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Effect of Butanol-Gasoline Blend Toward Performance Matic-Transmission Applied in Single Cylinder Capacity Engine

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Abstrak

Ketersedian bahan bakar minyak yang semakin menurun sementara tingkat konsumsi semakin meningkat. Hal ini mendorong perlunya pengembangan energi alternatif guna meminimalisir krisis. Penelitian ini melakukan investigasi tentang karakteristik bahan bakar dan motor pembakaran transmisi matic. Bahan bakar yang digunakan adalah butanol variasi B7, B12 dan B18 (7%, 12% dan 18%) dan pertalite (RON-90). Motor bensin yang digunakan berkapasitas 110 cc dengan kompresi rasio 9.5:1, sistem transmisi otomatis dan pendingin udara. Peralatan uji performa yang digunakan adalah Dynotest-chassis tipe 50L-BRT. Variasi bahan bakar diterapkan pada pengujian performa mesin menggunakan kecepatan mesin 3000-9000 rpm. Hasil penelitian menunjukkan bahwa pemakaian butanol 18% dapat meningkatkan daya output dan efisiensi termal sebesar 8.3 kW dan 923,95 kPa pada kecepatan 8000 rpm. torsi dan MEP (tekanan efektif rata-rata) mengalami peningkatan sebesar 8 N.m dan 923,95 kPa pada kecepatan 5000 rpm. Sedangkan SFC (konsumsi spesifik bahan bakar) mengalami penurunan sebesar 0.35 kg/kWh pada kecepatan 8000 rpm.

Keywords:
butanol-gasoline;
matic-transmission;
performance;
single cylinder.

Abstract

The availability of fuel oil is decreasing while the level of consumption is increasing. This encourages the need for the development of alternative energy to minimize the crisis. This study investigates the characteristics of fuel and automatic transmission combustion engines. The fuel used is butanol variations B7, B12 and B18 (7%, 12%, and 18%) and pertalite (RON-90). The gasoline engine used has a capacity of 110 cc with a compression ratio of 9.5:1, an automatic transmission system, and air conditioning. The performance test equipment used is the Dynotest-chassis type 50L-BRT. Fuel variations are applied to an engine performance test by using engine speeds of 3000-9000 rpm. The results showed that the use of 18% butanol increased the output power and thermal efficiency by 8.3 kW and 923.95 kPa at 8000 rpm. torque and MEP (average effective pressure) increased by 8 N.m and 923.95 kPa at 5000 rpm. Meanwhile, SFC (specific fuel consumption) decreased by 0.35 kg/kWh at 8000 rpm.

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1. Introduction

Butanol can reduce the level of fuel consumption in the engine. Butanol has a high-density capacity compared to standard fuels—the effect of detonation when delaying the ignition process on butanol results in a decrease in engine efficiency. Butanol capacity with high additives results in increased engine performance [1][2]. Butanol has a four-carbon group (C_4H_9OH), a biofuel fuel that can compete with ethanol and methanol. In addition, butanol can be produced at a low price; therefore, this fuel effectively produces more [3][4]. Conventional fuels injure the surrounding environment, such as gasoline and diesel. Therefore, additives are added to gasoline to reduce air pollution levels and fuel consumption in the engine. The experimental results showed that mixing butanol in gasoline resulted in a 13.7% reduction in carbon monoxide and 25.2% hydrocarbon emissions. Fuel consumption also decreased quite significantly by 8.22%. Nevertheless, the engine power output decreased by 11.1% in the butanol-gasoline mixture [5]. Adding 50% butanol to standard fuel results in higher knock and a heavier knock intensity on the engine than using a lower percentage of butanol mixture. When the fraction ratio increased by 80%, it decreased the cooling process in the combustion chamber, resulting in an increased knocking effect. The adequate pressure in the combustion chamber significantly increases the addition of butanol. Directly proportional to the specific fuel consumption, which also increases when the mass fraction of butanol is added by the fuel, but the results of the analysis of this study indicate that butanol is very efficient for use in the dual injection type in the SI engine [6].

