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SOLID BIOFUELS BURNING PLANT AND THE OBTAINING OF THERMIC ENERGY FOR HEATING A GREENHOUSE

PhD. Stud. Adrian Imireanu[1], Prof. PhD. Eng. Adrian Mitroi[1],
Prof. PhD. Eng. Gabriela Teodorescu[2],
[1] University of Agronomical Sciences and Veterinary Medicine, Bucharest
[2] Valahia University of Târgovişte
E-mail: imireanu@yahoo.com, adimitroi33@yahoo.de, theo_0200@yahoo.com

Abstract

The research covered by this article was realized using a plant for obtaining thermic energy by solid biofuels burning, based on the gasification technology, in order to obtain the thermic energy necessary to achieve a greenhouse warming. The small power plant was realized by the National Institute of Research and Developing for Machines and Installations destined to Agriculture and Food Industry INCD INMA Bucharest. For obtaining biofuel gaseous more categories of woody biomass were used as raw material.

Keywords: solid biofuels, gasification, thermic energy, greenhouse heating

1. INTRODUCTION

The greenhouses are big energy consumers. The high energy consuming leads to high production costs for greenhouses products. The diminution of these costs can be achieved through technical improvements, which reduce specific energy consumption, but also by lowering costs for the thermic energy used, for example by using the energetic locally available biomass.

A big advantage of using biomass is the fact that for the heat obtaining can be used solid biofuels, such as wood waste and agricultural residues. Our country has large amounts of wood waste from logging and wood industry, and also large quantities of straw, cobs and other waste from crops [4, 5, 8, 9]. It is relevant also that the energetic exploitation of biomass has an important ecologically contribution, because it is realized a closed circuit of carbon dioxide, without discharge of greenhouse gases in the atmosphere [2, 3, 6].

The thermic energy can be obtained either by direct combustion of solid biofuels, either by the using of modern technologies of biomass gasification [1, 10]. The systems using biomass gasification can be built in a power range, from tens of kW, used for small and isolated communities, to plants of hundreds of MW power. Such a system can be developed also for the small farms equipped with greenhouses.

The waste biomass can be combustible biomass source, the greenhouse being the immediate heat user and ash can be a component of the fertilizers used in agricultural farm.

According to data provided by GTC (Gasification Technology Control), in the last years, in the world, there is an annual growth rate of fossil fuel gasification capacities of 10% [11, 12].

The biomass technical gasification process consists in its partial burning using an auxiliary substance, such as the air, without ignition, at temperatures of 700 ° to 900 ° C.

Unlike normal combustion, in which results carbon dioxide (CO_2), mainly carbon monoxide (CO) is resulting from gasification. The generated gas by this partial combustion also contains hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4), and some trace elements and impurities, depending on the characteristics of the used biomass. The solid wastes are the ash and the coke.

At low temperatures, some substances such as bitumen and water can condense. The generated gas by the gasification plant can be burned in an ulterior process, providing heat. Applications of the procedures for obtaining heat from biomass gasification are found in different areas.

A wide range of running plants, such as large gasification plants, in a fluidized layer, with powers of tens or hundreds of MW power assure, for example, combustible gas for power plants or cement plants, while the small gasification plants, of tens or hundreds of kW, are suitable for isolated areas where steam power plants can be built to work with mixed fuel made from biomass and conventional fuels [1].

2. MATERIAL AND METHOD

The GG-60 heating plant using generator gas was realized at INMA, Timisoara branch, in order to

produce the thermic energy necessary to heat a greenhouse.
This is characterized by the use of a technology based on the gasification in descending system of the woody biomass pieces, the filtration and the cooling of the generator gas obtained, and the burning of this gas in a burner for direct heating of the greenhouses. The power for which it was designed is 60 kW.
The components of the heating plant using generator gas GG-60 (fig. 1) are: gasificator, gas filter, group for gas circulation (blower), group for generator gas burning (burner), support frame, flexible tubing.

