The Effect of Different Octane Number on Power and Specific Fuel Consumption in Gasoline Compression Ignition Engine

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Article Information

Manuscript Received 2024-06-20
Manuscript Revised 2024-07-05
Manuscript Accepted 2024-07-14
Manuscript Online 2024-07-14

ABSTRACT

Internal combustion motors are a type of engine used as the main source of power for transportation equipment. This engine functions to convert heat energy into kinetic or motion energy. Compression ignition (CI) utilizes the increase in temperature and pressure during compression to ignite the fuel. The piston, as the main component of an internal combustion motor, plays an important role in transferring the energy produced from burning fuel in the combustion chamber to other drive mechanisms such as the crankshaft. Apart from that, the piston is also responsible for regulating the flow of fuel and air in the engine. Fuel is any material/substance that can be converted into energy. Fuel contains heat energy, which can be released during oxidation or combustion. The octane number or research octane number (RON) indicates the maximum pressure that can be received before gasoline burns itself. A lower octane number increases the likelihood of detonation of the fuel. Gasoline with a higher-octane number is basically designed to prevent premature ignition or auto ignition of the gasoline in the engine. This research focuses on the power and specific fuel consumption of gasoline compression ignition engine at each variation in fuel octane number and engine speed. The fuel used is a mixture of 94% gasoline and 6% diesel fuel. The highest average power results at an engine speed of 1900rpm from 90, 92 and 95 octane fuel respectively are 0.475 kW, 0.728 kW and 0.764 kW. The average results of specific fuel consumption at 1900 engine revolutions were obtained for fuel with octane numbers of 90, 92, and 95 respectively at 0.92 L/kWh, 0.91 L/kWh, and 0.65 L/kWh.

Keywords: Octane Number, Power, SFC, Compression Ignition, Engine Speed.

1. INTRODUCTION

Internal combustion motors are a type of engine used as the main source of power for transportation equipment. This engine functions to convert heat energy into kinetic or motion energy [1]. Internal combustion engines are a type of engine that is widely used in motor vehicles and industrial equipment. It is predicted that internal combustion engines (ICE) will still be the main source of power for vehicles [2]. This applies to both types of engines (engines with spark ignition and engines with compression ignition) in the short and medium term [3]. The piston, as the main component of an internal combustion motor, plays an important role in transferring the energy produced from burning fuel in the combustion chamber to other drive mechanisms such as the crankshaft. Apart from that, the piston is also responsible for regulating the flow of fuel and air in the engine [4].

Internal combustion engines are divided into 2 types according to their fuel ignition system, namely spark ignition (SI) engines where the fuel is ignited using a spark and compression ignition (CI) engines which utilize increased temperature and pressure during compression to ignite the fuel. This can happen because the chemical reaction of a material is influenced by the prevailing temperature and pressure [5]. Spark Ignition engines are often called petrol engines according to the type of fuel, while compression ignition engines are more often applied to diesel engines [6]. The fuel ignition process in a compression ignition engine occurs when fuel is injected into a cylinder filled with hot, pressurized air. The fuel will burn by itself once the air temperature in the cylinder exceeds the flame temperature of the fuel [7].

Fuel is any material/substance that can be converted into energy. Fuel contains heat energy, which can be released during oxidation or combustion [8]. The octane number or research octane number (RON) indicates the maximum pressure that can be received before gasoline burns itself. Octane number plays an important role in reducing fuel consumption and optimizing engine performance [9].

A lower octane number increases the likelihood of detonation of the fuel. Fuel that easily detonates will reduce engine performance, because combustion occurs prematurely, causing a loss of power, and resulting in more wasteful fuel consumption due to incomplete combustion [10]. Gasoline with a higher-octane number is basically designed for high-performance vehicles such as sports and racing cars. This is done to prevent premature ignition or auto ignition of the gasoline in the engine, which can occur before the spark plug ignites the fuel for the combustion process [11].

Fuel oil is a basic need, both in industry, household activities and transportation, which causes an increase in fuel consumption nationally [12]. Vehicle fuel consumption is increasingly receiving attention because the price of fuel oil, which is the main energy source for vehicles, continues to increase [13]. Transportation is one sector that has a big responsibility in reducing fossil fuel consumption [14]. Now experts are trying to improve motor characteristics by increasing motor power and reducing specific fuel consumption [15]. Therefore, this research focuses on the power and specific fuel consumption of gasoline compression ignition engines at each variation in fuel octane number and engine speed.

