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EXPERIMENTAL RESEARCH ON THE INFLUENCE OF COMBUSTION AIR VELOCITY ON ENERGY EFFICIENCY AT TLUD GENERATOR

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Abstract: *Biomass energy dates back to the beginnings of human civilization and is one of the most important resources to meet the daily energy requirements for many people in developing countries. Biomass gasification is an important branch of heat production, electricity or biofuels. With the help of the TLUD gasification process, applied to heating systems or for cooking, thermal energy and biochar can be produced, contributing to the reduction of deforestation pressure, to the improvement of soil productivity and to a sustainable development.*
The article presents experimental tests on the influence of the speed of the combustion air (secondary air) on the energy efficiency of a laboratory testing equipment, of gaseous type TLUD. The results show a substantial increase in the temperature in the flame in case of increasing the flow of combustion air and its speed by 30% compared to the ratio of 1/3 recommended in other scientific articles on this topic.

Keywords: *TLUD Gasification, biomass, biochar, greenhouse gases, stoichiometric combustion*

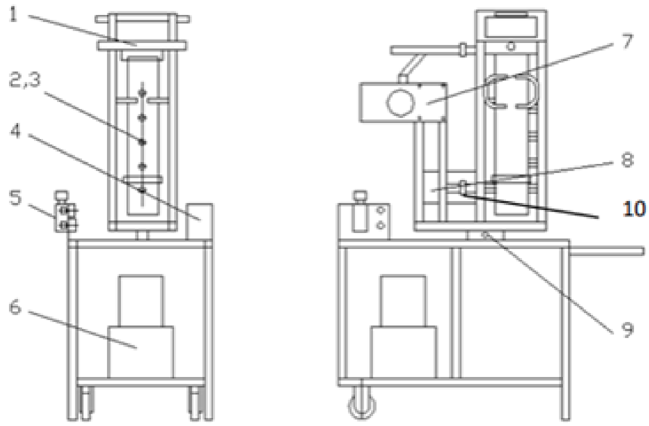
1. Introduction

Energy is an essential factor of socio-economic development and it is clear that in the future demand will increase worryingly much [1]. Problems with the need for energy are found in all developed or developing countries. For developed countries in the future, energy demand will be low compared to developing countries, where it is necessary first and foremost to improve energy accessibility [2].
Affordable energy for everyone is the starting point for poverty alleviation, and for the development of human capital [2]. For this desideratum, the economic cost is usually a priority, before the impact on the environment or the health of the population. This is shown in a United Nations report [4] which states that 3.2 billion people depend on solid fuels (wood, vegetable waste or coal) for heating. The imbalance between biomass supply and demand leads to massive deforestation and deforestation. It is worrying because these actions bring negative effects on the environment and on human health.
The negative effects of using biomass for energy production also result from the incomplete combustion of biomass and the release of CO2 and PM into the atmosphere, which results in an increase in global temperature and an increase in climate change [5]. Climate change mitigation and forest resource conservation have been two main motivations for most improved combustion system projects. In many developing countries, the cooking technique used is still the traditional open fire that has less than 10% energy efficiency. The percentage can be increased with the use of improved combustion systems, thus reducing the consumption of firewood and combating deforestation [6].
Energy consumption and economic growth have a two-way causality [2], as economic growth encourages energy consumption and the growth of energy consumption affects economic growth and the environment. The use of improved burn technology, such as the TLUD gasification process, which produces thermal energy and biochar, could help reduce deforestation pressure, improve soil productivity and heating systems, or for better performing and more environmentally

friendly cooking. Almost any form of natural organic material (woody) can be converted into biochar. Therefore, materials considered as wood waste can be efficiently transformed, through gasification, into energy and biochar which can be used as a basic material for the improvement of degraded soils, and to sequester carbon in the soil over a long period of time, contributing to the reduction of greenhouse gas emissions, to the achievement of an efficient protection of the environment and to the achievement of a sustainable energy development.
The name of TLUD was adopted due to the burning type Top Lit Up Draft [7, 8, 9], in which the ignition is made at the top, the pyrolytic front advances into the biomass layer and the gasification air (primary) penetrates through the biomass layer from the bottom up. More details about this process can be seen in various published articles [10,11, 12, 13].

