EVALUATION OF BOILER PERFORMANCE WITH USING OF BIO-ETHANOL ABSORBED WOOD PELLETS

by

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In current trends the wood pellets are very significance role in the replacing of boiler fuel, it is a surrogate and renewable fuel. For this study comparative analysis of the fuel performance in the boiler is carried out effectively. Two categorize of fuel like as raw wood pellets and wood pellets are immersed in the bio-ethanol are taken to this experimental work. The thermal characteristics and thermal efficiency of the boiler with influence of two types of fuels are conducted efficiently. Normally the wood pellets having small pores it is used to absorb the bio ethanol while in immersion. Wood pellets immersed in the bio ethanol are provided and increase the thermal properties as well as thermal efficiency compared to raw pellets, due to amid in the two fuels. The flue gas constituent's percentage such as CO_2, O_2, CO, and NO_x are analyzed, additionally the high temperature of flue gas also measured in the outlet of the chimney. No alteration is made in the boiler set-up which is comfortable to both fuels.

Key words*: wood pellets, bio ethanol, flue gas, boiler, thermal efficiency, CO_2*

Introduction

The infinite source of biomass are available in the world wide, it can be developed the social economic consideration. Bio fuel has the magnificent budding in RES it can be continually accumulate the hydrocarbons with the aid of sun light source [1-3]. Most of the

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countries believe the bio energy is the main source of the alternative fuel and gives important to this fuel in future [4]. Normally the wood pellet fuels are made by using of natural wastes (saw dust, wood chips, crop stalks, nuts, walnut shells, *etc*.) and formed into small size of cylindrical shapes, in general this pellets are formed different shapes and sizes based on the usage with standard procedure [5]. Wood waste are composed and separated to remove unwanted items present in the wood waste collection [6-8]. All the waste material of the wood are converted into the powder form by using of milling process. Moisture contents present in the powders are removed by applying of drying process after dried the powder materials are pelletized with influence of high pressure [9]. The pelletized parts are cooled and packed for utilization process. Bio ethanol sucked wood pellets are maximize the heating range of the fuel and progress the burning characteristics. Bioethanol fuel can be derived from agriculture feed stocks, commonly utilized the hemp, potato, cassava and corn for made a bioethanol fuel [10].

A novel route was implemented for this study such as immersed wood pellets in the bio ethanol were used to obtain excellent heating capacities. This wood pellets are compared to the raw pellets to improve the boiler performance characteristics. The result of outlet flue gas temperature, thermal efficiency, constituent's gas emissions are analyzed and the effects are compared with raw wood pellets.

Experimental work

In this study consider the preparation of fuel, boiler unit, arrangement of experimental set-up, measuring characteristics of the equipment's. In this study without modification of boiler working circumstances the two fuels are taken first one is raw wood pellets, second one is wood pellets were immersed in the bio ethanol [11]. The wood pellets of this experiment was 5 mm diameter and the length of 15-40 mm , the raw pellets are placed 10 L containers.

All the wood pellets are weighted (5 kg) and placed inside the separate containers with precision measurement. Pouring of bioethanol to all containers with correct level except one container for comparative analysis. Small size of pores in the pellets are absorbed the liquid bioethanol at maximum level after the absorption, the filtration process is carried out. The pellets are dried with atmospheric temperature for four days and sized. The 200 g samples are prepared and placed of each glass jar with pouring of bioethanol for measuring of absorption capacity [12]. During absorption the mass of the pellets were changed and it can be recorded. Bio ethanol pouring caused the bubbles it indicates the fast absorption of the liquid into pellets. The heating result of the fuel was measured by bomb calorimeter, the constituents gas elements are analysed by gas analyser equipment's. In this research smoke tube boiler was taken with the hopper capacity of 75 kg loaded physically. The tab. 1 illustrated the pellet boiler characteristics effectively. The using of stoker screw the pellets were received from hopper also used to ahead to the grate. Fuel is burned automatically by using of ignite and make guarantee in the combustion area.

