International Seminar on Bioenergy & Sustainable Rural Development

Casa de Gobierno
Paseo de la República 1500 Col. Oviedo Mota

Morelia, México
26-28 June 2003

SEMINAR PROCEEDINGS (Excerpt)

ANES

The International Seminar of Bioenergy and Sustainable Rural Development was held in Morelia, Mexico, from June 26 to 28 2003. It was organized jointly by the Latin American Thematic Network on Bioenergy (LAMNET), the Center for Ecosystem Research (CIECO) from the National Autonomous University of Mexico, the Food and Agriculture Organization of the United Nations (FAO), the National Association for Solar Energy (ANES) and the State Government of Michoacan, Mexico.

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Updated information on this workshop is available at http://www.bioenergy-lamnet.org, http://bioenergia.oikos.unam.mx and http://www.anes.org.

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WORKING GROUP 3: GASIFICATION

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

SMALL-SCALE COGENERATION – A NEW TAR-FREE GASIFIER

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INTRODUCTION

Interest in biomass gasification has increased during recent years because of environmental benefits associated with these fuels. Wood gasification to fuel commercial engines is considered to be one of the most promising techniques for an efficient production of electricity from biomass at a small or medium scale.

Unfortunately most of gasifiers produces wood gas incompatible with engine manufacturers specifications (up to 30 ppm tar and char vs. less than 10 ppm), so a very expensive and no profitable purification is needed.

As result of a demanding study and a long experimentation, a novel type of downdraft gas producer was designed and constructed. Relevant project features are:

a) a high oxide-reduction temperature matching the theoretical optimum level of 1500°C in the throat area,

b) the elimination of cold veins in the oxide-reduction zone,

c) an efficient heat recovery,

d) a proved and economic cleaning gas system.

The performances of the producer gas were evaluated coupling the gasifier with a 40 kW_e cycle Otto engine electricity generator.

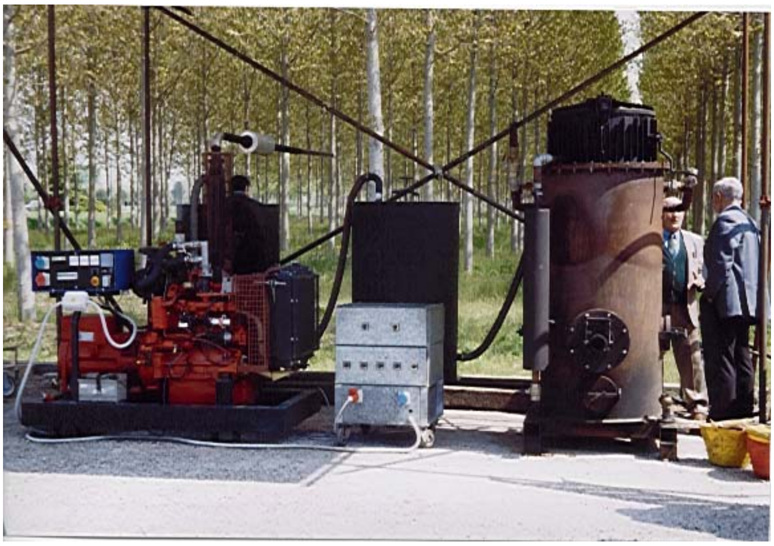
THE GAS PRODUCER

The gasifier, the gas filtration system and the generator set are shown in Fig. 1.

The gas producer unit is constituted of two cylindrical coaxial metallic structures. The section where the actual wood gasifying process occurs is made of a high temperature and chemical corrosion proof steel in order to resist the compounds developing during the process. The biomass, preferably blocks several centimetres long, is introduced at the top by a semiautomatic feeder.

