Realization and Testing of an Updraft Gasifier Preliminary Study

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***Abstract*—Waste management and the energy supply are two major challenges that human have recorded for millennia. The technologies for recovery of energy from wastes can play a vital role in mitigating the problems. The biomass gasification is one of the principal technologies of heat treatments, which offer the possibility of producing renewable energy called "synthesis gas" consisting essentially of combustible gases such as methane and hydrogen. The aim of our work is the realization and testing of a small up draft gasifier. The woodwork of the commune of Adrar generates an important quantity of sawdust, which is neither treated nor valued, of this fact, therefore we have chosen as the substrate for this study. In addition to the interesting energy characteristics (Low Heat Value LVH =4779.17 kWh/ton) the sawdust does not take part in the increase in the content of atmospheric CO_2. The gasification prototype realized during this study allowed a production of a flammable gas in a temperature reached 390°C with a reduction ratio of more than 87% by mass.**

***Index Terms*—waste, sawdust, renewable energy, heat treatment, gasification, gas of synthesis**

I. INTRODUCTION

Fossil energy shortage and management of the enormous waste quantities generated by various human activities are two acute problems that have led to a growing awareness to adopt scientific methods for safe elimination of waste and production energy while preserving our environment.

The energy recovery technologies from waste can play a crucial role in the attenuation of these problems. These technologies can lead to a substantial reduction of the quantities of total waste requiring final elimination, with valorization as energy and / or matter. [1]

However, the choice of the technology of treatment and valorization of waste depends on the type of waste and the nature of its subsequent destination. Conversion of waste into energy is proven to be a cost-effective technology. This is usually achieved with heat treatment such as combustion, gasification or pyrolysis, because they can reduce the volume of waste, toxicity, and produce a stream for later use. [2]

The biomass gasification is one of the technologies of heat treatment that allow an almost final disposal of organic waste and a production of a clean and fast energy called "syngas".

II. MATERIAL AND METHODS

A. Realization of the Prototype

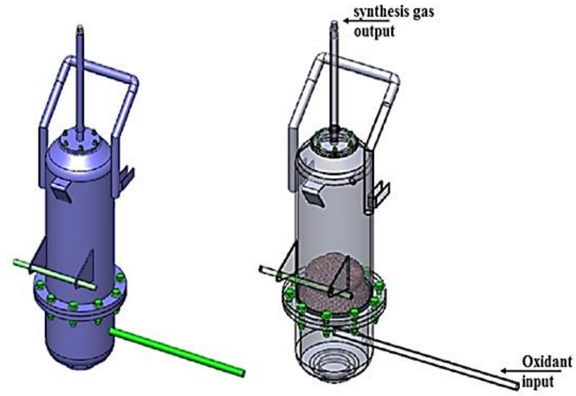
The gasification prototype (gasifier) is performed in the unit of research in renewable energy in Saharan medium (URER.MS Adrar).

The principal body of our prototype is built based on a powder extinguisher, with a total height of about 90cm, an internal diameter øint ~ 29 cm and a volume of about 0.06 m3, the air-flues are made using copper pipes.

The oxidant entry is fixed in the lower part of the gasification body at 12 cm of the bottom, with a bed for the substrate located at 9 cm above the oxidant entry.

The synthesis gas output is fixed in the upper part of the principal body as well as the substrate entry (Fig. 1).

The oxidant used, is the air resulting from a medium-sized compressor (25l), the choice of oxidant is made compared to the availability and the cost. The air is injected from the bottom upwards through holes 3mm in diameter at a rate of $0.2m^3$ / h. the airflow is measured using an anemometer Testo 435.



(a)

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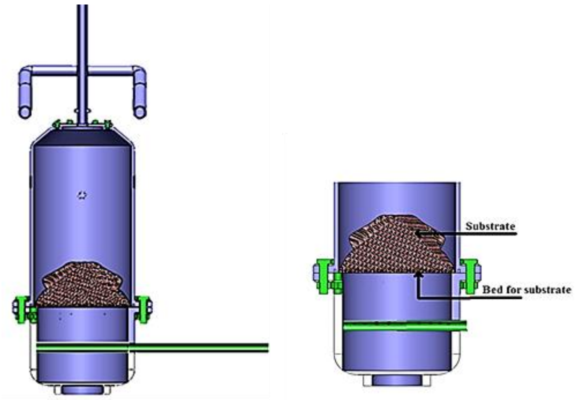


(b)

Figure 1. Prototype of gasification (Full view (a) and longitudinal section (b))

B. *Substrate Characterization*

As part of our study on gasification, we are interested more specifically in the lingo-cellulosic biomass. We chose to take as reference the sawdust, which comes from a local joinery in Adrar city.