At first, the burning gas passed into the 1st set of seven smoke tubes and then passed into 2nd set with ten smoke tubes. Finally, flue gases flow through exhaust pipe to surrounding. Cooling water surround the combustion chamber and the smoke tubes. Before the start up, the boiler parameters are controlled carefully, and pellets is ignited automatically using of igniter. The calorimeter was used to measure the heat transferred to the water. Emission characteristics were measured in the chimney by the way of gas analyzer every 60 seconds. The pellet's feed rate was measured by screw feeder and was uniformly maintained at the level of 3.5 kg/h.

Table 1. Pellet boiler characteristics

Characteristics	Top fed boiler
Type of boiler	Smoke Tube Boiler
Type of burner	Grate
Type of loading	Automatic
Length of Smoke Tubes (First Pass)	250 mm
Length of Smoke Tubes (Second Pass)	580 mm
Total number of smoke tube	17
Pressure (Working)	5 bar
Power (Thermal)	10 to 20 kW
Power (Fan)	50 to 70 W
Capacity of fuel tank	60 kg

Results and discussion

The bioethanol sucked of the pellets formed rapidly, but the absorption hold is very important because of the pellets has small pores, it can be verified by every day with consideration of mass. The fig. 1 illustrated that the mass variation of the untreated pellets and immersed pellets for each day at last the end of 40 days. The bioethanol sucked pellets were weighted frequently with explicit time periods, in the fig. 1 demonstrates that the mass changes were occurred up to 18 days for both pellets. After crossing of 20 days the mass has no changes in both pellets it proved that the pellets holds bioethanol liquid even it had a small pores. Finally the absorption capacity was estimated by the contrast between the mass before and after absorption, the result of absorption capacity of bioethanol sucked pellets were raised almost 20 %.

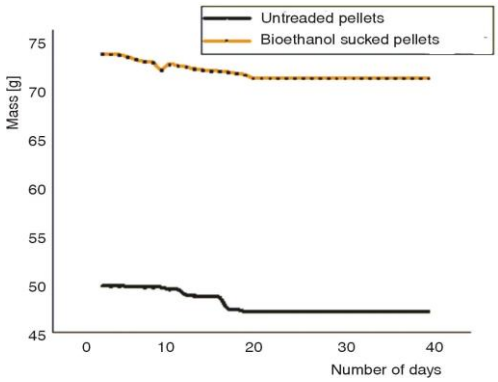

Figure 1. Mass variation in each day

Effects of flue gas temperature

Figure 2 presented the flue gas temperature variation with concentration of time period. Bioethanol sucked pellets fuel temperature were increased fastly contrast to untreated pellets, almost 110 °C of (maximum) flue gas temperature was observed in the bioethanol sucked pellets fuel similarly around 90 °C was observed in the untreated pellets fuel. The average flue gas temperature of bioethanol sucked pellets fuel and untreated pellets fuel were around 90 °C and 70 °C respectively.

Effects of emission

All the constitutents gas concentration of the emission gas were CO_2, O_2, CO, and NO_x were found to be in stable condition in starting of burning conditions. Figure 3 was illustrated that the percentage of CO_2 with consideration of time period. From the one hour time period the bioethanol sucked pellets were increased at the level of 20 minute. The maximum percentage of CO_2 was found to be 14.3% at 20 minute of time period in the bioethanol sucked pellets, similarly 10.2% of CO_2 was recorded in the untreated pellets. The average CO_2 percentage of untreated pellet fuel and bioethanol sucked pellet fuel were 8.8% and 10.2%, respectively. In fig. 4 the percentage of O_2 with deliberation of time period was clearly