Butanol fuel produces a more optimal knock effect and ignition timing in the SI engine. When the ignition timing increases, the pressure conditions in the cylinder and the heat release rate increase significantly in proportion to the increase in the amount of butanol; such conditions increase the engine's thermal efficiency. Cylinder pressure is affected by a mass fraction (MFB) of 50%. The release of heat when loading the engine results in an increase in engine speed. When the engine load increases, the thermal indicator also increases. The rate of combustion of gasoline-butanol varies with fluctuations in the rate of EGR rather than PG because it is influenced by oxygen capacity and temperature in the combustion chamber. The combustion chamber temperature will increase maximally due to the increased compression ratio [7]. This study adds butanol to gasoline by 10%-50% v/v—engine performance test using a speed of 2250 rpm to 4250 rpm. The throttle position uses a percentage of 30% to 70%. In this experiment, it was shown that the addition of butanol to the fuel decreased the fire propagation rate in the combustion process, thereby increasing engine speed. The effect of a 30% butanol-gasoline mixture can increase the output power and engine torque when the most negligible variation of throttle opening is in contrast to the specific fuel consumption conditions, which have decreased significantly. Exhaust emissions (CO_2, HC, and CO) using butanol variations are far more optimal than using gasoline. In contrast to NOx emissions, which increase in the use of butanol because a high octane value results in an increased combustion rate in the combustion chamber [8]. The experiment has combined gasoline (60%v/v) with butanol (40%v/v); the engine operates under WOT conditions and low speed. This experiment uses a variable fuel injection phase, ignition timing, combustion pressure, and ignition luminosity. At the time of testing, 40% butanol fuel variation increased injection duration, resulting in stoichiometry. Butanol produces the same level of performance as gasoline and can minimize the rate of incomplete combustion in the combustion chamber [9].

This study uses ABE and IBE in testing the combustion engine's performance and then compares the IBE and ABE characters which are more optimally applied to the engine. The results of the observations show that the gasoline-IBE variation produces an after-burning phase that has a shorter duration than gasoline-ABE. Gasoline-ABE produces a LaMDA of 0.8 to 1.2, a sufficient pressure of 3-5 bar, while IBE10 produces a thermal efficiency of 0.9-1.8%. Exhaust emissions of NOx, HC and CO, decreased by 1.6%-6%, 3%-25% and 0.9%-7%. Here, the butanol mixture can be used as a fuel (high octane value, low energy content and corrosion rate) [10]. Adding butanol to gasoline can reduce the temperature in the combustion chamber and increase optimal thermal efficiency. It shows that butanol is optimal for daily use in motorized vehicles. The results are shown in the use of 40% butanol at 10% WOT resulting in an increase in output power, sufficient pressure and torque. The use of butanol also results in decreased CO and NOx exhaust emissions [11][12]. They mixed butanol with gasoline 70%v/v to produce optimal engine performance. The observers' results showed that adding butanol up to 70%v/v could improve engine performance and reduce specific fuel consumption and exhaust emissions of NO because butanol is an oxygenated fuel [13]. Butanol is a fuel that has characteristics like gasoline. Variations of ethanol fuel produce more optimal engine efficiency, pressure, and output power than gasoline. The results showed that the use of butanol resulted in higher knocking combustion characteristics than ethanol [14][15].

Butanol-blended fuels (5%, 10% and 15%) are optimal alternatives fuel in SI-engine. The combustion process will be influenced by a well-balanced mixture of fuel and air entering the combustion chamber. The complete combustion process will be assisted by the installation of iridium spark plugs in the engine. The test results show that a significant increase occurs in the B15 variation of 8.15 kW at an engine speed of 8000 rpm. MEP experienced a relatively good increase of 893 kPa at an engine speed of 5000 rpm. SFC has decreased drastically by 0.36 kg/kWh at an engine speed of 8000 rpm. The use of variables such as variations in fuel and spark plugs will affect the performance of the SI engine. Future research needs to consider other variables, such as the number of cylinders, compression ratio, cylinder capacity, and ignition timing, which affect SI engine performance [16]. This research is continuous progress regarding the gasoline-butanol variation (7%, 12% and 18%), using a small capacity automatic engine of 110 cc, compression ratio 9.5:1 and air cooled. The hope of this research is that the use of butanol fuel in gasoline can produce optimal engine performance, low knocking rates and low fuel consumption.

2. Method

2.1. The comparison of fuel used.

This study investigated the addition of butanol to standard gasoline, which is shown in Table 1. Butanol is an optimal fuel, has a more competitive energy capacity and a low ignition rate. The characteristics of butanol which has a laminar density and a more optimal ignition rate compared to other fuels so that butanol has prospects as an alternative energy. In this study, three variations of the mixed fuel were tested in this study, namely B7 (7%v/v butanol and 93%v/v RON-90), B12 (12% v/v butanol and 88%v/v RON-90), B18 (18%v/v butanol and 82%v/v RON-90) and RON-90 (B0). All fuel variations will be calculated based on the mixture ratio. Butanol content can increase oxygen capacity, latent heat, and ignition rate in the combustion chamber. The density and the automatic ignition temperature increase with a slight increase in the butanol content. LCV, RON, and air/fuel stoichiometric ratio decreased with increasing butanol content. The properties of the butanol-gasoline mixture will affect the engine's performance.

