American Journal of Sciences and Engineering Research
E-ISSN -2348 – 703X, Volume 3, Issue 2, 2020

Energy Recovery of Biomass: Study Comparative Experimental of Fixed Bed Combustion Olive Grignons and Wood Biomass

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ABSTRACT: *Energy recovery of biomass is considered as an important source of energy. The main objective of this experimental study is to validate the use of olive pomace as an alternative fuel using a comparison with that of wood. Therefore a biomass boiler was designed and fabricated based on two separate compartments. Experiments tests showed that the average temperature in the boiler is around 700 °C for pomace and 670 °C for sawdust with variations up to 100 °C depending on fuel supply. In this study, the temperature distributions within of the combustion chamber of pomace and sawdust of wood are presented, evaluated and analyzed. The removal of combustion gas is produced via a probe of a multi-gas analyzer placed at the smoke outlet. Analysis of combustion gases such as NO, CO, CO2 and O2 are illustrated and discussed. The results showed that low values of nitrogen oxides NOx have been observed, well below standard limit values and absence SOx.*

Keywords: *Energy recovery, biomass, olive pomace, combustion, bed fixed, pollutants.*

I. INTRODUCTION

Sustainable development requires supply sustainable and accessible in clean and renewable energy to provide it does not cause social repercussions negative. Energy sources such as waste biomass are considered energy sources generally as durable [1].A variety of sources of agricultural waste such as olive pomace generates enormous quantities containing a proportion significant organic biodegradable material [2, 3].However, deforestation has taken on proportions and anever reached speed, and only for cuts around 2010, around 5 million hectare of forest which are cut per year [4].Olive pomace is available in many and different countries, therefore a boiler was designed and performed to identify the possibility of using olive pomace as fuel. This study will focus on the comparison ofburning olive pomace and sawdust on two levels, the first is the maintenance of temperatures and the second is the emission analysis ofgas. There are different thermo chemical conversion techniques for the utilization of biomass, combustion is the most developed common technique [5]. Therefore, in order to increase the development of combustion, this process needs to be evaluated in terms of cost and efficiency. All researches focused on three main aspects; boiler characteristics, fuel properties and emissions [6]. In this study the fixed bed will be used due to its simplicity, high automation, batch control and low costs [7]. González et al. [8] studied the combustion of pellets from olive stones, cardoon and tomato residues in a mural boiler with capacity of 11.6 kW. Their results showed that there is a significant decrease in SO_2 and NOx emissions. Arce [9] studied the different parameters that affect the biomass selection for energy use. The results showed that the particle size and the injected air supply on the bed basis are the most influenced parameters on the combustion process. Vershinina et al. [10] studied the combustion efficiency of fuels based on wood processing and oil production wastes. The results concluded that the fuel maximum relative efficiency occurs for 50% sawdust, 25% oil component and 25% water. Vamvuka et al. [11] studied theco-combustion of municipal waste materials with agricultural residue in a fluid bed unit. Temperature profiles, combustion efficiency and gaseous emissions were evaluated and determined under different operating conditions. They concluded that combustion efficiency ranged between 98.5 and 99.5%. The increase in fuel feeding or the reduction in excess air, resulted in higher NOx and SO_2 emissions. This study presents and experimental work for the use of olive pomace as an alternative fuel using a comparison with that of wood in a biomass boiler. The analysis of combustion gases such as

 Received- 06-03-2020, Accepted- 16-03-2020

NO, CO, CO_2 and O_2 are illustrated and discussed in details.

II. MATERIAL AND METHODS

2.1. Fuel properties

In this section the different properties of wood and olive pomace will be presented. These properties include the fuel calorific value and the chemical components such as C, O_2, H_2 and N_2 percentage values.

2.1.1 Wood properties

Wood is one of the most popular materials that used as a fuel. This is due to its high calorific value of approximately 19.10 MJ/kg [12], its average elementary composition is shown in Table 1. Fig. 1 shows a photograph of the sawdust of wood that used in the experimental setup.