2. Test device

The laboratory device on which the tests were performed (fig. 1) consists of a gas generator on the TLUD principle (1), equipped with air flowmeters (7.8) and adjustment throttles (5), seven temperature probes (2.3), four in the pyrolysis area, one for the supply air, one in the flame zone and one in the water bowl for power testing. All these elements are placed on an electronic scale (9) to establish the hourly consumption of biomass. For the measurement of the gasification air pressure (necessary for crossing the biomass layer) a pressure transducer is provided (10). Air is supplied by a compressed air source (6).



1-gasogen
2,3- temperature probes
4- electrical panel
5- adjustment throttles
6- compressed air source
7,8- air flowmeters
9- electronic scale
10- pressure transducer

Fig. 1. Test device component

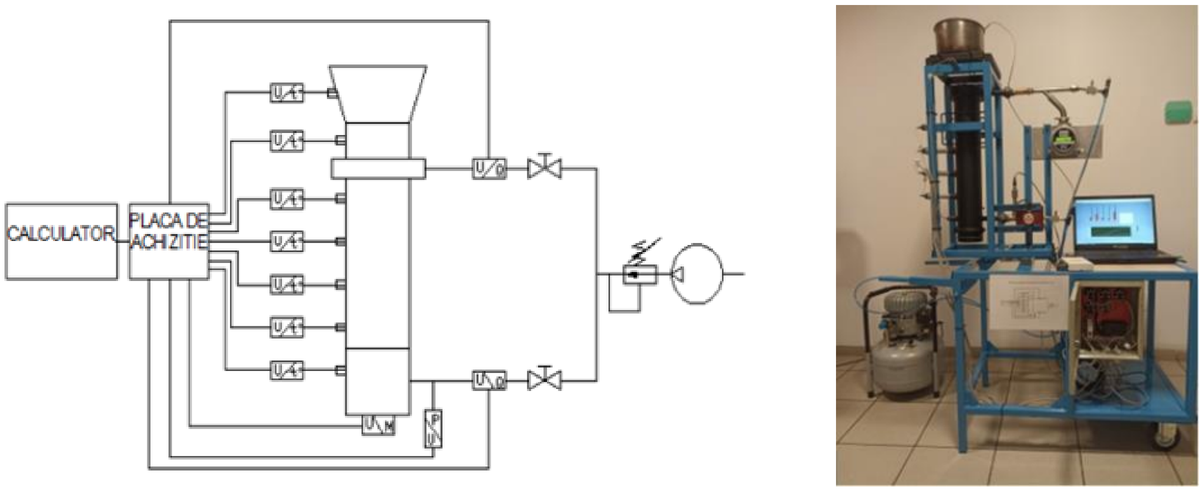


Fig. 2. Functional scheme / test device

According to the functional scheme (fig. 2) the data provided by the sensors are purchased and stored on the computer through a purchase board [13] [14].
A data acquisition program has been created in LabView, with a friendly graphical interface (fig. 3) that displays and records all the purchased parameters and their graphics in real time.

