

Utilization of Gasoline Fuel as an Alternative Fuel for LPG Substitution

Asril Mallombasang^a, Zuryati Djafar^{b,*}, Wahyu Haryadi Piarah^c

^aDepartment of Mechanical Engineering, Faculty of Engineering, Universitas Hasanuddin. Email: mallombasangchito@gmail.com

^bDepartment of Mechanical Engineering, Faculty of Engineering, Universitas Hasanuddin. Email: zuryatidjafar@unhas.ac.id

^cDepartment of Mechanical Engineering, Faculty of Engineering, Universitas Hasanuddin. Email: wahyupiarah@unhas.ac.id

Abstract

The subsidized gasoline conversion to LPG 3 kg in 2007 became the Indonesian Government's policy to reduce reliance on fuel oil. The increasing LPG consumption and obstacle distribution have been the scarcity of the LPG in all regions of Indonesia. The gasoline fuel stove has overcome from the LPG scarcity. So, this research has conducted by comparing the consume rate between both Peralite and Pertamina of gasoline types to fuel LPG at the boiling process 1 litre of water which has used the quantum gas stove, with several pressure variations from 1.5 kPa to 2.5 kPa. Test results showed that the highest fire temperatures for Peralite 430 °C fuel, Pertamina 530 °C fuel and LPG 578 °C fuel. Fuel consumption for Peralite 0.025 kg, Pertamina 0.027 kg and LPG 0.061 kg. While the distribution time is 682 s for Peralite, 669 s Pertamina and 503 s for LPG. The least compaction efficiency value occurs at 1.5 kPa pressure, for Peralite 6.136 %, Pertamina 7.730 % and LPG 9.018 %. The higher the pressure hence greater the fuel efficiency, instead the fuel consumption and water boiling time are reduced. The cost used to boil water on Peralite is 236 Rupiah, Pertamina 251 Rupiah, and LPG is 309 Rupiah.

Keywords: Air pump; efficiency; peralite; stove; tube reactor

1. Introduction

Indonesia is one of the countries which have abundant natural resources like petroleum. Natural resources have been processed and used in supporting daily activity such as industrial field, transportation, household but the main problem of petroleum resources is scarcity. Indonesian's Government has exhibited the issue policy to replace kerosene usage to LPG gas. The purpose of this policy is reducing consume rate of kerosene continuously [1].

LPG gas is a fuel taken from natural gas contained in the earth and processed into gas that can be used by the community as an innovation in the utilization of natural resources in Indonesia.

If the kerosene conversion to LPG gas is a success, the Indonesian Government is saving 15 to 20 trillion fuel oil subsidized every year [2]. The target of conversion of kerosene to LPG gas is to households and micro-enterprises. For household criteria that get it is a user of pure kerosene, does not have an LPG stove, earns less than 1.5 million every month and is a native of the area. While the criteria of micro-enterprises are consuming kerosene to production process [3].

The role of fuel oil (BBM) in this modern era is usefully significant that almost all activity has been using

fuel oil. This energy source has been used as long as thousands of years due to its flexible nature. As a simple example of using BBM in daily life is the use of an oil stove for cooking. Of course, we remember the government's efforts to replace kerosene stoves with gas stoves on the grounds of increasing efficiency. Some cases of fire that occur in Indonesia has caused by gas stoves because of the very flammable fuel of the LPG. When LPG gas became scarce, some of people returned to using kerosene and even firewood, but some also tried gasoline as an alternative to LPG gas.

Alkarim, et al., [4] in their research using a reactor tube containing Peralite connected to an aerator (air pump) as an air supply as well as a Peralite evaporation aid. So, Ridhuan and Darma [5] used a stove with premium fuel, This is to determine the variation in the number of holes and the diameter of the stove burner on premium fuel consumption. Another related research has been revealed by Sukandi and Porawati [6] that has used a reactor tube as a storage container of hydrogen gas as stove fuel.

