton Wood, Wood Chips, Paddy Husk, Julio-flora Wood, Eucalyptus Wood.

S. No	Type Of Fuel	Moisture Content (%)	Ash Content (%)	GCV (Kcal/Kg)
1	Rubber Wood	28	4.62	2622.55
2	Eucalyptus Wood	38	4.59	2668.27
3	Mixed Wood	30	4.57	2599.70
4	Palm Shell with Fiber	24	4.73	3811.13
5	Wood Chips	37	4.59	2645.41

1.2 Fuel Format

Fuels generally need to be processed to be useful – some typical formats are: Logs – Commonly found in domestic to light commercial with daily input required, Bales – Manually fed batch firing with daily input. Chipped/shredded Fuel – Usually found with automated systems and on larger scale (over 50kW systems), Pellets – Typically found with smaller and urban systems due to their greater energy density, Woodworking offcuts/sawdust – Usually furniture offcuts and sawdust.

1.3 Properties of Fuels

In that woods have built up the wall of Celluloses, hemicelluloses and lignin. Cellulose is the main structural constituent of the plant cell walls. Hemicelluloses have shorter molecular chains than cellulose. The lignin macromolecule consists of aromatic units which harden and strengthen the cell wall. Lignin also occurs in the middle lamella. Extractive and other constituents of wood include hydrocarbons, alcohols, sterols, tannins. It is in the combustion of the cellulose, hemicelluloses and lignin of biomass fuels that useful heat is generated. Instead of the biomass fuel have many important properties. But the following properties have played a vital role on fuel. Because they would be allocated the fuel as good and efficient fuel. They are Moisture content, Ash content, Calorific value.

2. MATERIALS AND METHODOLOGY

The biomass fuel materials used in this project was Rubber wood, Eucalyptus wood, mixed wood, Palm Shell with Fiber, Woodchips. Moisture content, Ash content and Calorific value are the most important quality parameters of the biomass fuel for a plant. When the biomass fuel has subjected the three equipment for the purpose of found the moisture content with the help of IR Moisture Balance and Ash Content has found with Muffle Furnace and Calorific Value has get by Bomb Calorimeter.

2.1 Determination of Moisture using IR Moisture Balance

In that moisture content level would be measured with the help of Infrared Radiation (IR) Moisture Balance. It was connected to power supply. And they have the two knobs.one knob is in the right position, and the other position is in the left position. The two knobs have set the 100% for the process during the testing time. After that open the top position and to feed the fuel for the process. When the IR moisture balance has the one main knob for the purpose of set the temperature level during the process. And then they have the measuring unit with the setup of red pointer and the level of the (0-100%). After that set the 0% with the help of feeding the fuel, switch on the IR lamp And then proceed the process to set the temperature at 110°C with the help of regulator. At-last note the final reading of the moisture content level.

Formula;

Where,

M_1 - Fuel weight before heating.

M_2 - Fuel weight after heating.

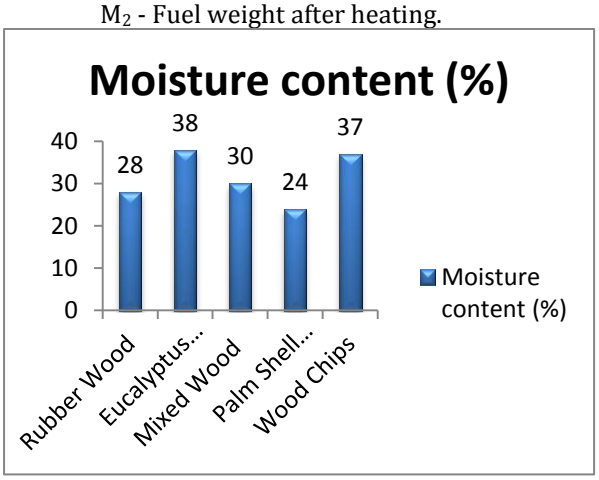

Fig 2.1 Bar Chart for Moisture Content.

In above bar chart has expressed the Moisture content of different biomass fuels was calculated and shown in fig 2.1. And then Eucalyptus wood has the highest moisture content. When the next high to low moisture content value such as Wood chips, Mixed wood, Rubber wood, Palm shell with fiber.

2.2 Determination of Ash using Muffle Furnace

The ash determination is a simple method used to measure ash yields for the fuel and that simple method is done by muffle furnace. It has a high ceramic fiber blanket and board insulation in the inner part of the furnace. And that high ceramic part has absorbed the high temperature. When the high temperature has uniform heating inside the chamber. When, they load the temperature with the help of controller. Instead of, we put the crucible on muffle furnace and then heat up-to initial temperature as 550°c for the 30 minutes. Put the crucible on weighing machine. And note down the value, after that feed the fuel on crucible as the weight of 2grams fuel. But the crucible on muffle furnace and set the temperature at 815°c for 1 hour. Instead of handling the muffle furnace, having the safety measurements such as tongs, heating element, gloves.

