HYBRID BIOFUEL: BIOMASS IMPREGNATED WITH LIQUID BIOFUEL

Marco Aurelio Cunha Alves, marco.alves@ufjf.edu.br
Leomar Marques, leomar.marques@engenharia.ufjf.br
Production and Mechanical Engineering Department
Federal University of Juiz de Fora
Rua José Lourenço Kelmer, s / n Campus Universitário.
Bairro São Pedro - CEP: 36036-900 - Juiz de Fora - MG
Phone: (32) 2102-3498

Abstract. *This paper proposes a hybrid biofuel obtained from the impregnation of biomass with liquid biofuels, specifically the impregnation of virgin timber, grain of high energetic capacity, agricultural waste, food leftovers and waste from industrial production with biofuels such as glycerin or oil waste from the processes of food preparation in commercial and domestic kitchens. This hybrid biofuel allows the combustion of liquid biofuel in equipment specifically prepared for biomass combustion - which is a simple equipment - without the need of a complex fuel system. Possible methods of biomass impregnation by liquid biofuel are discussed and some applications of this hybrid biofuel are presented.*

Keywords*: energy generation, hybrid biofuel, impregnation, residual oil, glycerin.*

1. INTRODUCTION

Biomass is defined as "organic matter of vegetal or animal origin that can be converted into thermal or electric energy" (ANEEL, 2008). The energetic potential of biomass is based on the storage of indirect solar radiation through the process of photosynthesis, absorbing CO2 from the atmosphere and incorporating carbon in their vegetal structure. Biomass can be classified into five groups (BEC, 2012): virgin wood, grains of high energetic capacity, agricultural waste, food scraps, and waste from industrial production. It has been observed that, in its earliest production, biomass is essentially solid. Later, after some kind of physical or chemical processing, biofuel is obtained in liquid or gas forms.

For the production of thermal or electric energy, this biomass or biofuel has to undergo a combustion process. Placing the physical state of biofuel on a scale of ease of combustion, it is clear that in a gaseous state the biofuel is of easier combustion, being sufficient that the gas mixes with the oxygen above a certain temperature so the combustion (oxidation) can happen. Located at the other extreme is biomass in a solid state. Located at an intermediate position is biofuel in a liquid state. According to Rendeiro at al (2008), the combustion of solid biomass consists of four distinct phases - Heating and Drying, Pyrolysis, Combustion and Post Combustion - but these phases can occur simultaneously in different regions of biomass under combustion. In liquid biofuel during combustion, there are three phases: spray, oxygen (air) mixing and combustion. Moreover, considering the conditions of storage and handling, the solid biomass presents much easier conditions than gaseous biofuel, which needs to be contained in pressurized vessels. In these cases, the liquid biofuel occupies an intermediate position. These conditions of ease of storage and handling are responsible for the fact that solid biomass has been used since ancient times.

Equipment used for converting biomass into thermal or electrical power is most often designed to use a particular biomass or biofuel in a particular physical state. Equipment designed to work with solid biomass can be quite simple, versatile, safe and useful, like stoves, furnaces and boilers that use coal or wood, despite the need for the modernization of this equipment. Working with gaseous biofuel can also be simple, if the gas has been properly conditioned, such as in systems for the gasification of biomass or biodigesters. Working with liquid biofuel requires relatively complex fuel systems, like those in internal combustion engines using ethanol or biodiesel. Noteworthy is the lack of versatility of such equipment, citing the case of diesel engines that are not capable of operating with vegetable oils in natura, requiring the transesterification of oils so biodiesel can be obtained. Stoves and furnaces using liquid biofuel are mostly old conceptions, but efforts have been made for the modernization and popularization of such equipment, such as an ethanol stove developed by Ebbeson (2000). In this case, the availability of liquid biofuel in certain geographical areas is clamoring for the existence of such equipment. Other two examples of the availability of liquid biofuel that are clamoring for an useful destination is that of glycerin derived from biodiesel production, as well as the residual oil resulting from processes of food preparation in commercial and domestic kitchens. A new purpose for glycerin adds value to the production of biodiesel, increasing the viability of biodiesel as an alternative fuel. The use of residual oil is a matter of preserving the environment. Residual oil disposed directly in the environment causes serious damage, contaminating rivers and lakes.

What is proposed is a hybrid biofuel obtained from the impregnation of biomass with liquid biofuel, more specifically the impregnation of virgin timber, grains of high energetic capacity, agricultural waste, food leftovers and waste from industrial production using biofuels such as glycerin or residual oil from the processes of food preparation in commercial and domestic kitchens. Hybrid biofuel, in others words, will allow the combustion of liquid biofuel in equipment specifically prepared for the combustion process of a solid biomass - which are simple equipments - without

the need for a complex fuel system. In the following, we will discuss possible methods for the impregnation of biomass with liquid biofuel and some of the possible applications of the hybrid biofuel obtained.

