Sustainable development through electricity generation for isolated communities in Amazon region using small-scaled biomass gasification systems – GASEIFAMAZ project

Desenvolvimento sustentável através de geração de energia em comunidades isoladas na região amazônica, utilizando sistemas de gaseificação de biomassa de pequena escala- projeto GASEIFAMAZ

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Abstract

The project "Comparison among Existing Technologies of Biomass Gasification in Brazil and abroad and Formation of Human Resources in the Amazon Region - GASEIFAMAZ", accord FINEP/CT-ENERG, is a partnership between CENBIO - The Brazilian Reference Center on Biomass, BUN - Biomass Users Network, UFAMA - Amazon University and IPT/USP - Technological Research Institute of São Paulo University. The main objective of the project is to test a small-scale fixed-bed gasification system (20 kWe) imported from the Indian Institute of Science, using biomass residues, offering an alternative to replace fossil fuel and providing sustainable electric energy for isolated communities. The operational and maintenance system tested at IPT/USP was adjusted to the local implantation conditions and later installed in Aquidabam Village, an isolated community at the Amazon region. Aquidabam village is located at the municipality of Manacaparu, at Amazon state. There are 700 people living at this community. They have Cupuaçu production, an Amazon fruit considered the community's leading agricultural resource. The implantation of the Gasification system will allow the formation of a local agro industry to sell frozen cupuaçu pulp (with a high added value), thus improving the community income and consequently, their quality of living. This paper will show the results on gasification system and the GASEIFAMAZ project.

Keywords

Biomass. Gasification systems. Electricity generation. Human resources. Amazon region.

Resumo

O projeto "Comparação entre Tecnologias de Gaseificação de Biomassa Existentes no Brasil e Exterior e Formação de Recursos Humanos na Região Amazônica - GASEIFAMAZ", convênio FINEP/CT-ENERG, é uma parceria entre o CENBIO – Centro Nacional de Referência em Biomassa, BUN - Biomass Users Network, UFAMA – Universidade do Amazonas e IPT/USP - Instituto de Pesquisas Tecnológicas da Universidade de São Paulo. O objetivo principal do projeto é testar um sistema de gaseificação de leito fixo em pequena escala (20 kWe) importado do Indian Institute of Science, usando resíduos de biomassa, assim oferecendo uma alternativa ao uso de combustíveis fósseis e fornecendo energia elétrica sustentável para comunidades isoladas. O sistema de operação e manutenção testado

no IPT/USP foi ajustado para as condições locais de implementação e depois instalado na Vila de Aquidabam, uma comunidade isolada na Região Amazônica. A vila Aquidabam é localizada no município de Manacaparu, no estado de Amazonas. Existem 700 pessoas vivendo nessa comunidade. Lá há produção de cupuaçu, fruta amazônica considerada o recurso agrícola principal da comunidade. A implementação do sistema de Gaseificação permitirá a formação de uma agroindústria local para a venda de polpa de cupuaçu congelada (produto com um maior valor agregado), assim melhorando a renda da comunidade e, conseqüentemente, sua qualidade de vida. Esse trabalho mostrará os resultados do sistema de gaseificação e do projeto GASEIFAMAZ.

Palavras Chave

Biomassa. Sistema de gaseificação. Geração de eletricidade. Recursos humanos. Região amazônica.

GASEIFAMAZ Project

The project "Comparison Among Existing Technologies of Biomass Gasification", accord FINEP/CT-ENERG 23.01.0695.00, is a partnership between CENBIO - The Brazilian Reference Center on Biomass, BUN - Biomass Users Network of Brazil, IPT - Technology Research Institute of São Paulo State and UA – Amazon University.

This project aims to test the Indian biomass small-scale fixed bed gasification technology, imported from the Indian Institute of Science – IISc and lead this to Aquidabam village in Amazon, providing electric energy in a sustainable way to isolated communities, offering an alternative to replace fossil fuel [CENBIO, 2001] which was them way of energy provide.

The project intends to evaluate the operation conditions of the gasification system: gas cleaning, electric energy generation also allowing the capacity building in the Amazon region and to replicate the system in other villages.

There are already institutions working with biomass gasification in the country. However there are gaps that prevent its commercialisation, mainly at gas cleaning procedure in order to feed the engine and simplified operation and maintenance procedures. Considering that India already makes use of this equipment over ten years running at isolated communities, similar to those in Brazil, this project will allow to enjoy the outcome of the Indian experience to improve the technology for energy generation in the Amazon's isolated communities. Thus, a 20 kW biomass gasification system was imported from the Indian Institute of Science – IISc [Mukunda et al., 1994].