The moisture of our substrate is determined according to ASTM standard method E871 [3], the ash content according to ASTM standard method D1102 [4], the volatile matter according to ASTM E872 [5] and the fixed carbon is calculated by the difference method according to the equation:

$$\mathbf{FC}\% = \mathbf{100} - (\mathbf{VM} - \mathbf{ASH})\%$$

where, VM and ASH represent the volatile matter and ash [6].

The substrate calorific value is determined by the abacus method [7]. The conversion rate (t) is calculated from the equation:

$$\mathbf{t}(\%) = \frac{(\mathbf{w_0} - \mathbf{w})}{\mathbf{w_0}} \times \mathbf{100}$$

C. *Temperature Monitoring*

During the experiments, the synthesis gas temperature produced is followed using a ceramic thermocouple high temperature (+1260 ℃) standard K and the gasification temperature using a needle thermocouple of the type K (1100 ℃). The two thermocouples are connected to a data acquisition Fluke Hydra Series II.

III. Results and Discussion

The gasification prototype developed has been changed several times to make it perform and easy to use; the final model is a fixed-bed gasifier type Updraft. Wherein the substrate is introduced from the prototype top and the air is injected through the bottom.

A. *Substrate Characterization*

Fig. (2) represent the average composition of the substrate

The lignocellulosic biomass selected for the study is the sawdust issued from a local joinery. It is a very abundant and not values waste.

Any fuel contains one part water that emerges during combustion in the form of steam, this moisture plays a major role on the energy content of the fuel. The average moisture content obtained is 5.87 + 0.13%, a low but satisfactory value from the point of view energy that moisture is inversely proportional to the calorific value. [8]

The substrate characterization has shown a low ash content of about 0.47 ± 0.12% in dry weight, a value which corresponds to the interval [0.5-8%] cited in literature [9] with a margin of error, so that clean wood (0.5%). [8]

The volatile matter is evaluated of 88,562% on dry weight, a value close to that found by Wander & al. [10]

Fixed carbon value is 11.009 ± 0.875%, compared to the results find by Wander & al [10] 12.93%, we can conclude that our result is coherent.

The lower heating value LHV obtains is 4779.17 kWh/ton equivalent of 17205.02 j/g, interesting value from the energy standpoint.

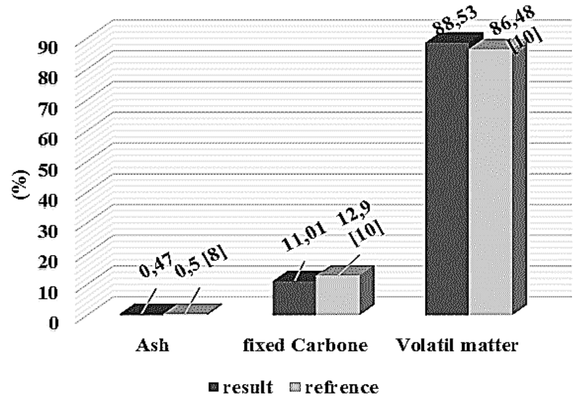
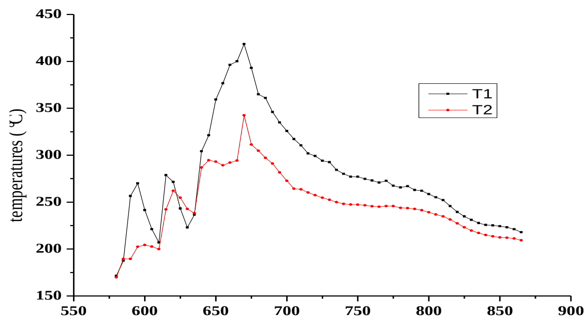
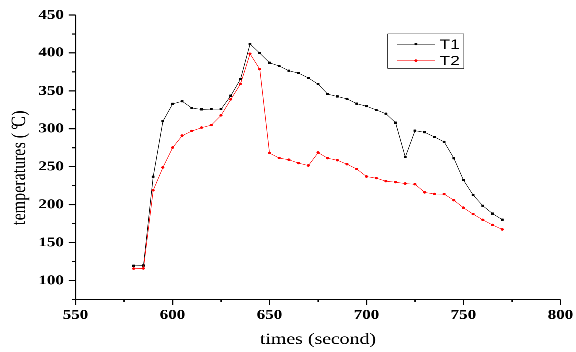