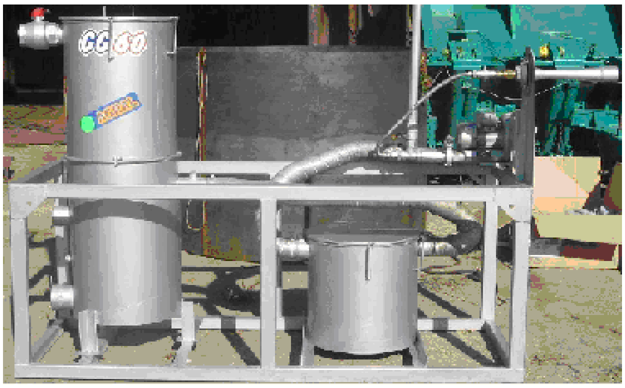

Figure 1 – The heating plant GG-60 using generator gas

The gasificator is stratified type, uniflow, open top and it is composed of the following main units:
The gas drum, cylindrical, equipped with nipple for ignition, nipple for ash discharge, generator gas discharge pipe, support legs and a shaking mechanism, consisting of a mixing set with lever that move a mobile grill.
The fire hose, equipped on top with a circular plate with the same size as the gas drum, the cylindrical tube itself and a mobile grill, suspended by 3 chains of the fire hose circular plate.
The biofuel tank, cylindrical, eqquiped on top with a sealed lid and an air inlet valve. A clamp makes the connection between the 3 elements of the gasificator, after a prior sealing with resistant material to high temperatures;
The gas filter is cylindrical and consists of: body equipped on top with joints, two compartments with supports for chimneys, two nipples, for the inlet and the outlet of the gas and at the bottom, it is equipped with nipple with valve to discharge the condensate.
The chimney supports the filter element made of biofuel used in combustion.
A cap ensures the regular replacement of the filter element from the two chimneys and the sealing on top of the filter.

The group circulation of gas is composed of: the reducing piece that makes the connection between the flexible tubing of the output pipes of the filter and the blower of the generator gas circulation; the flap valve that ensure the adjustment of the depression created by the circulation group blower in the gasificator, the gas filter and the flexible tubing; the nipple enabling the connection to the gas pipeline of the burner, at the blower outlet, after tee piece; the pipe which facilitates the exit of the gas into the atmosphere, at start-up, to the enter into the normal operation (8 - 10 min); the tee piece, which ensures the double joint to the burner and to the flue pipe fitted with ball valve; the blower, which allows the plant operation from the producing of the gas from the biofuel tank to the burning of the gas in the burner; ball valve, which stops after the gas exit into the atmosphere after the entry in normal operation of the plant.
The gas combustion group is composed of: the antivibration joint, that makes the elastic connection between the gas burner and its stabilization filter; the ball valve, which allows the coupling and decoupling of the gas burner and its stabilization filter; the gas pipeline, which makes the elastic connection between the nipple of the gas circulation group and the gas burning group of the plant; the burner, that realize the combustion of the generator gas in order to direct heating in mixture with the inside air and the air added from outside greenhouses.
The support frame is a set of welded rectangular pipes, angles, support plates for all plant components, with protecting role of the operator for not touching the hot areas and easy to access to the operation elements, adjustment and handling.
The flexible tubing is a aluminum pipeline, with role of transport and cooling the gas, which makes the elastic connection between the gasificator and the gas filter but also between the filter and the blower.
All the plant elements are fixed on the support frame, outside the greenhouse, under a metal roof.
The experiments with the heating plant GG-60 using generator gas were made in the Testing Department of INMA Bucharest.
For the no load and load experiments of the heating plant GG-60 using generator gas were used oak, beech and fir wood waste, wood chips with minimum sizes of 20 mm and rectangular pieces of maximum 50 mm with a 18% humidity.
The no load experiments were aimed to determine the technical characteristics of components of the heating plant GG-60 using generator gas, given that they have worked without extracting the generator

gas, so without burning of woody biomass waste from the gasificator, as well as the proper functioning of the blower of the generator gas circulation group and the general sealing facility.
In the load experiments of the plant it was monitored the general behaviour of the heating plant GG-60 using generator gas.
For this purpose they were weighed 200 kg of oak, beech, fir waste with 18% humidity, pieces of 20 to 50 mm length, to prepare ten gasificator loads and one gas filter load.
In the load experiments of the plant was realized the gas circulation produced by gasificator by using the incomplete combustion of the chopped and dried woody biomass.
By direct measurement or by calculation, the following parameters were determined:

