International Journal of Advanced Engineering and Technology
ISSN: 2456-7655; Impact Factor: RJIF 5.54
Received: 06-08-2019; Accepted: 08-09-2019
www.newengineeringjournal.com
Volume 3; Issue 4; October 2019; Page No. 26-29

Evaluation of alternative fuel for the generation of thermal energy through a boiler

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Abstract
This paper aims to compare fuel alternatives to a boiler used for steam generation. Among the options compatible with the boiler model used by the company, the fuel options were firewood of *Acacia decurrens*, *Eucalyptus globulus*, *Pinus taeda* or *Pinus elliottii* and dry biomass. There was the cost versus calorific value of the alternatives found, and the wood of Acacia decurrens is the fuel that has the lowest price.

Keywords: energy production, boiler, alternative fuels

1. Introduction

A definition of energy is the ability to perform work or to transfer heat [1]. The sizeable national biomass production is an important energy source for the generation of heat and energy [2].

It's possible to obtain biomass for energy generation with the use of solid waste, which represents one of the most severe environmental problems in the modern world, with a tendency to increase with population and economic activity [3].

The concern with cleaner and environmentally responsible production, the reduction, and even the elimination of organic waste production have promoted the debate on the alternatives in their treatment and use [4]. Renewable energy sources, such as biomass, play a crucial role in the energy, environmental, and socio-economic context [5-6].

1.1. Steam boiler

The boiler or steam generator is an equipment that is designed to generate steam through a thermal exchange between the fuel and the water. The equipment has plates and tubes whose purpose is to warm the water. The steam boiler has the purpose of generating energy through the steam, causing the water to pass from the liquid to the gaseous state [7].

According to Regulatory Standard 13 (NR 13), it establishes minimum requirements for the management of the structural integrity of steam boilers, pressure vessels, and their interconnection pipes in aspects related to installation, inspection, operation, and maintenance, aiming at the safety and workers' health [8].

A steam boiler consists of two main parts: the furnace, which provides heat, usually by burning a fuel, and the boiler itself, a device in which weather turns water into steam.

1.2 Alternative fuel sources for cogeneration and energy generation

Some options for alternative fuels for boilers are well known. However, their use may be impracticable due to the company's suitability for this new option. The literature presents some possible alternative fuels, such as diesel oil, natural gas, and chip. Diesel oil, which is a fuel derived from petroleum formed mainly by hydrocarbons (carbon and hydrogen) and in low concentrations by sulfur, nitrogen, and oxygen [9].

Diesel fuel is a mixture of hydrocarbons obtained by distillation of crude oil. The essential properties that are used to characterize diesel fuel include cetane number, fuel volatility, density [10].

Natural gas is a source of clean energy that can be used in industries, replacing other, more polluting fuels, making it an alternative fuel option. Natural gas (NG) is the mixture of light hydrocarbons that at room temperature and atmospheric pressure remain in the gaseous state [11].

Natural gas consists mainly of methane and 3.6 to 7.9% of the methane from the production of shale-gas escapes into the atmosphere in ventilation and leaks over the life of a well [12].

The chip is a renewable resource obtained from wood chips. It has a calorific value lower than 2,500 kcal/kg, a specific mass of 330 kg / m³. In comparison, Arruda (2009) also states that wood has a lower calorific value of 2,300 kcal/kg, a specific mass of 340 kg / m³ [13]. The use of agricultural waste biomass as a source of energy in Europe is for heating, combined heat, and power. Use of straw as fuel is a form of waste disposal [14]. The forest products and agriculture industry generate waste whose use as fuel represents among the most socially and environmentally beneficial biomass resources. Energy crops are exclusively for their energy content [15].

Biomass is the name given to all living matter of the earth. It is the general term for material derived from plants growing or from animal manure. It is a reasonably simple term for all organic materials that appear from plants, trees, plants, and algae [16].

When the biomass is used directly in an energy application without chemical treatment, then it is burnt. The conversion can be carried out by thermochemical, biological or chemical processes [16]

Biomass fuels are similar to fossil fuels. They are readily available all over the world. In the developing world, biomass is still the primary source of energy [16].

Applying biomass technology is both an environmental and

human need if on a local scale to get rid of sludge, waste and refuse, or on a global scale reduce the carbon dioxide content in the atmosphere and therefore reduce global warming (YUSO, 2004).
Renewable energy is a commodity like any other energy. It has an important role to play in responding to global energy demand needs and in combating the danger of global warming [17].

2. Materials and methods

2.1 Boiler model

The model of the boiler or steam generator installed in the footwear factory is the CVS-CL 1500. Its energy source is wood burning. It has a thermal efficiency of over 78%. It is compact, requiring little space for installation, automatic operation. Having a thermal capacity of 960000 kcal/h.

Fig 1: Boiler CVS-SCL 1500.

2.2 Manufacturing Process

Currently, the boiler works six days a week, 24 hours a day. The supply of the same begins on Sunday at 6:00 p.m., and runs until Saturday at 6:00 p.m. The boiler takes 2hs until it can generate thermal energy from its initial drive. The company has qualified employees to make as much control as the supply of the boiler. It appears in a separate area from the production halls.

Fig 2: Boiler in operation.

