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Preliminary Study of Gasification of Sawdust

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Abstract— **Waste management and the energy supply are two major challenges that human have recorded for millennia. Heat treatment is one of many technologies that meet this challenge enables an optimal and rapid reduction of the treated waste and produce clean energy recoverable at the end of treatment.**
The gasification of the biomass is one of the principal heat treatments which offers 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 design and testing of a small gasifier type "Up draft".
The woodwork of the commune of Adrar generate 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 (LHV =4779.17 kWh/ton) the sawdust does not take part in the increase in the content of atmospheric CO_2.
The gasification prototype constructed during this study allowed a production of a flammable gas in a temperature reached 390°C with a reduction ratio by mass of more than 87%.

Keywords— **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. Among the various existing technology we can quote the heat treatment, as its name indicates it, this technology is based on the thermal conversion of waste.

Heat treatment is often described as "mature" technology with little place for improvement, because it was used by humanity for millenniums, the fire for warmth, cooking and production charcoal were the first thermal processing of biomass controlled by humans.

Heat treatment is a technique whose results are fast and waste disposal is almost definitive.

This work is a preliminary study on one of the thermal treatment process which is "gasification".

II. MATERIAL AND METHODS

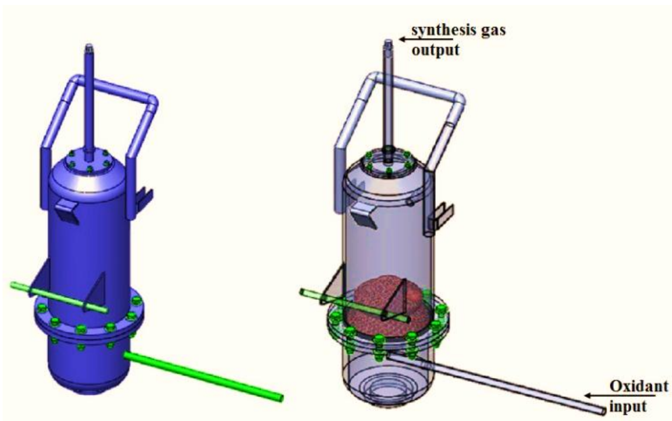
A. *Realization of the gasification prototype*

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

The principal body of our prototype was built based on a powder extinguisher, with a total height of about 90cm, with an internal diameter $ø_{int}$ ~ 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).



(a)

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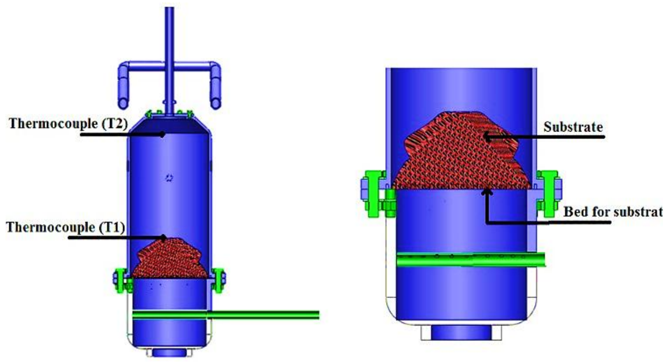


(b)

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

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

B. Substrate characterization

As part of our study on gasification, we were 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 was determined according to ASTM standard method E871 [2], the ash content according to ASTM standard method D1102 [3], the volatile material according to ASTM E872 [4] and the fixed carbon was calculated by the difference method according to the equation:

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

Where VM and ASH represent the volatile matter and ash [5].

The substrate calorific value of was determined by the abacus method [6]. The conversion rate (t) was calculated from the equation:

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

Where w_0 was the raw material weight, and w was the solid residue weight after the reaction.

C. Temperature monitoring

During the experiments, the synthesis gas temperature produced was followed using a ceramic thermocouple high temperature (+1260°C) standard K and the gasification temperature using a needle thermocouple of the type K (1100°C). 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 was a fixed-bed gasifier type Updraft. Wherein the substrate was introduced from the prototype top and the air was injected through the bottom.

A. Substrate characterization

The average composition of the substrate was represented in figure 3.

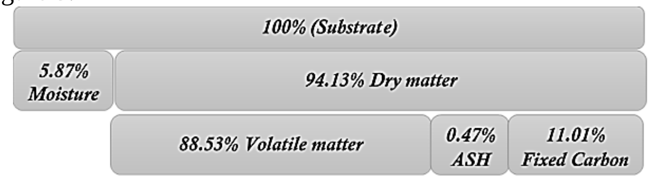


Figure 3. Substrate average composition

The lignocellulosic biomass selected for the study was 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 was inversely proportional to the calorific value. [7]

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 [8] with a margin of error, so that clean wood (0.5%). [7]

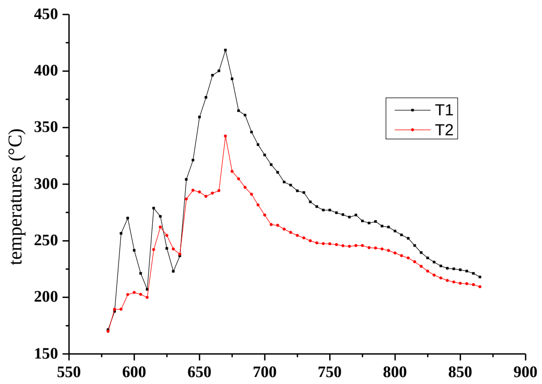
The volatile matter was evaluated of 88,562% on dry weight, a value close to that found by Wander & *al.* (2004) [9]

Fixed carbon value was 11.009 ± 0.875%, compared to the results find by Wander & *al* (2004) [9] 12,93%, we can conclude that our result was coherent.

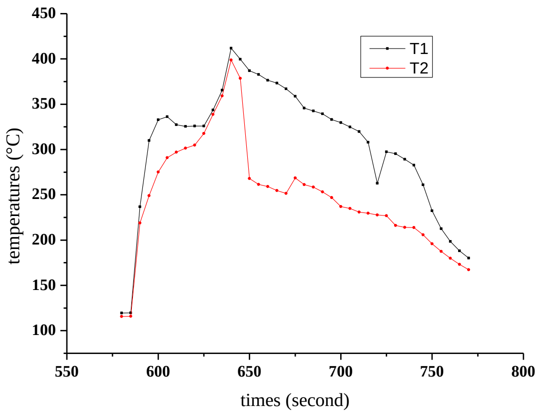
The lower heating value LHV we obtains was 4779,17 kWh/ton equivalent of 17205,02 j/g, a value which we can consider interesting from the energy point of view.

B. Temperature monitoring

The substrate temperature profile (T1) and the produced gas temperature (T2) are represented in figure 4.



(Test 1)



(Test 2)

Figure 4. Evolution of the temperature during the gasification

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°C, a value close to the interval [500 -1000°C]. [10]

The synthesis gas temperature produced varies in an interval of 200-400°C, which is in conformity with the fixed-bed gasifier theory with air as the gasifying agent. [11]

C. *Syngas product*

The synthesis gas product was 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 5. The produced gas inflammability test

D. *Biomass conversion rate*

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

IV. CONCLUSIONS

The biomass gasification is one of the main short-term options that allows 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…) [12], renewable production of hydrogen [13], the combustible batteries fuel cell [14].

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.

The characterization results showed a water content of 5.87%, 11.009 fixed carbon, 0.47% of ash and 88.52% of volatile material, the LHV is estimated to 4779.17 KWh / ton using the nomograms.

The gasification temperature reached the 418°C and that of produced gas exceeded 390°C 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.

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