- produced gas flow, in m^3/h;
- biomass specific consumption, in kg/kWh;
- mass flow of biomass, in kg/h;
- total gas flow, in m^3/h;
- duration of the input cycle in normal operation, in h;
- pressure loss through gasificator, Δp1, in mm H_2O;
- pressure loss through the filter, Δp2, in mm H_2O;
- gas temperature at the gasificator exit, at the filter exit, at the burner entry, ºC.

The temperature values were measured using digital device for measuring speeds, temperatures and airflows TESTOTERM 4000.

3. RESULTS AND DISCUSSIONS

The preliminary experiments on the GG-60 plant have confirmed the ease of assembly and disassembly of the elements and the gasificator and the gas filter caps, of the components of the generator gas circulation group, and also of the generator gas combustion group.
Also, the experiments confirmed the serving and the technical maintenance convenience.
During the no load experiments, the gas heating plant GG-60 using generator gas responded to the commands, no mechanical failures or blocking occurred, and the moving elements fell within normal limits in terms of kinematics characteristics. This provided the conditions for the hot starting of the plant and the transition to the load experiments.
The gas flow produced by the gasification plant was determined by the measurements after the gas filter and it is presented in table 1.

Table 1. The gas flow produced by solid biofuel gasification plant GG-60

Determined parameter	UM	Determined Value		
		I	II	III
Gas velocity	m/s	0,4	0,8	2,09
Pipeline diameter	mm	90	90	90
Produced gas flow	m^3/h	9,1	18,3	48
Burned gas velocity	m/s	0,4	0,8	2,09
Pipeline diameter	mm	180	180	180

The chemical composition of the generator gas was determined using digital gas analyzer Temptest 50. The results are presented in table 2.

Table 2. The chemical composition (in %) of the gas produced by solid biofuels gasification plant

Woody biomass	CO	H_2	CH_4	C_nH_{2n}	CO_2	N_2
Dry oak	18,3	16,9	2,8	0,5	16,0	45,5
	18,2	16,7	2,9	0,6	16,3	45,3
	18,5	16,6	2,7	0,4	16,2	45,6
Dry beech	18,7	17,0	2,6	0,6	15,0	46,1
	18,9	17,0	2,5	0,5	15,1	46,0
	18,7	17,1	2,5	0,7	14,9	46,1
Dry fir	15,0	17,5	1,6	0,9	15,0	50,0
	15,1	17,4	1,5	0,8	15,1	50,1
	15,0	17,2	1,7	1,0	15,1	50,0
Charcoal	31,2	6,3	2,9	-	2,5	57,1
	31,3	6,4	2,8	-	2,4	57,1
	31,3	6,4	2,7	-	2,4	57,2

The mass flow of biomass was determined by weighing and ranged from 20 kg/h for beech and 22 kg/h for fir, resulted a biomass specific consumption of 21 kg/h.

4. CONCLUSIONS

Rated at 60 kW power, the biomass specific consumption is 0.35 kg/kWh.
The duration till the normal operation conditions was timed and ranged between 10 and 15 min.
The pressure loss through the gasificator, Δp1 [mm H_2O] was determined by measuring the depressions before and after gasificator and it had values between 30 and 50 mm H_2O.
The pressure loss through the filter, Δp2 was determined by measuring the depressions before and after the gasificator, its values being comprised between 15 and 25 mm H_2O.
The generator gas temperature at the exit of the gasificator was determined in the same time with gas velocity, in places especially chosen and had an average value of 79 °C.

The generator gas temperature at the exit from the filter was determined in places especially chosen at the filter and had an average value of 35 °C.
The generator gas temperature at the entry into the burner was determined in similar circumstances, and had an average value of 28 °C.
The general appearance of the plant meets the requirements to protect the operator from accidentally touching hot surfaces. The quality of the fixed joints, of the welds and of the removable joints is also appropriate.

5. ACKNOWLEDGMENTS

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