

Greenhouse heating by using an installation of biomass gasification

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Abstract. The use of renewable energies has seen a significant increase in energy demand in agriculture, in competition with solid, liquid or gaseous fossil fuels. Wood and other forms of biomass including energy crops, agricultural and forest biomass are transformed into energy through thermal, biological or physical processes. Thermo-chemical conversion, biomass gasification, is the most attractive technology that offers a high conversion efficiency compared to direct burning or rapid pyrolysis.

1. Introduction

Generator gas, called gas, can be used directly for thermal applications: cooking machines and heating installations, where changes have been made to ensure an optimal combustion air excess, and after proper filtration at the generation of electricity by feeding internal combustion engines, Stirling engines, or in the perspective of combustion cells[1,2,3,4].

The gasification of the biomass produces a generator gas with an average calorific value of 5 MJ / Nm³, with a power conversion of the wood mass in the 70-85% range, is at least 3 times more efficient than direct combustion. Conversion efficiency depends on: the design gas-generator solution, the composition, dimensions and humidity of the fuel, as well as the generator operating load [1,4,5]. Air conditioning of greenhouses, heating and ventilation is an essential condition for achieving economically efficient production but is requiring large-scale installations at the same cost, which has made it more and more abandoned. At present, traditional systems with trunking networks that occupy a lot of space, make it hard for operators and little mechanization, contain a great deal of metal and cost a lot. Obviously, this system has advantages in terms of high heat inertia, heating and radiation, high operating safety and lower maintenance personnel [1].

The main issue with regard to the fuel used for heating greenhouses is that of the price on which production costs depend. The second is the level of pollution. Combustion fossil fuels increase the concentration of CO₂ in the earth's atmosphere, spill into the environment particles of smoke, NO_x and uncharged hydrocarbons that all contribute to increased

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environmental pollution. The smallest pollution is obtained when gaseous fuels are consumed and combustion is controlled to reduce as much as possible the production of pollutants [1].

Most small and medium greenhouses cannot benefit from methane gas, LPG or diesel, but more often CLU and fuel oil, are much cheaper. Combustion of CLU or naphtha is done with the release of pollutants and requires hot or steam heating systems that are expensive as investment and maintenance [1, 2].

As an alternative to these energy sources in the last decade, it is found that the energy produced from the gasification of wood or agricultural biomass is increasingly used in rural thermal applications where there is a sufficient amount of gas-based biomass at a cost of use to reduce [1, 2, 3].

Taking into account the seasonality of greenhouse heating, the heat source needs a very small initial investment or outside of the greenhouse season to be used in other applications to lower the share of the investment's depreciation [1, 3, 4].

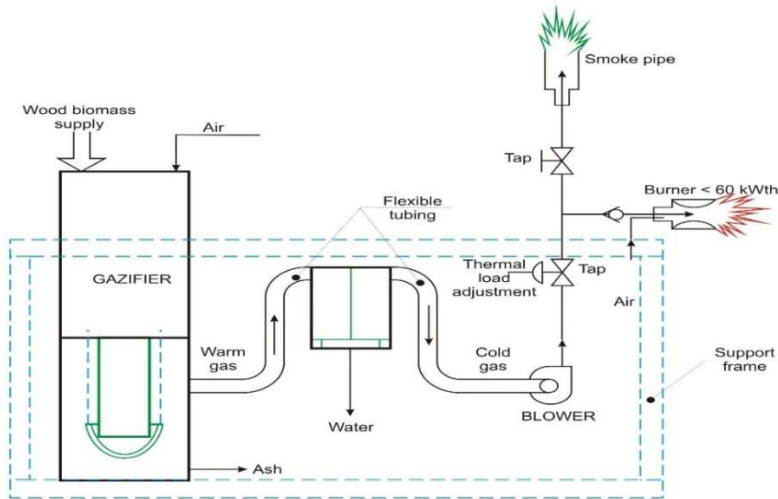


Fig. 1. Sketch of the heating system with producer gas.

2. Methodology

In the cold mixing chamber, a mixture of a recirculated air flow from the inside and an outside air flow is made. It is located at the bottom, at ground level, and consists of external air intake valves mounted on the outside wall and recirculated air intake valves mounted inside the greenhouse. The recirculated air / outside air ratio is controlled by the simultaneous actuation and the actuator that receives a command signal from the automatic steering system.