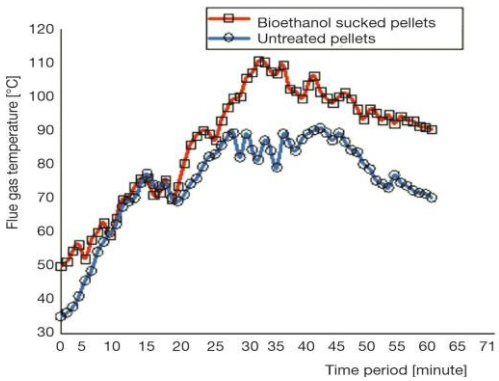

Figure 2. Flue gas temperature variation concentration of time

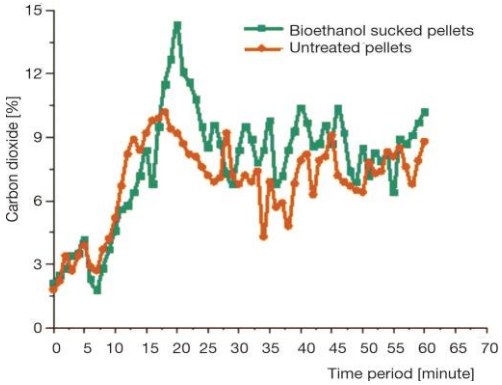

Figure 3. The CO_2 percentage with concentration of time

illustrated. From starting the attentiveness of the O_2 was high further increasing of time period it would be reduced consistently. Bioethanol sucked pellet fuel required higher air level compared to untreated pellets. From starting time period the O_2 percentage of untreated pellet fuel and bioethanol sucked pellet fuel were observed as nearly 20% and 22%, respectively.

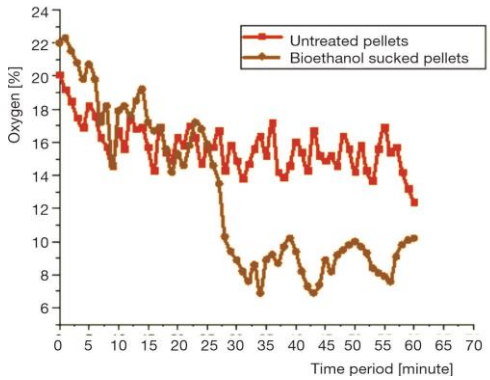

Figure 4. Oxygen percentage with concentration of time

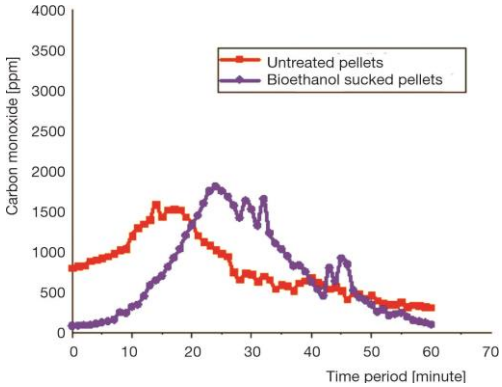

Figure 5. The CO ppm with concentration of time

After one hour time period the bioethanol sucked pellets fuel O_2 percentage level was reduced as 10% similarly untreated pellet fuel O_2 percentage concentration was found to be 12%. From both fuel the bioethanol sucked pellets fuel had lower oxygen concentration than untreated pellet fuel.

In fig. 5 shows that the CO with contemplation of time period was clearly illustrated. Higher emission level was obtained in the bioethanol sucked pellet fuel compared as untreated pellet fuel. The maximum CO was observed in the bioethanol sucked pellet fuel was 1812 ppm and the maximum level of CO presented in the untreated pellet fuel as 1587 ppm. At last the reduced level of CO was 310 ppm and 98 ppm of untreated pellet fuel and bioethanol sucked pellet fuel, respectively.

From the fig. 6 illustrated clearly, the NO_x present in the both fuels with concentration of time period. Beginning the NO_x level was increased rapidly in both fuel at last converted into steady-state. The maximum NO_x level was found to be as 85 ppm of the untreated pellet fuels and 76 ppm of the bioethanol sucked pellet fuel. The average NO_x ppm of untreated pellet fuel and bioethanol sucked pellet fuel were 60 ppm and 55 ppm, respectively.

Effects of thermal efficiency

Figure 7 illustrated the thermal efficiency of the untreated pellet fuel and bioethanol sucked pellet fuel with time period. Applied of both fuels the thermal efficiency was uniformly raised and the maximum thermal efficiency of the bioethanol sucked pellet fuel was recorded as 94.7% and the untreated pellet fuel thermal efficiency was observed as 92.88%. It can be evidently proved that the bioethanol sucked pellet fuel was recorded at correct level of absorption of bioethanol.