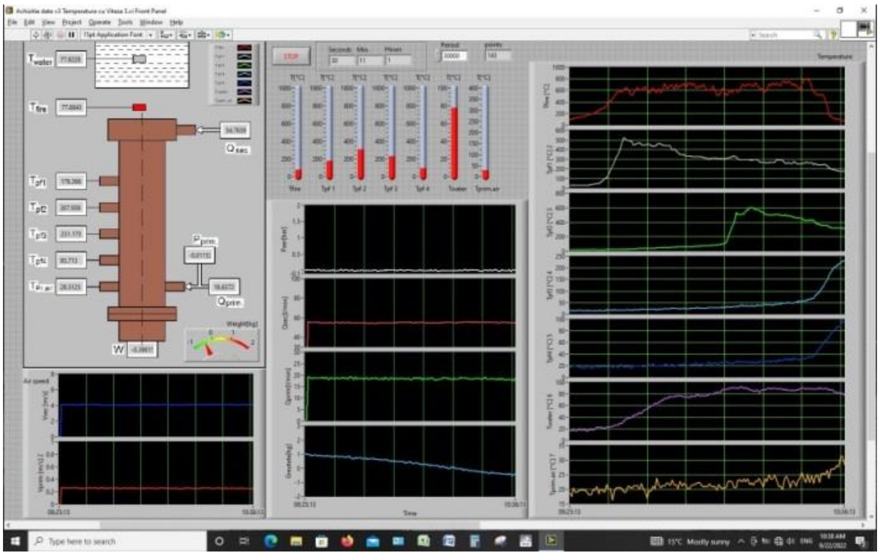


Fig. 3. Graphical interface created in LabView

Technical data of the test device:
- Di = Ø106 mm
- H max=450 adjustable by sieve positioning
- Biomass volume / 0.1 m = 0.78 dm³
- Hourly consumption: 0.8 kg/h
- Operating time / 0.1 m biomass layer height =0.7-1 h
- Thermal power at the burner = 2.7 kWth
- Gasification air section 12 cm²
- Combustion air section 2.3 cm² or optional 20.3 cm²

TLUD modules with powers of 3-4 KWth generally have a biomass consumption of 10-15 g/min and require a primary air flow (gasification) of 15-25 l/min and secondary air (combustion) of 30-50 l/min, for the reactor diameter of 100 mm.

3. The testing methodology refers strictly to this construction of TLUD gasifier

For each test, the TLUD type laboratory device is lit at the top and the pyrolytic front, initially formed, advances into the fixed bed of biomass. The primary air (gasification) is regulated using the flow meter at the value of 25 l / min and is introduced into the lower part through 130 holes with a total section of 12 cm². It penetrates through the biomass bed to the pyrolytic front area where the gas that rises is generated, due to the ascending current, at the top, and mixes with the secondary air, necessary for complete combustion, regulated to the value of 50;65 l/min, supplied through 18 holes with a total section of 2.3 cm². The mixture burns at the top with the flame open.
The values of the flows, of the primary/secondary air velocity and of the flame temperature are recorded in real time and stored in the computer through the data acquisition board.

4. Results

Two tests were made in order to track the influence of the primary air velocity (of combustion) or on the energy produced in the flame.

Test 1

For the first test, the primary/secondary air flow was adjusted with the ratio of 1/3 respectively of 25/50 l/min (fig. 4) and a ratio of speeds of 0.35/3.5 m/sec (fig. 5) was recorded (for this TLUD construction) and the average temperature recorded in the flame was about 700°C (fig. 6).

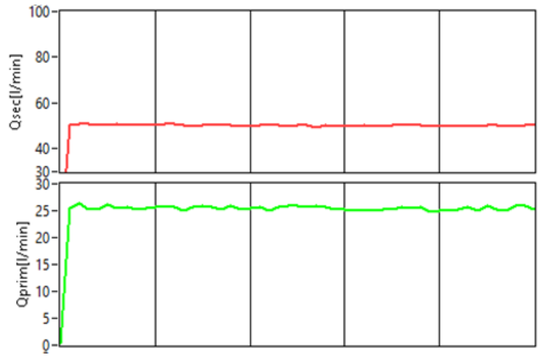


Fig. 4. Variation of primary/secondary air flow during the test (25/50 l/min)

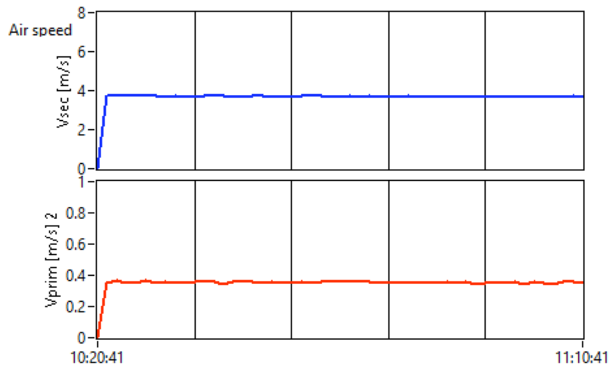


Fig. 5. Variation in primary/secondary air velocity during the test (25/50 l/min)

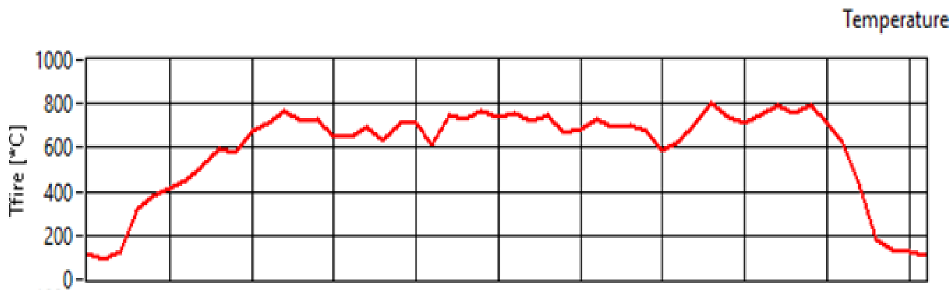


Fig. 6. Flame temperature variation during the test (25/50 l/min)