Figure 1 - 20 kW Gasification system being tested at IPT/USP (CENBIO, 2002)

Figure 2 - Diesel Engine adapted to the gasifier system (CENBIO, 2002)

Gasification System

Gasifier description

The gasifier imported from IISc is downdraft stratified, or either the solid fuel outflow flows in same direction as the gas. Both the biomass stream and the air stream get in on the top of the gasifier that is open top and goes to the base, as indicated on Fig. 3. The gasifier operates in depression, with inside pressure lightly lower than the atmospheric pressure, enough to guarantee the gases outflow through the biomass load.

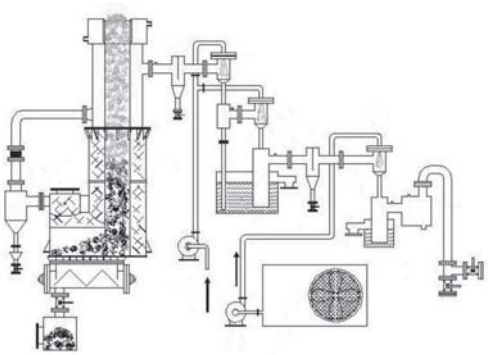

Figure 3 - Working flow (Ushima, 2003)

Description of installed instruments in the gasifier

To evaluate the gasification system fulfilment a set of instruments were installed in the gasifier body, like: four temperature measures, three pressure measures and one flow measurer, the latter to determine the gas generated outflow. The instruments location is showed in Fig. 4.

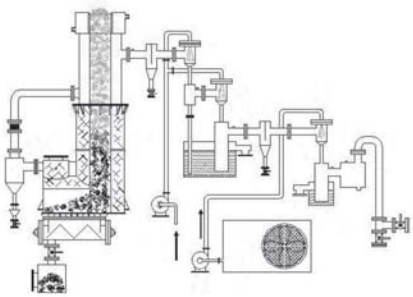

Figure 4 - Set up of the instruments in the gasifier (Ushima, 2003)

The thermometers were installed along the gas circuit to measure the gas temperatures: in the gasifier exit (T1), before the cyclone; in heat exchanger exit (T2), after the primary cleaning system (T3), and the last one after the secondary cleaning system (T4). It was installed three pressure measures in order to measure and monitor the pressure along the gasifier: in the gasifier exit (P1), in the primary cleaning system exit (P2), and the last one in the secondary cleaning system exit (P3). The gas outflow is measured through the flow measurer.

In this system, the gases monitored in a continuing way are: CO (% vol.), CO_2 (% vol.), CH_4 (% vol.), H_2 (% vol.) e O_2 (% vol.). The amount of other gases or combustive steams with bigger molecular weight than methane (ethane, pentane, benzene, etc) and non–monitored gases are very low (usually lower then 1%), it could be avoided being possible to calculate the nitrogen amount by difference.

The amount of tar and particulates in the gases are measured in two points identified as PAM 1 and PAM 2 in Fig. 4. The first point is before the gas cleaning system while the second is after it. These amounts findings will allow to determinate the gasifier gas cleaning system efficiency. The methodology applied here to evaluate the amount of tar and particulates was developed in the project "Energy project EEN5 – 1999 – 005507 (tar protocol)", sponsored by the European Union (Ushima, 2003).

Evaluation of the gasifier performance with different types of biomass

During the period of 20 KWe power generation system evaluation at IPT, had been used four different biomass types: Eucaliptus chips; Eucaliptus residue pelets; Cupuaçu rinds and Babaçu rinds. The great majority of gasification assays, 78,2 % of them (43 assays), it was carried through with Eucaliptus chips, 10,9 % (6 assays) with Eucaliptus pelets, 7,3 % (4 assays) with Cupuaçu rinds and only 3,6 % (2 assays) with Babaçu rinds. The number of assays carried through with each biomass was proportional to its available amount in the IPT for test.

The Eucaliptus ships had been supplied by the Cia Suzano de Papel e Celulose, corresponding the ships used for the cellulose production. Eucaliptus residue pelets had been bought of the BioEnergy Company of Brazil, located in São Mateus, Espirito Santo, manufactured from Eucaliptus residues planted for cellulose production. The Cupuaçu rinds came from Aquidabam community, Amazon, it was collected in the proper community, much time after the end of the harvest, presenting, therefore, raised humidity and soil contaminations. The Babaçu rinds, more specifically, the Babaçu coconut internal part (Babaçu rind without the fiber layer and starch) was supplied by a North region ceramic material producer, Mr. Fernando Volpato, interested in using this biomass as combustible in its industry.