Formula;

Where,

M_1 – Empty Crucible,
M_2 – Crucible with Fuel,
M_3 – Crucible with Ash,
M_4 – Cleaned empty Crucible.

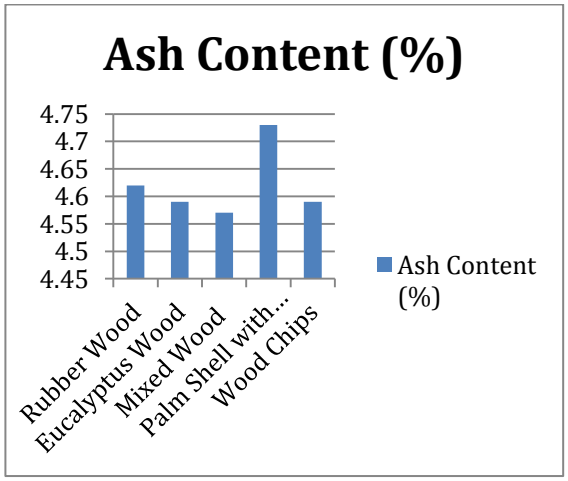

Fig 2.2 Bar Chart for Ash Content

In above bar chart has expressed the Ash content value of different biomass fuels was calculated and shown in fig 2.2. And then Palm shell with fiber has the highest ash content value. When the next high to low calorific value such as, Rubber wood, Wood chips, Eucalyptus wood, Mixed wood.

2.3 Determination of GCV using Bomb Calorimeter

It is the principle of a known weight of biomass fuel is burnt in the presence of excess oxygen in the closed pot, and the products of combustion are cooled, to get GCV of the fuel. A Bomb calorimeter consists of Bomb Pot, Stirrer, Calorimeter, Thermometer, Water and Air Jackets, Insulator stands, Oxygen cylinder, Crucible, Battery.

Formula;

Where,

Mass of fuel = X grams
Mass of water in calorimeter = W grams
Water equivalent of calorimeter set = w grams
Rise in temperature of water = $(t_2 - t_1)$
Corrections = $t_f + a$

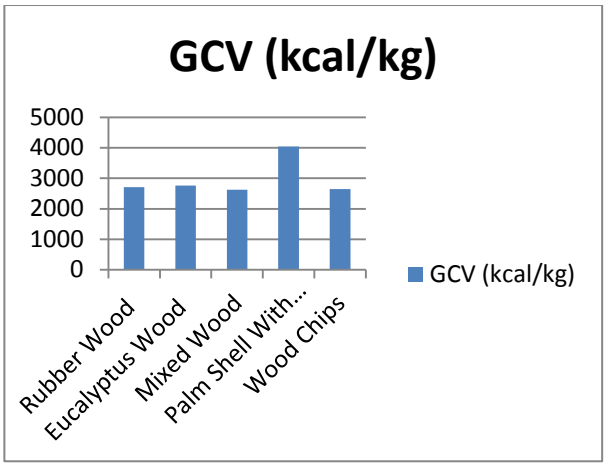

Fig 2.3 Bar Chart for Calorific Value.

In below bar chart has expressed the Gross Calorific Value of different biomass fuels calculated and shown in fig 2.3. And then Palm shell with fiber has the highest calorific value. When the next high to low calorific value such as Eucalyptus wood, Rubber wood, Wood chips, Mixed wood.

3. ECONOMICAL ANALYSIS

The economical analysis is mainly divided in two parts, the project input and project results. The input parameters are data that the user can fill in as well as some additional data which are originated by trainee. Regarding the results parameters part, is consisted by formulas which have been used for the financial estimation of the desired project. The operating costs are expenses that are related to the project operations. There are two categories of operational costs, fixed cost s and variable cost. For the better examination and financial estimation of the possible project we assume that the operational costs are fixed, so

there is no fluctuation on the feedstock, energy prices and all the parameters which can be considered as mutable during the examined times.

3.1 Feedstock cost

The price of feedstock is one of the most sensitive and major factors that can influence the feasibility of a biomass project. For the estimation of feedstock demand the boiler efficiency and the energy content must be approximately estimated. And that following formulae has been used for the calculations. **Formula;**

1. Feedstock cost =
Demand x Feedstock price
2. Demand(tons/year) = [Boiler capacity ×Energy content x Running hours]/
Boiler's efficiency.
3. Energy content (%) =[[GCV× Organic dry matter content]- [Energy required to dry 1kg of water × moisture content]]
4. Organic dry matter content (%) = [100% −Moisture content (%)] x [100% −
Ash content (%)]

3.1 Tabulation for Demand

For the production of the demanded heat would be calculated and tabulated as below,