Test 2

For test 2, the primary air flow adjustment of 25 l/min was kept and the secondary air flow was supplemented by 30% i.e. 65 l/min (fig. 7) to increase the speed (turbulence) of the mixing air and a ratio of speeds of 0.35/4.5 m/sec (fig. 8) was obtained (for this TLUD construction) and the average temperature recorded in the flame was about 800°C (fig. 9).

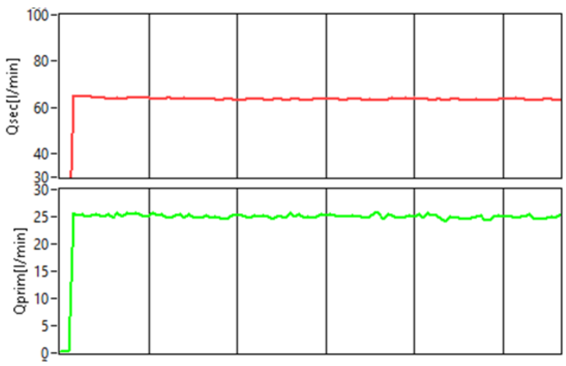


Fig. 7. Variation of primary/secondary air flow during the test (25/65 l/min)

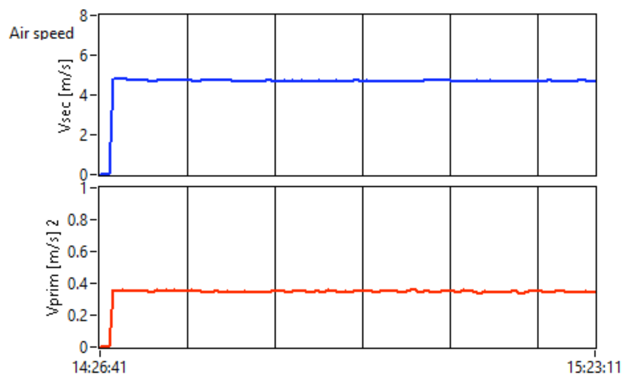


Fig. 8. Variation in primary/secondary air velocity during the test (25/65 l/min)

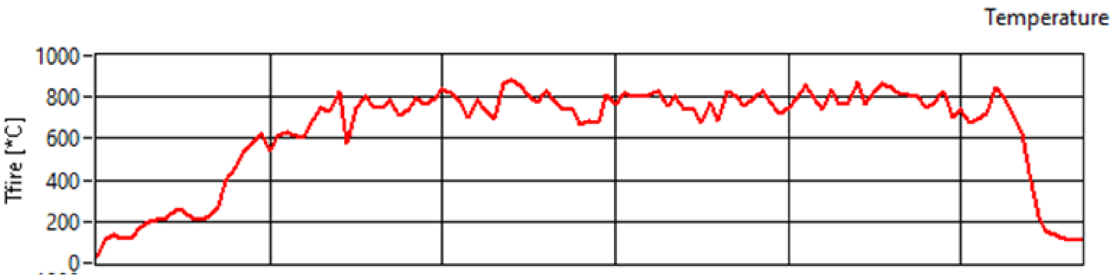


Fig. 9. Flame temperature variation during the test (25/65 l/min)

5. Conclusions

The increase of the secondary (combustion) air flow by 30% led to the increase of its speed from 3.5 m/sec to 4.5 m/sec on the same supply section and to the realization of a turbulent mixture with superior calorific value.

The test results indicate a higher efficiency of the equipment (flame temperature higher by 100°C) when the flow rate and speed of the combustion air has been supplemented by 30%.

Further studies and research are needed to obtain the best performance on this equipment that proves to be environmentally friendly, which can contribute to the reduction of greenhouse gas emissions, to the achievement of an efficient protection of the environment and to the achievement of a sustainable energy development.

Acknowledgments

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