2. IMPREGNATION PROCESSES

The impregnation processes of biomass with liquid biofuel can be similar to those used on wood preservation. According to Jankowsky et al (1993), the impregnation of wood can be performed in an autoclave or in treatment cylinders – these are the pressure processes - or by simple processes without the need for special equipment, known as homemade processes or without pressure. The pressure processes are more efficient, while the homemade processes are suitable for the treatment of small volumes. The power consumption required is an argument against pressure processes.

Another method that can be used is baking biomass into biofuel. In this process, if it is performed at a temperature above 100°C, the absence of moisture in the hybrid biofuel obtained would be ensured. This additional consumption of energy is an argument against this process.

In preliminary impregnation experiments, using the homemade process, it has been possible to impregnate 18% of the weight of soybean oil into a specimen of eucalyptus wood, as shown in Figure 1.

In another impregnation experiment, using eucalyptus charcoal, it has been possible to impregnate 48% of the weight of soybean oil.

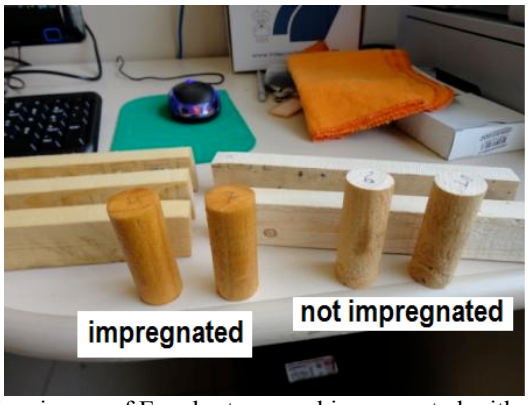

Figure 1 - Specimens of Eucalyptus wood impregnated with soybean oil.

Tests for the impregnation of different biomasses (firewood, charcoal, sawdust, rice hulls, leaves, garden debris, grass, paper, etc.), with different biofuels (oils, glycerin, etc.) are being performed.

3. COMBUSTION VISUALIZATION OF HYBRID BIOFUELS

For the preliminary verification of the combustion process of hybrid biofuel, a culm of bamboo (Dendrocalamus giganteus) was stuffed with sawdust from different species of wood, impregnated with soybean oil and set into combustion. Figure 2 shows the appearance of the flame developed during the process. It has been observed that the soybean oil participated in the combustion together with volatiles from the sawdust and the bamboo.

The hybrid biofuel obtained by this process of filling bamboo with biomass impregnated with liquid biofuel will be used mainly in domestic wood stoves. For an efficient combustion and no interior smoke, an ECOFOGÃO (Miranda, 2003) will be designed, which will be modified to operate with bamboo stuffed with hybrid biofuel.

Figure 2 - Combustion of a load of sawdust impregnated with soybean oil.

4. HYBRID BIOFUEL APPLICATIONS

The applications of hybrid biofuel are numerous. Basically all applications that use biomass as fuel can also use the hybrid biofuel. Below are some applications, but two applications should be highlighted: wood stoves and the recycling of liquid biofuel.

4.1 Wood stoves

Many think that a wood stove is an outdated equipment, being found only in some homes in the countryside, where there is plenty of firewood, and even so being used as auxiliary of gas stoves. But this is not quite the reality. And worse, the real situation points to a condition of health risks. The smoke from solid fuel stoves (wood, charcoal and coal) is the tenth leading cause of death worldwide, with two million premature deaths annually; of these, ten thousand occur in Brazil, according to the WHO (2009). Moreover, it is proven that the use of a wood stove is an imminent risk that can lead to mouth and larynx cancers, affecting mostly women, those who are most at risk (Bortolini, 2008).

In 2005, in Brazil, 21% of all households used biomass stoves, or nine million households, divided between those who use firewood (14%) and charcoal (7%), which points to a great use of this utensil in the country. (Shell Foundation, 2007). In the same sense, wood is not a fuel from the past, as one might think. The proof is that in the U.S., in the last decade, the production of home heating energy from wood rose in 25 states of the federation, more than any other energy source, and in Brazil, renewable fuels (among them wood) represent 26% of energy consumed, reaching 90% in the cooking of food in some places (Lopez, 1999).

The environmentally friendly modern stove uses half the fuel when compared to the traditional stove, and a traditional wood-burning stove uses up to eight times more energy than the gas stove (CEMIG, 2010).