Previous research that has been carried out regarding the octane number of power and specific fuel consumption shows quite significant differences between petrol engines, including research results show that gasoline with RON 98 and 100 reduces acceleration duration by 2.7% and 6.7% respectively compared to RON 95. In stable conditions, the power produced at the wheels increases along with the increase in the octane number of the fuel. RON 98 petrol increases power by 3.4%, while RON 100 increases power by 7.7% compared to RON 95 [16].

According to Rashid, et al. research, engines using RON97 fuel had average torque increases of 15% and 12% compared to engines using RON95 and RON102 fuels. In addition, RON97 fuel produced the most brake power, followed by RON102 and RON95 fuels [17].

Rahmat & Wijaya's research states that at 6000 Rpm, the engine using RON 92 gasoline produces 7.2 KW of power, while the engine using RON 100 gasoline is able to produce 7.8 KW of power. This proves that gasoline with a high-octane value is more resistant to detonation, resulting in more optimal power [18].

1.1.Power

Power is the result of work, or in other words power is the work or energy produced by a engine per unit time when the engine is operating [19]. The mechanical power produced by the engine comes from heat energy produced from burning a mixture of fuel and air. Not all of the heat energy produced during the expansion stroke is converted into kinetic energy. In a gasoline engine, only about 25% of this energy can be used effectively [20].

1.2.Fuel and Octane

Fuel is a substance that can store heat energy through combustion, which can then be converted into energy through release and processing. Gasoline consists mainly of hydrocarbons obtained through fractional distillation of petroleum and enhanced with various additives. Natural gasoline contains C5-C12 alkanes and cycloalkenes (naphthene) [21]. Octane number is an indicator used to measure the quality of gasoline used as gasoline motor fuel [22]. The octane number can be defined as the ratio of iso-octane to n heptane which has the ability to prevent knocking in the engine [23]. Knocking, often called detonation, is a sound resulting from abnormal combustion of fuel in the combustion chamber [24]. Therefore, high fuel compressibility is very important for gasoline engines. Using low-octane gasoline can cause engine knocking [25].

1.3.Compression Ignition Engine

A compression ignition engine is an engine that uses the temperature of compressed air to ignite the fuel. In a compression ignition engine, the only thing the piston sucks into the combustion chamber is air, then the air is compressed until it reaches a high temperature and pressure. Moments before the piston reaches top dead center, fuel is injected into the combustion chamber. When the temperature and air pressure in the cylinder increases, the fuel molecules will burn and form a combustion process [26]. Compression ignition engines are characterized by a high compression ratio which is used to produce the pressure and temperature required for automatic ignition [27].

1.4.Specific Fuel Consumption

Specific fuel consumption (SFC) is a parameter commonly used in internal combustion engines to describe fuel usage. Specific fuel consumption is defined as the ratio between the fuel mass flow rate and the resulting output power. In other words, SFC shows how efficiently fuel is used by the engine to produce power. A low SFC value indicates efficient fuel use, so it is highly desirable to achieve optimal fuel efficiency [28].

$$SFC = \frac{\mathrm{Vf}}{\mathrm{P}}\ (L/kWh) \tag{1}$$

Whereas, SFC is specific fuel consumption (L/kWh), Vf is fuel flow rate (L/h), and P is engine power (kW),

1.5.Complete Combustion Reaction

The theoretical basis for gasoline fuel is that it contains CmHn with n m value of around 8, while n varies according to compounds such as pentane, pentene, or pentyne, as well as the possibility of the presence of other by-products [29]. During combustion, chemical energy is converted into heat energy, and each combustion produces flue gas containing the flue gas components CO2, NO2, H2O, SO2, and CO. The combustion process converts fuel energy into kinetic energy, and this energy change is caused by fuel combustion [30]. In theoretically complete combustion of gasoline, the combustion reaction is as an equation 2.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O \tag{2}$$

2. RESEARCH SIGNIFICANCE

This research focuses on power and specific fuel consumption in gasoline compression ignition engines. Gasoline compression ignition (GCI) is an engine similar to a diesel engine. The main difference lies in the relatively lower reactivity of gasoline fuel compared to diesel. Research and development to improve GCI combustion continues, as demonstrations of GCI combustion have shown very promising results in achieving efficiencies equivalent to diesel engines [31]. The octane number of-fuel can indicate the quality of the fuel. From several studies that have been carried out, it was found that the higher the octane number, the higher the power produced.

