A Study of the Chemical and Physical Properties of Cane as a Biofuel After Thermal Treatment Processes (Tarification)

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Abstract:

The purpose of this study is to examine the physical and chemical properties of cane as a biofuel after torrefaction processes. The main objective study is to increase the use of biomass as renewable energy resources and improve the efficiency of technologies and equipment used to burn fuel. Sugar cane specimens were collected directly from the agricultural lands with a moisture content 11.45%. All specimens have been dried. Calorific value, heat capacity, percentage of some elements and carbon monoxide emissions have been measured. The rustles indicated calorific value for cane more than straw rice and barely while less than straw wheat and corn, high carbon content, acceptable hydrogen, oxygen, and sulfur content, and low nitrogen content, carbon monoxide emissions and .

Keyword: biomass, torrefaction, cane, calorific value

1. Introduction:

In recent decades, the renewable energy is hot topic in the scientific research, the main objective was to increase the share of the use of renewable energy resources, especially different types of biomass, while increasing the efficiency of technologies and equipment used to burn fuel [1]. Biomass is supposed to be considered a promising source of energy for many countries in the near future due to its main characteristics, such as renewability and environmental friendliness compared to other fuels, and a lack of influence on the free carbon balance in the atmosphere, which leads to improvement of the "greenhouse effect" [2].

The European Union (EU) has defined biomass as the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry, and related industries, as well as the biodegradable fraction of industrial and municipal waste[13]. The
disadvantages of the direct burning of the biomass fuel is the increased ash content and low ash melting temperature, due to low density and high humidity in biomass, which leads to the formation of slag conglomerates, reduces the efficiency and reliability of boiler equipment. [4]. Therefore, a preliminary biomass preparation is required, which mainly includes the heat treatment of the raw biomass, then grinding and granulation to obtain the granules, which is called torrefaction. The term torrefaction is generally used to describe processes in which Thermally treated granules are preferred products from biomass[5]. Another advantage of thermally treated granules is that their combustion heat is higher compared to the combustion's raw fuel in any type of boiler equipment[8]. In order to biomass (granules) produced have better long term stability for storage and higher energy density properties, use densification process by compaction of the raw materials into pellets or granules. Pellets have a length smaller than 38 mm (1.5 in.) and a diameter around 7 mm (0.3 in.). Briquettes can be produced through a process called screw extrusion, where biomass is extruded by a screw through a heated die [22].

Gabriel O.I. Ezeike has been done study about the quality of fuels is determined by the elements that make up its composition, namely, carbon (C), hydrogen (H) and Oxygen(O). The higher the percentage of these elements in the biomass, the larger is the amount of heat generated upon complete combustion[3].

In 2012, Anthony E.J. carry out an investigated study focus effect increase ratio confirmed that the combustible sulphur is an undesirable and even harmful component of fuels because on combustion it yields the product sulphur dioxide (SO2), a gas of unpleasant suffocating odor which in the presence of moisture forms sulphuric acid (H2S04) which destroys the metallic parts of heat generator furnaces. Likewise, nitrogen is an undesirable element because when burning it yields nitrogen oxides harmful to the environment. Therefore, the lower the ratio of these elements, the greater the quality of the fuel[12].

Solts (1988) indicated in a previous study that the various chemical thermal conversion processes developed for the biomass are part of a continuous chain where at relatively low temperatures and in the absence of oxygen, the biomass materials are divided into tar ... and gases. was developed a number of biomass chemotherapeutic processes, to production of granules with high water resistance and weather and biological effects. This new quality allows to solve the most complex problems transport and storage[7].

In order to effectively use biomass as fuels, the calorific values and the chemical and physical properties have to be known to biomass. The objective of this work therefore was to experimentally determine the gross calorific values and study of the chemical and physical properties of cane as a biofuel. With such information, it would then be feasible to determine their potential contribution to the national energy requirements and other thermal applications.
2. Methodology

Cane samples were collected directly from farmland, the moisture content were 11.45% for all the samples. The samples were dried using a (VL50) device, and grind it into small pieces not exceeding 6-8 mm. The thermal value, mass defect, the concentration of some elements, heat capacity and the percentage of carbon monoxide emissions have been tested.

2.1 Experimental test

a- Calorific value and mass defect: The calorific value and mass defect of the cane sample were calculated using the (NETSCH STA 409 PC / PG) device as shown in Figure (1), the sample weight was (11, 72 mg), start heating from 0°C until the temperature reaches 800 °C, the heating rate was 40 degrees per minute.