In figure 2, it is possible to see the boiler supply port. Inside, there is a grille bottom (about 5 cm from one grid to another, with steel bars, 10 cm wide), which causes all the ash generated by the burning to descend to another compartment that facilitates its removal.
The steam generated is piped through to the company's production system. The use of steam is both to supply the thermal energy in autoclave machines and smaller presses used in the production of footwear. In addition to the supply, the employee is responsible for checking the pressure levels and temperature control of the equipment, through the panel of figure 3.

Fig 3: Control panel and boiler activation.

After use, the water in the boiler undergoes a treatment process for its reuse. The equipment responsible for this process is located behind the boiler, as shown in figure 4.

Fig 4: Boiler cooler.

2.3 Maintenance of the boiler

Maintenance must be carried out periodically, according to Regulatory Norm # 13 (NR 13) to avoid accidents caused by lack of maintenance. It is necessary to check the electrical part, panel, wiring, welding situations, pipes, cleaning with removal of accumulated waste.
To facilitate preventive maintenance, the boiler has a liquid pressure system, which every two hours dispense a concentrated jet of water and other products, which help prevent it from creating waste on the inner walls of the pipe.
The company has as a standard, once a month, to clean the entire tubing of the equipment. Also, it must undergo a technical evaluation every six months for it to be proven through an award if it follows the standards required by the rule.

2.4 Alternative Fuel

Other types of fuel may be used to generate power in the boiler, making the necessary changes to change fuel or depending on the fuel without changing. The viable fuels would be diesel oil, natural gas, biomass. It would be more feasible to use biomass or chip.

The use of chip or biomass, a renewable energy generation is not necessary to make a change in the boiler, check the condition of the calorific value.

3. Results

3.1 Production Costs

The boiler required an initial investment of approximately R$ 160,000.00. Considering the cost of the equipment, its implantation in the company and the qualification of the professionals who work in the sector.

Monthly are spent around R$ 500.00 for cleaning, in addition to costs with acacia wood, which is fuel. In total, prices reach approximately R$ 7,000.00. The energy costs of the autoclave (average energy consumption is 65kWh, at R$ 0.2908 / kW, which reaches a price of almost R $ 11,000.00 per month), already shows how profitable the machine is for the company.

3.2 Fuel and energy efficiency

Acacia has the calorific value of 4430 kcal/kg. Among other types of wood, there is, for example, eucalyptus, whose calorific value can reach 4300 kcal/kg, pinus 4100 kcal/kg. The biomass varies according to its quality or what type of biomass, this differs from 1300 kcal/kg to 4200 kcal/kg. Next, Table 1, followed by Figure 1, illustrates what would be the monthly cost of some alternative fuels. Thus, it is possible to make a comparison between the fuel currently used in the boiler, and its possible substitutes.

The comparison is as follows: the monthly consumption of acacia wood is approximately 90m³ per month. Dividing this consumption by the calorific value of the same obtains the calorific quantity necessary monthly by the boiler. With this data, it is possible to estimate how much in m³ we need the other fuel options. The unit costs per m³ are in table 1.

Table 1: Comparison of costs

Fuel	Calorific power (kcal/kg)	Costs (R$/m³)	Total Costs (R$/month)
Acacia decurrens	4430	R$ 70.00	R$ 6,300.00
Eucalyptus globulus	4300	R$ 80.00	R$ 7,417.00
Pinus Taeda or *Pinus Elliottii*,	4100	R$ 75.00	R$ 7,290.00
Dry Biomass	4200	R$ 140.00	R$ 13,290.00
Wet Biomass	1300	R$ 120.00	R$ 36,803.00
Electricity	860	R$ 0.29	R$ 11,000.00

In this paper, an attempt was made to evaluate the saving of electric energy after the installation of the steam boiler. From the moment it was installed in the company, there was a drastic reduction in the electricity bill, generating a considerable monthly disbursement.

It observed that the fuel currently used by the boiler, acacia wood, has the best performance (calorific value X cost-benefit) when compared to other fuels mentioned above.

However, it is possible to emphasize that through the negotiation of prices, one has the wood of eucalyptus and wood of pinus, that have calorific power relatively close to the one of acacia wood, and that with this they become options of substitute fuels acacia wood.

It is then up to the company to decide to use one of these options to lower its fuel cost to the boiler. Recalling that the factors considered that suggest this analysis, are the calorific value of the fuels and their cost of purchase

4. Conclusions

In this paper, we have evaluated the saving of electric energy after the installation of the steam boiler. From the moment it was installed in the company, there was a drastic reduction in the electricity bill, generating a considerable monthly disbursement.

The fuel currently used by the boiler, the wood of *Acacia decurrens*, has the best performance (calorific value versus cost-benefit) when compared to the other fuels mentioned above.

However, it is possible to emphasize that through the negotiation of prices, one has the wood of *Eucalyptus globulus* and wood of *Pinus Taeda* or *Pinus Elliottii*, that have calorific power relatively close to the one of acacia wood, and that with this they become options of substitute fuels acacia wood.

It is then up to the company to decide to use one of these options to lower its fuel cost to the boiler. Recalling that the factors considered that suggest this analysis, are the calorific value of the fuels and their cost of purchase.

Acknowledgments

This study is part of projects of a group of researchers of Professors and students of Production Engineering from Taquara, Brazil. The research group does not receive any funding to support it.

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