3. RESEARCH METHODS

3.1. Experimental Setup

Fig 1. Shows the installation scheme and tools needed for testing

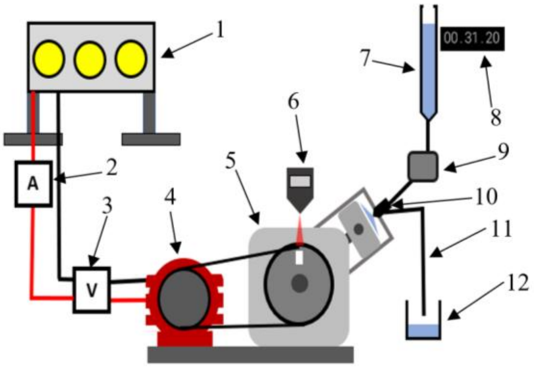


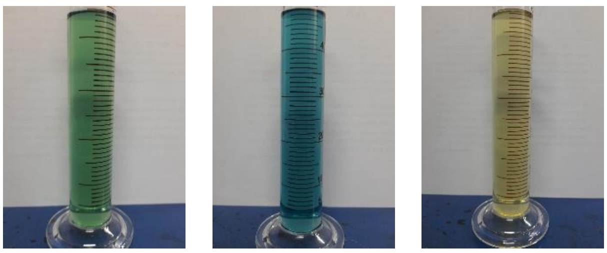
Fig. 1. Installation Scheme

Whereas: 1. Load 2. Ampere Meter 3. Volt Meter 4. Generator 5. Compression Engine 6. Tachometer 7. Burette 8. Timer 9. High Pressure Pump 10. Injector 11. Return Pipe 12. Measuring Cup.

Fig 1 shows the installation scheme of the equipment used in testing the power and specific fuel consumption of a gasoline compression ignition engine.

3.1. Material

This research uses gasoline with octane numbers of 90, 92, and 95 which has been mixed with 6% diesel to lubricate the high-pressure pump. The materials for testing can be seen in **Fig. 2.**



(1) (2) (3)

Fig. 2. (1) Mix Gasoline RON 90 and diesel fuel (94% : 6%), (2) Mix Gasoline RON 92 and diesel fuel (94% : 6%), (3) Mix Gasoline RON 95 and diesel fuel (94% : 6%).

Fig. 2 shows gasoline that has been blended with diesel fuel at 6% of the total fuel volume.

3.2. Experimental Procedure

This research uses a type of experiment using gasoline compression ignition by varying the fuel octane number of 90, 92, 95 and engine speed of 1300, 1600, 1900 rpm for specific power and fuel consumption. For specification can be seen in **Table 1**.

Table 1. Specification for testing

Engine Type	Single Cylinder 4 stroke, 2 valve OHV compression ignition
Bore x stroke	68mm x 54mm
Compression Ratio	22 : 1
Injection Pressure	100 Bars
Fuel	Mix 94% gasoline 6% diesel fuel
Generator	Max Load 1000watt, 50Hz
Load	750 watts

The experiments setup can be seen in **Fig. 3.**

Fig. 3. Experimental Setup

Fig. 3 shows the equipment needed in testing the power and SFC of a gasoline compression ignition engine. Data was obtained by conducting experiments directly on the vehicle which was the test equipment using a generator to determine power and a measuring cup to determine fuel consumption, while the data collection tool was in the form of a table. The data collection tool is in the form of tables which will then be processed, resulting in graphs of specific power and fuel consumption for the engine that is the test tool. In the specific fuel consumption test, a fuel volume of 6 ml was used.

4. RESULTS AND DISCUSSION

4.1. Power

The result data octane number for correlation engine speed to engine power, can be seen in **Fig. 4**.