Therefore, it is thought that the main use of hybrid biofuel obtained from the impregnation of wood with a liquid biofuel - soy oil or glycerin - is in household stoves and industrial stoves.

4.2 Wood-fired Oven

Another great application of hybrid biofuel is contributing to firewood savings in the ovens in bakeries and pizzerias.

4.3 Steel industry

The steel industry is a great consumer of biomass energy, particularly that from coal. We have to study the technical and economic feasibility of the use of hybrid biofuel obtained from the impregnation of coal with a liquid biofuel, perhaps glycerin.

4.4 Recycling of residual cooking oil

The impregnation of biomass with residual vegetable oil meets the current need of recycling oil originating from cooking processes. According to Valle et al (2009), the recycling of cooking oil and its transformation into a product which combines economic feasibility with the generation of employment and income and environmental protection is still very small.

4.5 Ceramic Industry

Another application for hybrid biofuel - wood impregnated with liquid biofuel - is in the ceramic industry. Given its energy needs, this industry consumes a lot of wood and has caused serious environmental impacts, especially in the northeast of the country, with the destruction of the caatinga vegetation. In this application, the liquid fuel impregnation of the biomass could not be originated from biomass but from a petroleum derivative; in other words, the use of oil from internal combustion engines collected at the service stations. The usage of this oil meets sustainability criteria, giving a target to a product whose disposal causes environmental impact.

4.6 Biodiesel production

A liquid biofuel that can be used for the impregnation of biomass is glycerin derived from the process of biodiesel production. There is a need to develop a new use for the glycerin, in addition to the conventional ones, with the aim of inducing a higher economic feasibility for the production of biodiesel.

5. CONCLUSION

The works with hybrid biofuel are just beginning and there is a need to develop a lot of research on their production and use. An important factor in development is related to the production logistics of hybrid biofuels, because an important point is the possibility of giving a new destination to biofuels that currently have little purpose, such as glycerin and residual oil from domestic and industrial kitchens. In any manner, the use of hybrid biofuel is broad and can potentially provide a new impulse for the use of biomass in stoves and furnaces.

6. ACKNOWLEDGEMENTS

The authors acknowledge Ecofogão Ltd. for the donation of a test stove and the provision of valuable information concerning the reality of the use of wood stoves worldwide.

6. REFERENCES

ANEEL, 2008. Atlas of electric power in Brazil. National Agency of Electric Energy, Brasilia.

BEC, 2012. Sources of biomass. Biomass Energy Centre, Available at: **Erro! A referência de hiperlink não é válida.**. Accessed on March 25, 2012.

Bortolini, L. V., 2008. The use of wood stoves as a risk factor for cancer of the mouth and larynx: case-control study in the municipalities of Goiânia, Rio de Janeiro and Sao Paulo. MsC. Thesis, Fundação Oswaldo Cruz, Rio de Janeiro, RJ, Brazil.

CEMIG, 2010. 25º Energy Balance of the State of Minas Gerais - BEEMG, base year 2009. Companhia Energética de Minas Gerais, MG, Brazil.

Ebberson, B., 2000. “Fuel container for a spirit stove”. Aktienbolaget Eletrolux, US Patent 00612446, 17 ago.1998, 11 jan. 2000.

Jankowsky, I. P., Fernandes, P. S. and Wehr, J. P. P., 1993. "Use of fencepost of different pine species." Technical Series IPEF, v.9, n.27, p.91 – 98. ; Piracicaba

Lopez, J. C. F., 1999. Analysis of consumption and sustainability strategy of firewood for domestic use in Cachoeira de Santa Cruz. MsC. Thesis, Universidade Federal De Viçosa, Viçosa, MG, Brazil.

Miranda, R. C., 2005. "Eco wood stove, efficient and smokeless". BR Patent n. PI0303647-2A; 14 out. 2003; 31 mai. 2005.

Rendeiro, G. et al., 2008. Combustion and gasification of solid biomass: Energy solutions for the Amazon. Ministry of Mines and Energy, Brasilia.

Shell Foundation, 2007. Brazil market analysis for improved stoves. Winrock International, Final report-Stage 1.

Valle, M. C. T., Teixeira, E. L. and Pimentel, S. S., 2009. "Home Economics: working on the recycling of used cooking oil." In Proceedings of the XX Brazilian Congress of Home Economics, Fortaleza, Brazil.

WHO, 2009. Global health risks: mortality and burden of disease attributable to selected major risks. WHO Library Cataloguing-in-Publication Data, World Health Organization.

7. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.