Table 1: Average percentage of components chemicals in wood

Chemical element	C	O_2	H_2	N_2	Ca, K, Mg
Percentage (%)	49.8	43.1	6.2	0.2	0.7

Fig. 1: Photograph of the sawdust of wood

2.1.2 Properties of olive pomace

Olive pomace is made up of skins, residuespulp, stone fragments, water and an amountof residual oil. Their compositions change fromolive type to another but in general they areconsisting of water, ash, volatile matter andfixed carbon. Olive pomace is also known for its powercalorific of these residues high 22.14MJ / kg [13].Table 2 presents the average percentage of components chemicals for pomace and Fig. 2 shows a photograph of the raw olive pomacethat used in the experimental setup.

Table 2: Average percentage of components chemicals forpomace [14]

Chemical element	C	O_2	H_2	N_2	Ca, K, Mg
Percentage (%)	52.11	41.16	6.73	1.40	0.3

Fig. 2: Photograph of the raw olive pomace

2.2 Description of the biomass boiler

The biomass boiler was designed and produced on two separate compartments, one of which represents the combustion chamber centered on the inlet primary air, injected by a variable flow blower as shown in Fig. 3. A convergent is deposited on the second compartment and is connected to the chimney in order to channel smoke and limit air infiltration by the top. Vertically arranged holes were drilled in each side of the two compartments at different heights to put different sensors measurements (temperature, pressure, flow meter, etc.). In in addition, the external faces of the room are equipped with tinted glass portholes for viewing the flow and the flame inside the boiler, similarly the boiler is provided with a system which ensures wall cooling (Fig. 3).

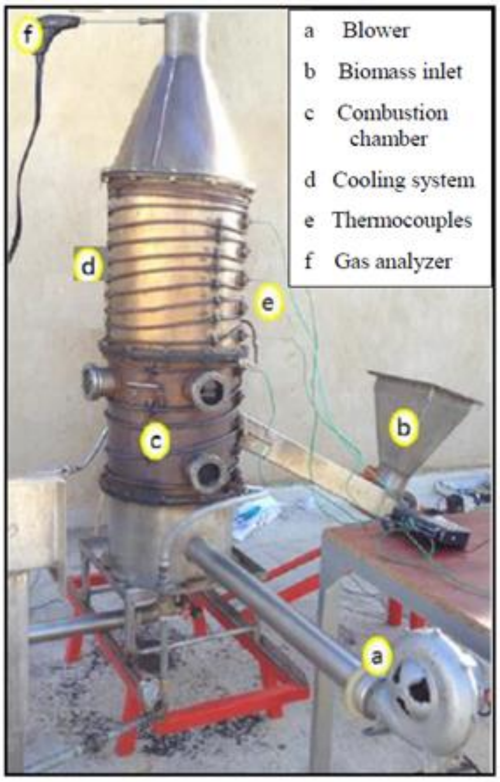

Fig. 3: Photograph of the biomass boiler in operating mode.

III. MEASUREMENTS AND INSTRUMENTATION

3.1 temperature measurement

The temperature was measured by the k-type thermocouples (Nickel-Chromium / Nickel-Alumel) with data acquisition during the experimental setup. The k-type is the most common type of thermocouples. The temperature measurements include the biomass temperature material in the gasifier core, the engine exhaust gas temperature. Fig. 4 shows a photograph of k-type thermocouple with digital display.

Fig. 4: Photograph of k-type thermocouple with digital display

3.2 The Computerized Gas Analyzer

The gas analyzer was used to identify the engine performance and mechanical problems and test the running efficiency of the engine. The computerized gas and smoke analyzer was used to measure the exhaust gases of hydrocarbon HC, nitrogen oxides NOx and carbon monoxide CO in addition to carbon dioxide CO_2 and oxygen O_2, as shown in Table 3. The device was provided with programmable software "ANOI Software" and the results appeared on the screen. Fig. 5 shows a photograph of the computerized gas analyzer used in the experiments.

Table 3: Specifications of the exhaust gas analyzer

Species	Detection	Resolution	Uncertainty
CO_2	Infrared	0.1%	± 5%
HC	FID	± 10 ppm	± 5%
CO	Infrared	1 ppm	± 5%
O_2	Galvanic cell	0.1%	± 5%
NO_x	Chemiluminescence	1 ppm	± 5%

Fig. 5: Photograph of computerized gas analyzer

3.3 Experimental procedure for starting the boiler

1. Preparation of the granules of olive pomace: On uses sieves to obtain a particle size homogeneous.
2. Introduction of a specific quantity of the biomass in the combustion chamber via the screw endless, and spread it out at the bottom of the room.
3. Cleaning the portholes with acetone if they are dirty.
4. Installation of temperature sensors at the level walls.
5. Launch of the gas analyzer and installation of its sampling probe at the smoke outlet.
6. Installation of fans for air injection.
7. Injection of a low air flow.
8. Ignition with a gas igniter through the ports optics.
9. Adaptation of the air injection rate and the introduction of biomass until obtaining of a stable flame.
10. Biomass is fed periodically every 30 seconds.