2. Fundamental Theory

2.1. Peralite fuel

Peralite is an oil fuel issued by Pertamina company with Research Octane Number (RON) 90, an announcement in May 2015, and green bright in color characteristics [7]. The rule of the mixture used for

*Corresponding author. Telp. +62-812-8047-7465

Jalan Poros Malino km. 6, Bontomaranu,
Gowa, South Sulawesi, Indonesia 92171

manufacturing Peralite is Naphtha where has RON 65 - 70. Enhance the quality of RON becomes RON 90 can be conducted by mixed with *High Octane Mogas Component* (HOMC), and EcoSAVE additives have also added to make the engine smoother, cleaner, and more efficient [8].

2.2. *Pertamax fuel*

Pertamax was first launched in 1999 to replace the premium mixture (premix 98) because it contains Methyl Tertiary Butyl Ether (MTBE) compound that is not environment friendly. Pertamax is a recommendation for vehicles produced after 1990, especially those that have used technology equivalent to electronic fuel injection (EFI) and catalytic converters (catalytic converters). Pertamax is produced by Pertamina base on the decision of the Directorate General of Oil and Gas No. 3674/K24/DJM/2006, dated 17 March 2006 concerning specifications for gasoline, 91 [9].

2.3. *LPG (Liquified Petroleum Gases)*

LPG stands for Liquified Petroleum Gas, which means gas that is liquefied at any pressure and has obtained from fractionated petroleum. The types of LPG based on its specifications have mixed LPG, propane LPG and butane LPG. Whereas currently circulating in the community based on the Decree of the Director-General of Oil and Gas Number: 25K/36/DDJM/1990 is a type of mixed LPG. To reduce the risk of explosion and find out the gas leak in the tube, Pertamina has added mercaptan gas that has a distinctive odor and has nose piercing properties [10].

2.4. *Calorific value*

The heating value is a property of a fuel which states the energy magnitude of the fuel. Determination of the calorific value of the fuel can be done by testing or by estimating based on the raw components of the fuel [11]. Meanwhile, low heating value (LHV) is the heating value where it has assumed that water and hydrogen are in the vapor phase [12]. The calorific value, density and fuel price of Peralite, Pertamax and LPG can be seen in Table 1.

2.5. *Maturity Efficiency*

Maturity efficiency is the ratio between the useful heat needed to heat water a certain amount from the initial temperature until mature with the heat provided by the fuel [15].

The method used is to boil 1 (one) liter of water to a temperature between 95 °C to 99 °C on the one eye stove using gasoline types Peralite, Pertamax, and 3 kg LPG

Table 1. Calorific value (LHV), density and price of fuels [9], [13], [14]

Type of fuel	Calorific value (LHV) (kJ/kg)	Density (kg/m ³)	Price (Rp.)
Peralite	44260	732.9	7,850
Pertamax	44791	768.7	9,200
LPG	47089.29	1.5	17,000

fuel. The measured water volume and the mass of gasoline (Peralite and Pertamax) and LPG fuel that has used, so that the heating efficiency has calculated by the following formula.

$$m_{bb} = m_a - m_{ak} \tag{1}$$

$$\dot{m}_{bb} = \frac{m_{bb}}{t} \tag{2}$$

where

- m_{bb} = mass of fuel consumed (kg)
- m_a = initial fuel mass (kg)
- m_{ak} = final fuel mass (kg)
- \dot{m}_{bb} = fuel mass flow rate (kg/s)
- t = boiling time (s)

Combustion Power (P_{in}) is the heat energy contained in the fuel multiplied by the mass flow rate (\dot{m}) used in the boiling process.

$$P_{in} = \dot{m}_{bb} \cdot LHV \tag{3}$$

where

- P_{in} = net power to raise the water temperature (kW)
- LHV = the lowest calorific value of fuel (kJ/Kg)

Output power (P_{out}) is the ratio of the energy used to heat water to the length of time which it takes to reach its boiling point [16].

$$P_{out} = \frac{m_{air} \cdot cp_{air} \cdot \Delta T_{air} + m_{panci} \cdot cp_{panci} \cdot \Delta T_{panci}}{t} \tag{4}$$

where

- P_{out} = nett power (kW)
- m_{air} = water density (kg)
- Cp_{air} = specific heat of the water (kJ/kg °C)
- m_{panci} = the mass of pan (kg)
- Cp_{panci} = specific heat ofpan (kJ/kg °C)
- ΔT = difference in temperature (°C)

The heating efficiency (η) is ratio between net power that is used to boil water and the combustion power of the fuel.