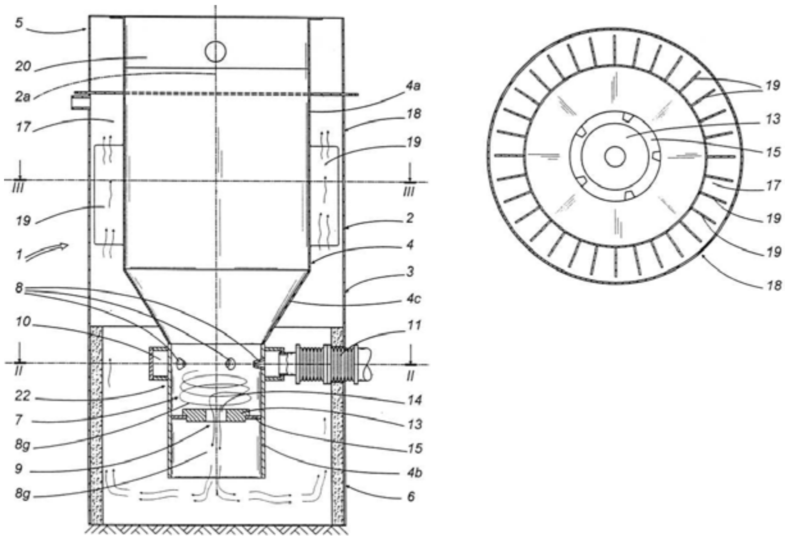
Coming down, the biomass passes through a drying zone, a pyrolisis zone and then gets into the core of the gasifier. Here the fuel meets an air stream, introduced by wall tuyeres opportunely oriented.

Fig. 1: Gasifier, gas filtration system and generator set



In this zone the gasification process is carried out at high temperatures (about 1400-1500°C) in order to assure the cracking of any possible tarry residue. The gases are drawn off from the bottom and flow upward in the interspace between the two coaxial structures. The external one is coated by an insulating material, while the internal is provided with radial fins as recuperator to improve the energetic balance of the gasification reaction and to reach the above mentioned temperatures. (Fig. 2).

Fig. 2: Scheme of the gasifier



For the achievement of the temperature uniformity trough the whole reaction zone, a necessary condition for the full cracking of the tars, cold points should be avoided as they could also stress the metal walls. This is obtained by tuyeres oriented so as to send an air stream properly directed in the oxidation zone, delimited at the bottom by a transverse grate. In such way the ash particles settle on the metallic wall of the reactor. This layer, whose surface is in a fuse state, drops and continuously re-forms, thus protecting metal walls from thermal aggression and mechanical stress.

The gas leaves the gas producer at a moderate temperature and is practically tar free. Final cleaning, mainly from dust, is carried out by a very simple and cheap three stages system, made up of a cooling and scrubbing unit, a demister and a final filter.

The cooling unit is a cylindrical tank filled with an inhomogeneous cheap material (expanded clay). The gas is cooled and scrubbed countercurrent by water. The used water is cooled and recycled. A cylindrical tank filled with the same inhomogeneous material constitutes the demister while the final filter is a steel cylinder filled with wood chips or sawdust.

The gasification tests were performed using different biomass. Characteristics of typical samples are reported in Tab. 1

Tab. 1: Characteristics of biomass

		Robinia	**Forest residues**	**Wood wastes**
C	(%wt mf)	51.2	51.3	51.8
H	(%wt mf)	5.7	6.1	6.1
N	(%wt mf)	0.5	0.4	0.3
Ash	(%wt mf)	1.0	1.3	0.6
Moisture	(%wt)	16.3	23.1	21.3

The size and shape are very important for the behaviour of biomass in the gasifier as to the movement, bridging and channelling. Also the thickness of the oxidation zone and the pressure drop depend on these characteristics. Sizes about 6x6x4 cm are recommended; 30 percent of sawdust in the feed or sawdust pellets can be processed.

Moisture affects the heating value of the gas and the steadiness of the gasification process because it absorb heat to vaporise. Maximum allowable limits are 20 - 25%. In any case most of the water vaporises in the pyrolysis section of the gasifier and it is condensed at the top of the reactor and collected.