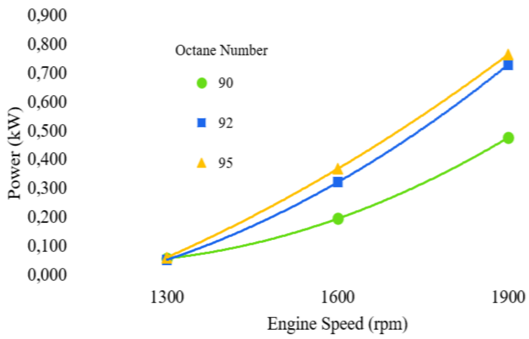


Fig. 4. Octane Number for correlation Engine Speed to Engine Power

Fig.4 shows that the average power at an engine speed of 1900 rpm from each 90, 92 and 95 octane fuel is 0.475 kW, 0.728 kW and 0.764 kW respectively. This happens because the higher the octane number of the fuel, the better the fuel is able to withstand the compression pressure of the piston. This allows more complete combustion to occur in the combustion chamber. There is no significant difference in power between 92 and 95 octane gasoline because the fuel's resistance to compression pressure is almost the same.

4.2. Specific Fuel Consumption (SFC)

The result data octane number for correlation engine speed to specific fuel consumption, can be seen in **Fig. 5**.

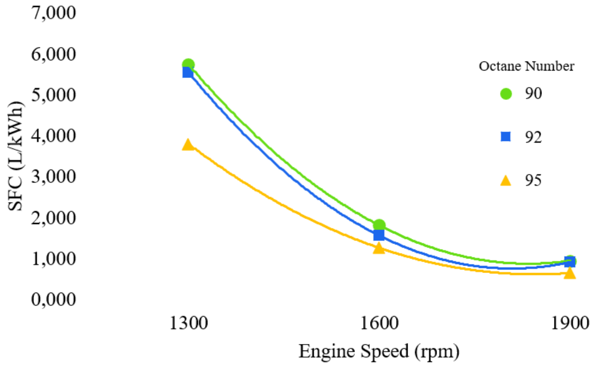


Fig. 5. Octane Number for correlation Engine Speed to SFC

Fig. 5 shows the result of specific fuel consumption data at 1900 engine revolutions was obtained for fuel with octane numbers of 90, 92, and 95 respectively at 0.92 L/kWh, 0.91 L/kWh , and 0.65 L/kWh. This is due to the high power of 95 octane gasoline with less fuel consumption. The difference in SFC for 90 and 92 octane gasoline is not very significant. This happens because 92 octane gasoline requires more fuel consumption to produce high power. Judging from the specific fuel consumption in fig.5, it shows that the higher the power, the lower the SFC produced. Because in equation (2) fuel consumption is divided by the power produced, so that if the power produced is high then the SFC produced is also low.

The limitation of thiis research is that it discusses the power and specific fuel consumption of gasoline compression ignition engine with fuel RON of 90, 92, 95 and engine speed of 1300, 1600, 1900rpm. The mixture gasoline and diesel fuel of 6% of the total fuel volume.

5. CONCLUSIONS

From the research that has been carried out, the following conclusions can be drawn:

1. The average power at 1900rpm engine speed from 90, 92 and 95 octane fuel respectively is 0.475 kW, 0.728 kW and 0.764 kW. There is no significant difference in power between 92 and 95 octane gasoline because the fuel's resistance to compression pressure is almost the same.
2. The specific fuel consumption shows that the highest at 1900 engine revolutions is obtained for 90 octane fuel, namely 0.92 L/kWh and the lowest is obtained for 95 octane fuel, namely 0.65 L/kWh.

6. ACKNOWLEDGEMENTS

The author would like to thank Prof. Dr. Ir. Drs. Bambang Irawan, MT as the supervisor for this research and the parents who always provide support. Don't forget, the author would also like to thank all the authors of reference articles who have shared the results of their research, so that this article can be completed well.

7. AUTHOR CONTRIBUTIONS

Conception and design: Mohammad Adam Fernanda, Bambang Irawan
Methodology: Mohammad Adam Fernanda
Data acquisition: Mohammad Adam Fernanda
Analysis and interpretation of data: Mohammad Adam Fernanda
Writing publication: Mohammad Adam Fernanda, Bambang Irawan
Approval of final publication: Bambang Irawan
Resources, technical and material supports: Bambang Irawan
Supervision: Bambang Irawan

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