The gas-fired burner, specially designed for combustion of low calorific gases, is supplied with a gaseous flow rate at a pressure of 6 to 20 mbar adjusted with the regulating valve and a pre-heating combustion air flow rate that is regulated with a flap.

The heating agent is guided into a polyethylene tube stretched across the greenhouse and hanging in the ceiling. The tube has clamp-shaped cutouts that distribute hot air in the form of jets oriented so as to wash the exterior walls and achieve good mixing with the greenhouse air to smooth the temperature inside. The side walls of the greenhouse, are provided with the exhaust flow, equal to the outside air flow introduced into the greenhouse. The self-closing flaps are adjusted to maintain an overpressure in the

greenhouse in the 20 ... 60 mbar range, depending on the construction of the greenhouse and the current crop.

The biomass was transported to the location of use, where it was stored in a covered enclosure to dry naturally to 10-20% relative humidity. For gasification, the biomass was minced to the size of 1-5 cm and the hopper loaded and unloaded it to the top of the gas generator until it reached the upper level measured with a capacitive level transducer that outputs a signal. The supply was done sequentially, with constant operating periods, to increase the durability of the conveyor [6-13].



Fig. 2. Overview of the producer gas heating system



Fig. 3. Biomass material used for testing



Fig. 4. Front view of the producer gas heating system



Fig. 5. Apparatus used for testing



Fig. 6. Evaporation of condensate from the producer gas generator

To start the fire in the gasifier, the blower was used to create an air-sucking airflow through the biomass from the fuel tank. When the wood gas leaves the gasification unit, all the oxygen pressed down with the air through the fire tube was chemically modified and contained carbon monoxide (CO) and water (H₂O). Wood gas can not burn unless combined with a correct amount of oxygen. The tightness of the gas burner unit is absolutely essential.

Ideally, while wood gas enters the burner, it must be mixed with air in a 1: 1 or 1.1: 1 ratio (air to gas) in volume.

The fire tube is filled with coke up to 100 mm above the grid. The fuel tank is filled with dry woody biomass, the lid is closed and fully open the air valve.

For the determination of the kinematic, technological and electric parameters (power voltage, current absorbed by electric motors) the following tools were used:

Table 1. Instrument or apparatus used

No.crt.	The name of the instrument or apparatus	Range of measurement
1	Metal roulette	0 ÷ 2 m
2	Callipers 200 × 0,1	0 ÷ 200 mm
3	Callipers with depth 200 × 0,1	0 ÷ 200 mm
4	Gradient scale	0 ÷ 500 mm
5	Chronometer	- minutes - seconds
6	Laboratory balance	-
7	BENQ digital camera	-
8	Sound Level Meter Type 2237 B vibrometer	30 ÷ 140 dB
9	Technical thermometer with solid capillary	- 20 ÷ +30 °C
10	Differential electronic manometer type TESTO 506	0 ÷ 1 mbar 1 ÷ 10 mbar 10 ÷ 200 mbar
11	MICRODUST PRO digital dust detector	0,001 ÷ 2.500 mg/m ³
12	Digital TESTOTERM 4000 Air Flow Meter, Temperature and Flow Meter (Testovent)	0,4 ÷ 40 m/s - 120 ÷ +1.300 °C 10 ÷ 500.000 m ³ /h
13	Digital apparatus for measuring electrical parameters type UNITEST CHB 140	0 ÷ 400 A 0 ÷ 600 Vc.a. 0 ÷ 400 Ω
14	Digital thermometer with laser type UNITEST 94009,	- 50 °C ÷ 0 °C 0 °C ÷ +200 °C +200 °C ÷ +1.333 °C
15	Gas analyzer Code 99F20006 Tempest 50	O ₂ /CO/NO

The general behavior of the gasifier heating system was observed and the determination of the production capacity and the quality of the combustion operation in order to determine the optimal technological parameters for the design of a 50 kWth producer gas heating system.