S. No	Inputs	Values
1.	Boiler Capacity	15 TPH
2.	Moisture content	32%
3.	Ash content	4.62%
4.	Gross calorific value	2849.412 Kcal/Kg
5.	Boiler's Efficiency	78.9 %
6.	Energy required to dry 1 kg of water	588.642 Kcal/Kg
7.	Organic dry matter content	64.8584 %
8.	Energy Content	17.59 %
9.	Demand	29294.68 (approximately **30000** tons/year)

3.2 Tabulation for Feedstock Cost

When the feedstock cost has played a vital role for savings the money to the industries. Instead of we have the cost of thefeedstock and calculated the production demand. So that calculate the total feedstockcost for 1 year and tabulated as 3.2

S. No	Type Of Fuel	1 Ton for	1 year Feedstock
		Price (Rs)	Cost (Rs)
1	Rubber Wood	3300	99,000,000
2	Eucalyptus Wood	4000	120,000,000
3	Mixed Wood	3100	93,000,000
4	Palm Shell with Fiber	4500	135,000,000
5	Wood Chips	3600	108,000,000

4. RESULTS AND DISCUSSION

What would be need for optimization and then choose the variables and that variables would be formulated. And then formulated variable would be optimized and then get the obtain solution. So that we optimized the biomass fuel with the variables of Calorific value, Cost Savings, Efficiency. Instead of we made done a example combinations of three biomass fuels. These example combinations are taken from the above bar chart and tabulations. That are listed below,

1. Palm Shell With Fiber + Rubber Wood + Wood Chips.
2. Palm Shell With Fiber + Eucalyptus Wood + Wood Chips.

4.1 Comparisons

In that we consider the two combinations. When palm shell with fiber, wood chips have the highest calorific value. So they have taken the compulsory one. Consider the Quantity of steam (dry) generated 400 tons/day. Feed water temperature as 80^{o}C and Steam pressure and temperature as 10 bar and 180^{o}C. and using the steam table we get the Enthalpy of Feed water h f = 336.6 kJ/kg, Enthalpy of Steam hg = 2782.36 kJ/kg. So that (h f - hg) = 2445.76 kJ/kg.

Combination 1;

- Input fuels = 100 tons.
- Palm Shell With Fiber (30 tons) + Rubber Wood (40 tons) + Wood Chips(30 tons).
- GCV of (Palm Shell With Fiber + Rubber Wood + Wood Chips)
  = (3811.13+ 2622.55+ 2645.41)
  = 9079.09 Kcal/Kg.
  = 3026.36 Kcal/Kg
- Average GCV of Combination1
  = 12662.29 KJ/Kg.
- Boiler efficiency = 77.26 %
- Total Cost of fuels
  = (4500×30)×(3300× 40)× (3600 × 30)

= Rs. 3,75,000.

Combination 2;

- Input fuels = 100 tons

- Palm Shell With Fiber (30 tons) + Eucalyptus Wood (40 tons) + Wood Chips(30 tons)
- GCV of (Palm Shell With Fiber + Rubber Wood + Wood Chips)
  = (3811.13+ 2668.27+ 2645.41)
  = 9124.81 Kcal/Kg
  = 3041.60 Kcal/Kg
- Average GCV of Combination 2
  = 12726.11 KJ/Kg.
  - Boiler efficiency = 76.86 %.
- Total Cost of fuels
  = (4500×30)×(4000 × 40)× (3600 × 30)
  = Rs.4,03,000.

4.2 *Cost Savings ;*

Cost Savings = (Combination 2 - Combination 1)
= (4,03,000 - 3,75,000)
= Rs.28,000/day.
= Rs.8,40,000/month.

In Calorific value, Combination 2 has containing the highest GCV to compare the Combination When boiler efficiency side, we assume the quantity of steam would be same value. So that Combination 1 has higher efficiency than Combination 2. In cost savings side, Combination 1 has so much amount deviation to compare the Combination 2. So that recommended a Combination 1 to feed the fuel for the boiler.

5. CONCLUSION

In the presented work of 'Optimization on Biomass Boiler Operation and Maintenance' has expressed a Fuel Management. It also touches and briefly explains the equipment of IR Moisture balance, Muffle furnace, Bomb Calorimeter and how to handle the industrial environment. When the moisture content in biomass fuel generally decreases its heating value and also higher heating value of a biomass fuel decreases with increasing of its moisture content. The average moisture content in the presented work as 32%. The average ash content is 4.62%. The average Gross calorific value in the presented work as 2849.412 Kcal/Kg. After evaluation of the economical analysis results, and get the overview about the demand and cost of the biomass fuels. That would be proved that is capable for using the cost savings method. That is able to provide the more accurate operational costs and financial results. And then made a two combinations of biomass fuel such combination1 as Palm shell with fiber, Rubber wood, Wood chips and combination 2 as Palm shell with fiber, Eucalyptus wood, Wood chips. So that recommend to suggest the fuel of combination1. Because it gives the clear value in Fluctuation of cost and high Calorific value and high efficiency.

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