In energy terms, the tested biomasses are practically equivalents, excepting it that the ash and sulphur texts of Cupuaçu rinds had been higher than the other biomasses. These differences had also been reflected in "generated leached ashes". Considering the gasifier performance evaluation with diverse biomasses, this analysis was harmed in function of the small available biomasses amount for tests, in exception of the Eucaliptus chips, as it presents the table below.

Figure 5 – Types os tested biomass (Ushima, 2004)

Table 1 - Gasifier operational parameters, operating with different biomasses

Assayed biomass		Eucaliptus chips	Eucaliptus residue pelets	Cupuaçu rinds	Babaçu rinds
Biomass average humidity (% massa b.u.)		16.2	9.4	15.4	14.2
Gas average composition (% vol. b.s.)	CO	17.9	19.4	20.0	17.6
	H_2	15.0	18.4	14.7	12.6
	CH_4	1.9	2.5	2.2	2.0
	CO_2	11.0	13.3	11.6	12.7
	N_2	54,2	46.5	51.5	55.1
Gas average calorific power (MJ/kg, b.s.)		4.8	5.3	5.1	4.2
Gas average calorific power (MJ/Nm³, b.s.)		4.9	5.8	5.3	4.6
Gas outflow (kg/h)		39.2	31.6	26.2	27.6
Gasifier Power (kW)		46.1	46.7	37.1	31.5

Main tests results in 20 kW gasification system

Below, we will present the main tests results in 20 kW gasification system realized at IPT.

Table 2 - Main tests results

HHV (MJ/Nm³)[1]	5.7
Thermal Power (kW)	67.1
Electric Power (kWe)	20
Biomass Outflow Feeding (kg/h)	~18
Ash Outflow Discharge (kg/h)	1.3

[1] The HHV was calculated from the fuel gases composition (CO, H_2 and CH_4).

Isolated community – Aquidabam village

The Gasification system it will be installed to generate power, replacing the existing the diesel engine at Aquidabam village, the chosen one, located at the municipality of Manacaparu, in Amazon state. There are 700 people living in this community, around 180 households. One of the agricultural products produced by the community is Cupuaçu (an Amazonian fruit), which is sold in natura, with a very low added value, due to the non-existence of electricity that would allow them to keep the cupuaçu pulp frozen (CENBIO, 2003).

The gasification system implementation will allow the local agro industry development to sell frozen cupuaçu pulp (with a high added value), thus improving the community profit and consequently, their quality of living.

Figure 6 - Aquidabam village (CENBIO, 2002)

Results

Considering biomass influence in the gasifier performance, It can be affirmed that as minor as will be the fed biomass humidity, as greater as its dimensional uniformity, as greater as will be the care with the gas cleanness (adequate laudering water outflow and frequent engine filter exchange), greater will be the system efficiency and minor will be the engine and gasifier maintance frequency.

The main results:

Energy efficiency - 72% (literature 79%);

Engine efficiency operating with gas (75% of substitution) - 35%;

Gasifier-motor group - 20%.

Considering the power consumed in the peripheral electric equipment (water bombs, coolant and drier fan) - the generated power falls of 20 for 14 kWe and the group energy efficiency, leading in consideration

the biomass and diesel consumption, falls for 14%.

The system operation It is relatively simple, demanding the presence of two operators (one technician and an operational one, one of them with engine diesel operation and maintenance experience).

About security, the system can be considered safe, mainly as the explosion risks, for being atmosphere open top and for counting on distributed water stamps to the long one of the gas laudering system. Any brusque pressure rise in the gasifier interior readily is alliviated through the gasifier top and the water stamps.

Conclusions

The tests in gasification system with all used biomass, eucalyptus chips, cupuaçu and babaçu had been satisfactory.

The Aquidabam village has the basic conditions for the system implementation: biomass disposal, experience in diesel engine, easy access and mainly great interest and involvement of the community in the project.

The obtained results will be shared with local research institutions. It is a particularly relevant project, because of the great local availability of biomass residues. The results of the project will be replicated in other similar communities in Northern Brazil. This project is of special importance to existing programs of the region energy access increasing, as established in 2003 by the Federal Ministry of Energy.

With the experience acquired in this project, CENBIO will develop the GASEIBRAS Project "Nationalization of the Gasification Technology and Formation of Human Resources in Amazon Region" approved by Federal Ministry of Energy, that will go to reply the GASEIFAMAZ project, discussing the perspectives of local manufacture of the system in the country.

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