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% \tag{5}$$

The initial conditions of the study in the form of air density and specifications of other research materials can be seen in Table 2.

2.6. *Economic value*

The economic value of the use of petroleum fuel types Peralite and Pertamax and LPG fuel is the number of fuel costs used to boil 1 (one) liter of water. There are two parts economic value such as fix cost likely stove and its installation, and change cost likely consume rate of fuel in the boiling process of a litre of water with the time required in the boiling process.

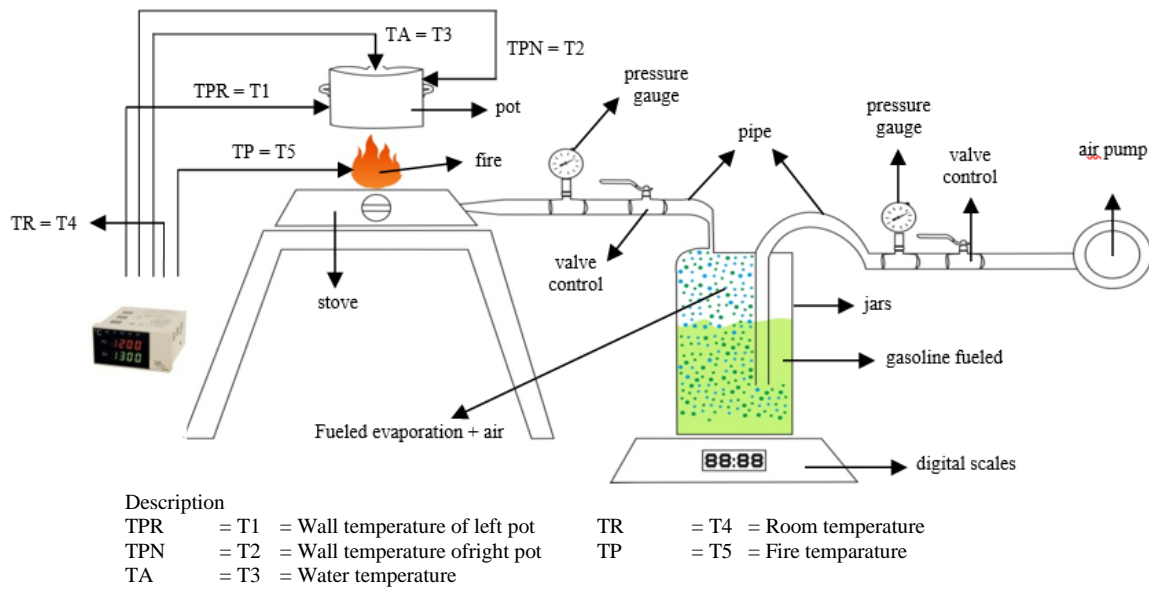


Figure 1. Testing sketch of boiling water

Table 2. Initial condition of research [14], [16], [17]

Initial Condition	Magnitude
Water mass	0.968 kg
Pan mass	0.219 kg
Cp (specific of water)	4.1866 kJ/kg °C
Cp (specific of pan)	0.9 kJ/kg °C
Air density (ρ)	1.2 kg/m ³

$$B_{bb} = m_{bb} \cdot H_{bb} \quad (6)$$

where

- B_{bb} = fuel cost (Rp)
- m_{bb} = consume rate of fuel (liter)
- H_{bb} = price of fuel (Rp)

3. Research Methodology

3.1. Research tools and materials

- Materials of Research
 - a. Water
 - b. Pertamina
 - c. Peralite
 - d. LPG 3 kg
- Tools of Research
 - a. Termokopel
 - b. Digital scales
 - c. Stopwatch
 - d. Manometer
 - e. Measuring glass
 - f. Stove
 - g. Air pump
 - h. Pot
 - i. Jars

3.2. Testing method

The testing method has conducted by using one eye stove for boiling a litre of water. Gasoline fuel in the reactor tube pumped with air pump, and at the same time use to vaporize gasoline fuel such as revealed in Fig. 1.