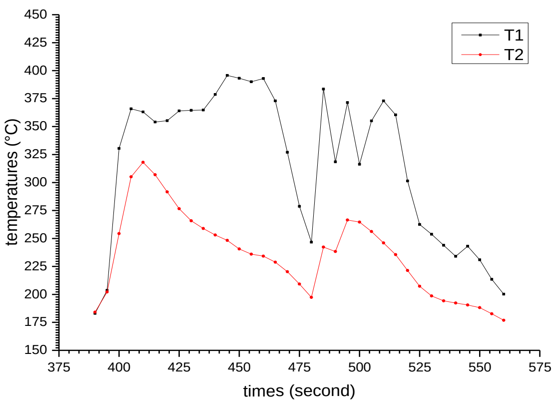
Figure 2. Substrate average composition



(Test 1)



(Test 2)



(Test 3)

Figure 3. Evolution of the temperature during the gasification

B. *Temperature Monitoring*

The substrate temperature profile (T1) and the produced gas temperature (T2) are represented in Fig. 3.

The profile of the internal temperature of the gasifier and the gas produced, for the tests carried out, have the same pace. The internal temperature of gasification exceeded the 418 ℃, a value close to the interval [500 - 1000 ℃] [11].

The synthesis gas temperature produced varies in an interval of 200-400 ℃, which is in conformity with the fixed-bed gasifier theory with air as the gasifying agent. [12]

C. *Syngas Product*

The synthesis gas product is a flammable gas, charged with particles and contains tar, two undesirable components which one must plan to eliminate before the use of gas for the energy production. The purification method chosen will depend on the mode of valorization envisaged.

Figure 4. The produced gas inflammability test

(a) (b)

Figure 5. Volume before (a) and after (b) gasification

D. *Biomass Conversion Rat*

At the end of the process, the substrate volume has decreased to more than 87% of the initial volume. The ash from the gasification is rich in minerals and can be used as fertilizer for soil.

IV. Conclusion

Technologies of sustainable and renewable development can be considered effective tools to remedy this lack while solving the waste problem. The studies conducted by different researchers and specialists have shown that renewable energies are the best choice especially in remote sites. Among the range of possibilities, biomass offers interesting routes through its many advantages and high potential to meet the energy supply technologies requirements.

The biomass gasification is one of the main short-term options that allow an almost final disposal of organic waste and the production of a clean and fast energy called "syngas".

The synthesis gas is mainly uses in units of cogeneration of heat and electricity, but other ways of valorization, are also possible: second-generation biofuels (methanol, dimethyl ether, precedes Fischer-Tropsch…) [13], renewable production of hydrogen [14], the combustible batteries fuel cell [15].

The designed prototype is a small up draft gasifier, which functions by using the air as a gasifying agent and thereby producing a combustible synthesis gas while reducing the substrate of 87%.

The biomass chosen for the experiment is as sawdust because it does not participate in the increase of the content of atmospheric CO_2 and it offers a high calorific value (LVH=4779.17 KWh / ton).

The gasification temperature reached the 418 ℃ and that of produced gas exceeded 390 ℃ what is in conformity with the theory.

The produced gas is load in particles and contains tar and other undesirable components, which requires a pretreatment to purify produced gas and used it thereafter as needed.

This work is a preliminary experimental test whose results are promising and realizable on land, especially for remote and deprived of heat and electricity, it is a way to treat useless biomass and produce a quick energy and directly usable.

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