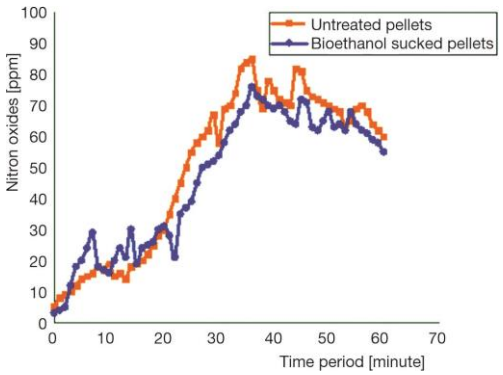

Figure 6. The NO_x ppm with concentration of time

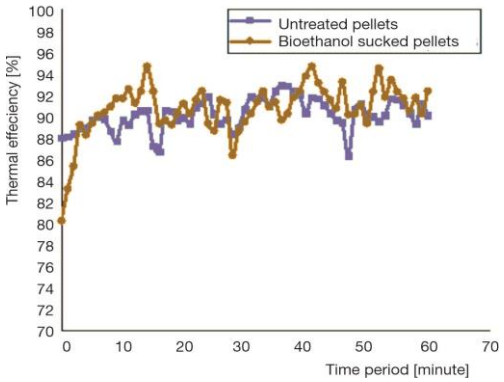

Figure 7. Thermal efficiency with concentration of time

The tab. 2 presented the average result of the experiment, the flow rate of water were same level in both fuels. The water inlet and outlet temperatures were varied, the highest water outlet temperature was obtained as 70.2 °C and also highest heat transfer to water was obtained as 21.4 kW.

Table 2. Summary of average values

Factors	Untreated pellets	Bioethanol sucked pellets
Flow rate of water [kgs^{-1}]	0.33	0.33
Inlet temperature of water [°C]	58.2	58
Outlet temperature of water [°C]	68.1	70.2
Difference between temperature	9.9	12.2
Heat transfer to water [kW]	15.2	21.4

Conclusions

The smoke tube boiler with two different fuel such as untreated pellet fuel and bioethanol sucked pellet fuel was implemented. The result of emission characteristics, flue gas temperature, and thermal efficiency was evaluated effectively and the comparative result of two fuel utilization was summarized as follows.

- Absorption capacity was estimated by the contrast between the mass before and after absorption, the result of absorption capacity of bioethanol sucked pellets were increased nearly 20%. Bioethanol sucked pellets fuel flue gas temperature was found to be almost 110 °C similarly around 90 °C was observed in the untreated pellets fuel. The average flue gas temperature of bioethanol sucked pellets fuel and untreated pellets fuel were around 90 °C and 70 °C, respectively.

- From the investigations the maximum percentage of CO_2 was found to be 14.3% at 20 minute of time period in the bioethanol sucked pellets, similarly 10.2% of CO_2 was recorded in the untreated pellets. The average CO_2 percentage of untreated pellet fuel and bioethanol sucked pellet fuel were 8.8% and 10.2%, respectively.
- From initial time period the O_2 percentage of untreated pellet fuel and bioethanol sucked pellet fuel were observed as nearly 20% and 22%, respectively. Finally the bioethanol sucked pellets fuel O_2 percentage level was reduced as 10% similarly untreated pellet fuel O_2 percentage concentration was found to be 12%. From both fuel the bioethanol sucked pellets fuel had lower O_2 concentration than untreated pellet fuel.
- From the test the maximum CO was observed in the bioethanol sucked pellet fuel was 1812 ppm and the maximum level of CO presented in the untreated pellet fuel as 1587 ppm. Finally the reduced level of CO was found to be 310 ppm and 98 ppm of untreated pellet fuel and bioethanol sucked pellet fuel, respectively.
- In this study the maximum NO_x level was found to be as 85 ppm of the untreated pellet fuels and 76 ppm of the bioethanol sucked pellet fuel. The average NO_x ppm of untreated pellet fuel and bioethanol sucked pellet fuel were 60 ppm and 55 ppm, respectively. The maximum thermal efficiency of the bioethanol sucked pellet fuel was recorded as 94.7% and the untreated pellet fuel thermal efficiency was observed as 92.88%.

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