For this purpose, within the limit of the quantity of product available for testing, weighing 150 kg biomass waste of oak, european beech (fagus) and fir, with a moisture content of less than 20% of the pieces with a length between 20 ÷ 50 mm were weighed for the preparation of ten batch of gasifier and one gaseous filter batch [11-13].

The products corresponding to a batch were manually loaded into the fuel tank, the fire tube, the gasifier grid and the gas filter, the blower started, and then passed the primary coke production cycle into the. Next, after 10 ÷ 15 minutes, during the normal gas

production phase (attempted by igniting the exhaust gas to the tube), the burner of the installation is switched on.

The flow of gas produced by the gasifier has been determined based on the measurements after the filter and gas-producing are recorded in the following table:

Table 2. The flow of gas produced by the gasifier

No. crt.	The measured feature	M.U.	The measured value		
			I	II	III
1.	The gas velocity	m/s	0,5	0,9	2,09
2.	Diameter of pipeline	mm	90	90	90
3.	The rate flow of produced gas	Nm ³ /h	9,1	18,3	48

The burned gas flow rate produced by the gasification system was determined on the basis of the measurements after the burner are recorded in the following table:

Table 3. The burned gas flow rate produced by the gasification system

No. crt.	Measured or calculated feature	M.U.	The measured value		
			I	II	III
1.	Speed of gas burned	m/s	0,5	0,8	2,09
2.	Diameter of pipeline	mm	180	180	180
3.	The gas flow burned	m ³ /h	36	72	188

The lower calorific value of the producer gas was determined on the basis of the chemical composition of the gas at the different biomass components are recorded in the following table:

Table 4. The lower calorific value of the producer gas

Wood Biomass	Chemical composition of gas in %						Inferior heat power. kcal/ m ³
	CO	H	CH ₄	C _n H _{2n}	CO ₂	N ₂	
Dry oak	17,8	15,9	3,2	0,4	16,1	-	1296
Dry beech	18,4	16,5	3,1	0,5	15,1	48,3	1321
Dry fir	16,1	18,1	2,2	0,8	15,7	56,1	969
Wood charcoal	32,2	7,3	2,8	-	2,6	57,1	1363
Charcoal brown briquettes	24	16	1	-	11	50	1223

Biomass mass flow rate (kg/h), determined by weighing, was between 20 (Beech) and 22 (Fir) kg / h so on average 21 kg / h. It results in a specific biomass consumption of 21 kg / h: $60 \text{ kW}_{ht} / \text{h} = 0.35 \text{ (kg / kW}_{ht})$.

The duration of the normal operating cycle was timed and was between 10 and 15 minutes.

The pressure drop through the gasifier, Δ_{p1} [mm H₂O] were determined by measuring the depressions before and after the gasifier being in the limits of 30 ... 50 mm H₂O so an average of 40 mm H₂O.

The pressure drop through the filter, Δ_{p2} [mmH₂O] were determined by measuring the depressions before and after the gasifier being in the limits of 15 ... 25 mm H₂O, an average of 20 mm H₂O.

The temperature of the producer gas at the outlet of the gasifier was determined with the gas velocity in the specially designated locations using the TESTOTERM 4000 (Testovent) digital speedometer, temperature and air flow meter and was around 80°C.

The producer gas temperature at the filter outlet was determined with the same apparatus at the specially designated locations of the filter and was around 35°C. The producer gas temperature at the burner inlet was determined under similar conditions and was around 28°C.

3. CONCLUSIONS

There is required legislative and organizational measures to reduce pollution and emission of greenhouse gases and dependence on crude oil imports more expensive and uncertain about oil being a source of exhaustion.

A solution is the use of biomass resources for the production of solid fuel, liquid fuel and gas. The use of biomass for the production of heat by gasification has the advantage of using a renewable energy resource that does not increase the concentration of CO₂ in the earth's atmosphere. The use of biomass for heating greenhouses has the advantage of reducing production costs.

Applying low energy efficient technologies, allowing long-term industrial plants to operate, will help reduce the cost of heating greenhouses all year round.

As a result of those presented above it can be seen that the heating of greenhouses with relatively cheap energy produced from the thermo - chemical gasification of wood or agricultural biomass is an economic solution for small and medium - sized greenhouses located in areas with high potential for gas - biomass collection.

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