![Fig. 1. The (NETSCH STA 409 PC / PG) device](image1)

b- Heat capacity: The heat capacity of the cane is calculated according to the measurement results in the device (IT-C-400) heat capacity meter after connecting to a computer using the LabVIEW program where it shows the results as a variable graph in accordance with the temperature change of the device.

![Fig. 2. Heat capacity device (ET–C–400)](image2)
c- Chemical elements concentration: The concentration of elements in the cane sample (C, H, O, N, S) was measured using an atomic absorption spectrum device[9].

d- Measurement emission of gas (CO): The flue gas analyzer device (MRU Sigma) in (Fig. 3) was used. The flue portable gas analyzer allows long-term carbon monoxide analysis and measuring the flue gas temperature when combusting different types of fuel.

![Flue Gas Analyzer (MRU Sigma)](image)

3. Results and discussion

3.1 heat capacity: From (fig. 4.) can be seen that the heat capacity at 60 °C is equal to (1000 J / (kg. °C)) and gradually increases with high temperature to reach the maximum value (2300 J / (kg. °C)) at 130 °C. The heat capacity decreases to (1100 J / (kg. °C)) at 190 °C. These values were measured for a dry cane sample, since the heat capacity increases with increasing humidity. The results of changes in the heat capacity of the cane samples depending on the temperature and processing time are presented. A comparison of the results indicates their identity in comparison with the IT - S - 400 method, and the possibility of using them in further calculations.

![Graph of Heat Capacity vs Temperature](image)
3.2 calorific value: (Fig. 5.) shown that in the range 0 - 90 °C, biomass loses structural water. The exit of volatile substances (thermal degradation) from biomass begins at a temperature of 140 °C, and the exit rate increases with increasing temperature. First, the decomposition of hemicellulose occurs and then, at a higher temperature, the decomposition of cellulose. At a temperature of 300 °C, when the complete release of most volatile substances occurred, the release rate of volatile components increases sharply. It was established that the transition from the endothermic to exothermic reaction is observed at temperatures above 320 °C, (Pyrolysis), we can ignore the thermal effects of the reaction in the proposed model more than in the studied temperature range (0-320 °C) [36]. It can be noted that non-lignocellulosic biomass (reed), has a high energy intensity of the process (the area under the DSC curve), it is also confirmed by the results of measuring the effective heat capacity. Moreover, the DSC – TG method, is more informative, since it allows one to track solid-state structural transitions for cane asample. A decrease (defect) in mass (TG curve) in the temperature range 0 - 270 °C indicates a slight decrease in the initial mass of the sample due to the release of volatile and liquid components of the STP. Decomposition products are tar, ash, and low molecular weight gases (CO and CO2) [36]. The residual mass of the “reed granule” sample was 23.29% (320 °C), i.e. ash content of the original cane biomass is high.

Fig. 5. DSC - TG analysis of the cane granule

3. 3. Percentage of some elements: Table No. (1) shows the results obtained from analyzing the cane sample compare with previous studies results of some biofuel[2,10].

Tab. 1. Some properties of cane compared to some type of biofuels

|                  | Wheat straw | Barley | Straw rice | Corn | Cane |
|------------------|-------------|--------|------------|------|------|
| Ash content, %   | 4.38        | 8.1    | 12.85      | 6.4  | 7.84 |
| calorific value, MJ/kg | 18.5        | 6.22   | 16.31      | 18   | 17.8 |
3.4 Carbon monoxide emissions: When dry cane before torrefaction was burned in a conventional boiler furnace with a layered burning, the amount of carbon monoxide (CO) was (1699 ppm), which exceeds the current (EU) emission standards by (10) times. When burning granular cane (Thermal treatment) in a fluidized-bed boiler, carbon monoxide concentrations were obtained (98 - 160 ppm), shown in Fig. 6, which corresponds to EU standards.

![Fig. 6 - The curve of the change in the concentration of carbon monoxide in the flue gases at the outlet of the fluidized bed furnace when burning cane pellets](image)

4. Conclusion

According to studying some of the chemical and physical properties of the cane as (biofuel), the results showed that it can be considered a good type of biofuel after the torrefaction (heat treatment) process, due to its relatively high calorific value (17.8), low ash content (7.84%), a relatively high carbon content, a low percentage of nitrogen, An acceptable proportion of hydrogen, oxygen, and sulfur, the emission ratio when burned is acceptable compared to other biofuels (wheat straw, barley, rice straw and corn) and in addition to providing it in most areas naturally, all this opens up new and broad horizons for the use of cane as a biofuel in industrial fields.

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