Biomass was successfully gasified with steady operation condition. Tab. 2 reports some composition of the producer gas. Always tar and dust content was lower than 2 ppm

Tab. 2: Composition of the producer gas

Test n°	**Compostion of the gas % vol.**						**Tar+ash ppm**
	CO	**H_2**	**CO_2**	**CH_4**	**O_2**	**N_2**	
1	16.6	14.7	18.4	0.31	0.2	50.6	< 2
2	14.7	11.2	19.7	0.19	1.7	52.4	< 2
3	13.2	13.2	20.3	0.15	1.3	51.7	< 2

INTERNAL COMBUSTION ENGINE AND ELECTRIC GENERATOR

The internal combustion engine is a 4 stroke full-diesel engine. Its conversion from diesel to producer gas was performed:

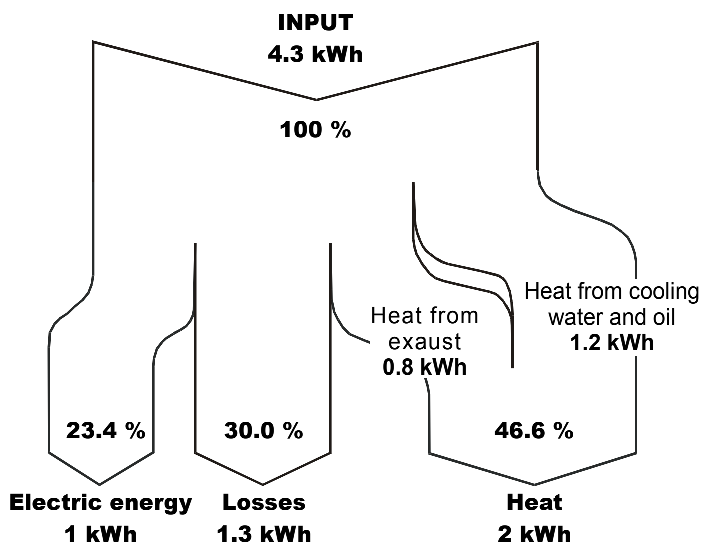
- decreasing the compression ratio from 17:1 to 11:1
- substituting the injectors with spark plugs and the injection pump with a distributor
- installing a special carburettor on the intake manifold.

The electric generator is a brushless AC electric generator:

Output	380 V, 40 kW_e
Frequency	50 Hz
Cos φ	0.8
Speed	1500 rpm

In addition to electricity, thermal energy can be produced recovering heat from cooling water, lubricating oil and exhaust. Up to 2 kW_t per 1kW_e can be obtained. Heat can be used to warm as well as to cool using an absorption chiller. A rated balance of the process is depicted in Fig. 3

Fig.3: Rated energy balance (per kWh_e)



CONCLUSION

By the collaboration between University of Sassari, NET S.r.l., and Mont-Ele S.r.l., a novel tar free gasifier based on the Imbert technology, was constructet and tested. A clean (tar and dust less than 2 ppm) low heating value gas was produced with a 75-80% efficiency.

The architecture of this downdraft fixed bed permits:

- maximum flexible matching capability with a wider range of waste wood conditions,
- lower costs of production by the use of standard components,
- guaranteed quality and stability in the produced gas according to the engine specifications,
- modular and flexible design which can be easily adapted to varying installation sites,
- reduced management costs.

Coupling the gasifier with a cycle Otto 40 kW alternator, electricity was produced with yields of 1 kWh_e per 1.3 kg of woody biomass (moisture 15%). Up to 2 kWh_t can be recovered using a cogenerative engine.

This gasifier can provide a competitive source of power in particular in developing countries where fuels handling is difficult, but also in developed countries with abundant biomass resources such as waste wood, sawdust, nutshells etc., in order to produce a costs reduction. The immediate production program covers the range 12-150 kW_e.

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This Thematic Network is funded by the European Commission, DG Research, (Project No. ICA4-CT-2001-10106).