IV. RESULTS AND DISCUSSION

4.1 Pomace temperature field olive and sawdust from the room combustion

By applying the experimental procedure for starting theboiler with a fixed bed for the combustion of a combustible (olive pomace or sawdust), it is able to light olive pomace(or sawdust fromwood). In these two cases, the flames obtained were stable.Fig. 6 presents a photograph of the flames from the combustion of pomace olive, which ensures good distribution offire on the biomass surface and distributionregular air given its uniform injection through thegrid area.

Fig. 6: Photograph of the flames from the combustion of pomaceolive.

The evolution of the temperature in the combustion is characterized by variations in teeth saw with an approximate periodicity of30 seconds and whose values vary around an average of 706 °C with a peak of 794 °C forpomace. On the other hand, for sawdust the temperature hovers around an average value of676 °C with a peak of 790 °C, the appearance of these two curves can be justified by the type of supply in biomass that is done by period (To maintain an average temperature required in the combustion), as well as the two stages that must undergo the biomass inside the chamber before combustion namely drying and pyrolysis (Fig.7).

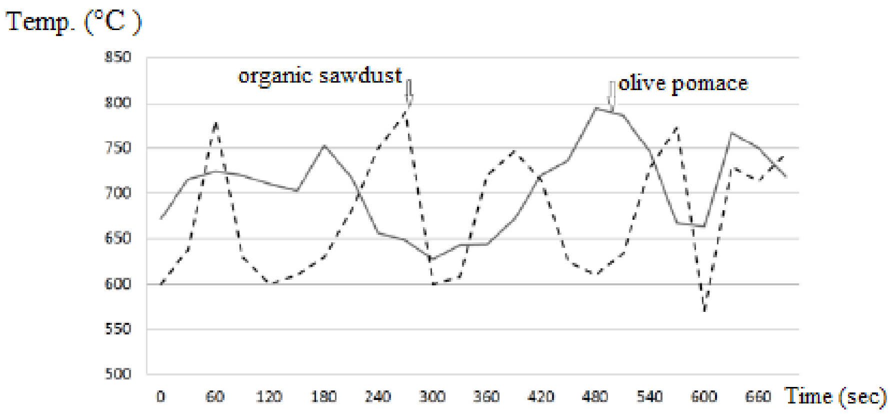

Fig.7: Evolution of the temperature of gases from the burning of pomace and sawdust inwithin the boiler

4.2 Analysis of combustion gases fromolive pomace and sawdust

Table 4 shows the results of the gas analysis at the outlet of the boiler. These are average values obtained from instantaneous values.Analysis of the combustion gases shows that theNOx emissions are relatively low. Those are very positive results because they are much lower than pollutant limitation standards [15].CO level is relatively very high for wood which exceeds 15000 ppm for the olive is around 1270 ppm.

Table 4: Analysis of the combustion gases from the cake olive and sawdust.

Gases	Smoke pomace	Sawdust smoke wood
CO (ppm)	1272.2	15485.2
NO (ppm)	59.8	16.4
CO_2 (%)	8.4	2.7
NO_x (ppm)	62.0	5.5

V. CONCLUSION

This study presented the obtained results by burning olive pomace and burning the sawdust in a biomass boiler in performing the same steps for both tests. The first one note concerns the good inflammation of the pomaceolive as well as sawdust and the stability of the combustion. Experiments have shown that evolution of the temperature within the combustion chamberis characterized by ripples whose values vary around an average value of 700 °C forcakes and 670 °C for wood. The strong values ofgas temperatures obtained will produce the steam which will eventually be used with a micro turbine for the production of electricity. Analysis of flue gas has shown very results interesting in terms of polluting emissions. Indeed,low values of nitrogen oxides NOx have been observed, well below standard limit values and absences Ox. On the other hand, the CO level is relatively strong for sawdust, a priori because ofthe heterogeneity of the product (presence of water vapor), as well as the mixture between reagents (air and wood).

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