4. Result and Discussion

4.1. Analysis of maturity characteristic

Testing has conducted on this research so we can analyze the relation of two variables that is pressure and fire temperature (shown in Fig. 2).

Figure 2 has revealed a firing temperature for Peralite fuel reach out 349 °C at 1,5 kPa of pressure and reach out the highest temperature at 430 °C on 2.5 kPa of pressure. For Pertamina fuel, the fire temperature at 1.5 kPa is 416 °C and the highest temperature is 530 °C at 2.5 kPa. Meanwhile, for LPG fuel, the firing temperature at 1.5 kPa of pressure is 483 °C, and the highest temperature in 578 °C at 1.8 kPa of pressure. There were fluctuations at several pressure points up to a pressure of 2.2 kPa to 2.5 kPa for Peralite and Pertamina fuels, the fire temperature continued to increase.

Figure 3 has reveals the relationship between pressure and consume rate of fuel. Figure 3 has shown that the higher pressure, the lower the fuel consumption. The highest of fuel consumption rate is used LPG fuel. by pressure variation has used among 0.054 kg to 0.066 kg. Rate fuel consumption pertamax and peralite fuel is relatively between from 0.021 kg to 0.033 kg. Figure 4 revealed relationship between pressure and boiling time of water.

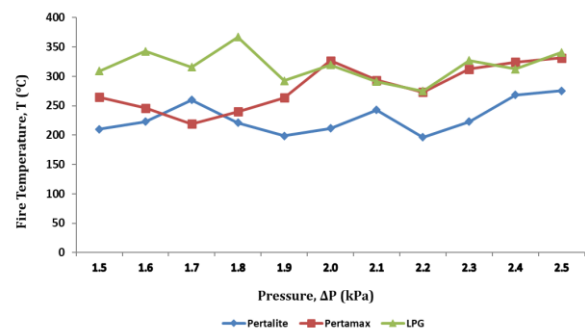


Figure 2. Relation of pressure (ΔP) to fire temperature ($^{\circ}C$) at gasoline fuel (Peralite, Pertamina) and LPG fuel

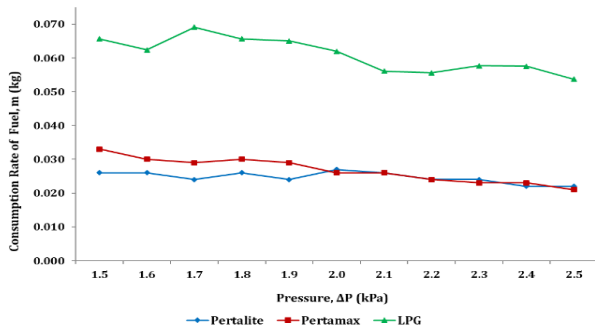


Figure 3. Pressure (ΔP) to consume rate of fuel the gasoline fuel (Peralite, Pertamina) and LPG fuel

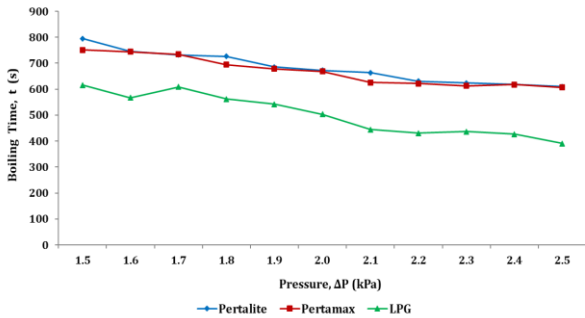


Figure 4. Pressure (ΔP) with boiling time in the gasoline (Peralite, Pertamina) and LPG fuels

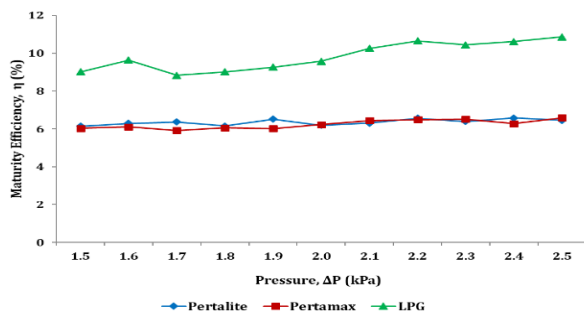


Figure 5. Pressure (ΔP) to Maturity Efficiency in the gasoline (Peralite, Pertamina) and LPG fuels

Figure 4 shows that the fastest boiling time has used LPG fuel that its time among 391 seconds to 616 seconds. Pertamina and Peralite fuel reveal relatively equal in the time and magnitude value that is the higher pressure, the shorter the simmering time required from 607 seconds to 795 seconds.

Figure 5 shows relationship between pressure and maturity Efficiency in the gasoline fuel. Figure 5 reveals that the efficiency value of peralite and pertamax fuels is relatively constant on ranges between 6.359 % and 8.020 %. For LPG fuel, there is enhance efficiency as long as increased pressure. The highest value of efficiency on 2.5 kPa (10.857 %), 1.5 kPa (9.018 %). This shows that the greater the pressure applied, the greater the tomaturity efficiency value.

4.2. Maturity cost analysis

The cost comparison parameter used is operational costs. For costs of investment are considered relatively the same because they is use the same stove despite using

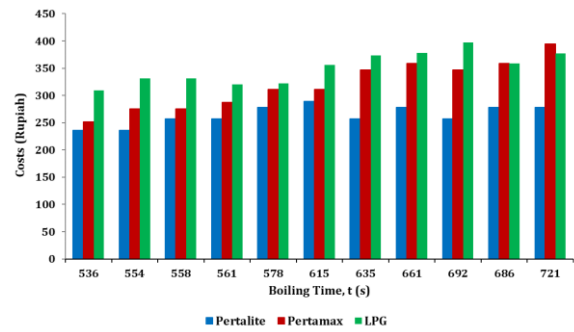


Figure 6. Boiling Time to Cost of Gasoline (Peralite, Pertamina) and LPG fuels

different fuel containers. Figure 6 shows that greater the time, and greater operational cost. It also appears that the lowest operating costs are peralite fuel then pertamax and finally LPG.

To boil water 1 litre of water with peralite fuel at a pressure of 2.5 kPa, it costs 236 Rupiah and for pertamax fuel of 251 Rupiah. As for LPG fuel amount to 309 Rupiah. For low pressure (1.5 kPa), it costs 278 Rupiah for Peralite, 395 Rupiah for Pertamina and 377 Rupiah for LPG.

5. Conclusion

The highest fire temperatures for Peralite fuel are 430 °C, Pertamina fuel 530 °C fuel and LPG 578 °C fuel. Fuel consumption at 2.5 kPa for Pertamina 0,021 kg fuel, Peralite fuel 0.022 kg, and LPG fuel 0.054 kg. For the fastest discharge time occurs at a pressure of 2.5 kPa, for LPG fuel takes 391 seconds, Pertamina 607 seconds fuel and Peralite fuel time is 610 seconds. While the fuel efficiency value at 2.5 kPa has obtained for Peralite fuel is 6.136%, Pertamina fuel, 7.730% and LPG fuel 9.018%. The cost required to boil 1 (one) litre of water is Peralite fuel amounting to Rp. 236,- Pertamina fuel Rp. 257,- and LPG fuel of Rp. 309,-. This research should be a reference for household users to overcome the scarcity of LPG.

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