Table 1. Characteristics of the Fuel Used [16][17].

Fuel Index	Butanol	RON-90
Laminar flame velocity (cm/s)	22	1
Stoichiometric AFR (-)	11	15
Vaporization Heat (kJ/kg)	716	410
AI Temperature (^{0}C)	343	294
Octan Number of Research	97	90
LHV (MJ/kg)	33	41
Density (kg/m^3)	810	733
Oxygen Level (%)	22	1

2.2. The Machine Performance Test

This study uses an automatic motor with a compression ratio of 9.5:1 with a cylinder dimension of 63.1 mm stroke length and 47 mm bore. The maximum power produced is 8.2 kW at 8.500 rpm and a torque of 9.3 N·m at an engine speed of 5.500 rpm. The clutch used is an automatic centrifugal dry type. Therefore, the engine has a fixed transmission ratio in this experiment, as shown in Table 2. Labs.

TMS is a place to test the performance of automatic vehicles, which are good recommendations. The test equipment used is a single roller chassis dynamometer with the Super-Dyno 50L type, as shown in Figure 1. Retrieval of performance data with dyno test using an engine speed of 4000-9000 rpm. The flow of performance data collection includes determining the air and fuel levels to the inlet of the combustion chamber using an injector, and the combustion process will occur after there is the ignition of the spark from the spark plug so that it has an impact on the rotation of the crankshaft due to the combustion process. Tests are observed on the chassis-dynamometer and displayed as a power or torque graph on the CPU- Super-Dyno 50L.

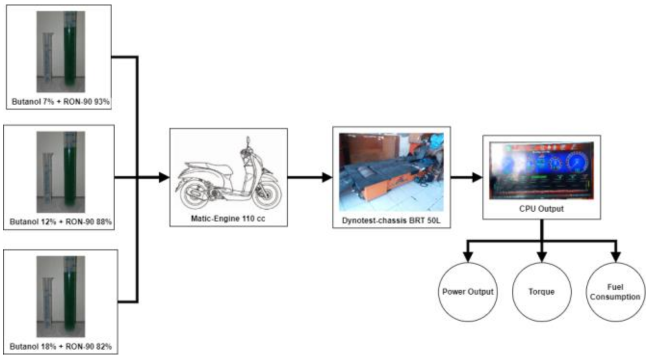

Figure 1. The Machine Performance Test.

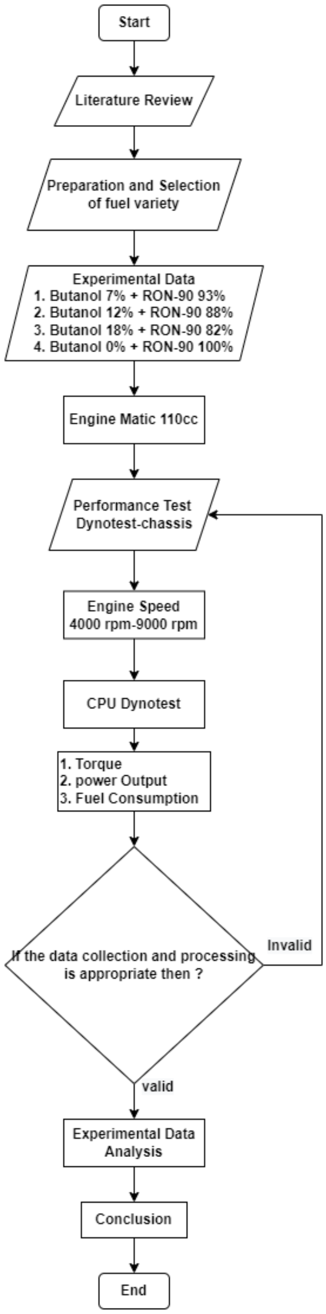

Figure 2. Process of Research.

2.3. Research Flowchart

This experiment was carried out at various engine speeds (variable speed) from 4000 rpm to 9000 rpm. The engine speed regulation is carried out through a dyno test chassis coupled to the vehicle's wheels. The following steps are taken during standard engine testing: First, start the automatic engine at idle speed (± 2000 rpm) for 10 minutes to achieve steady state or stationary conditions. Second, open the butterfly valve until it is fully open (open throttle). In this condition, the engine speed is 9000 rpm, the maximum speed of the Sinjai engine. During maximum speed, the dyno test chassis identifies power and torque. Third, if the engine speed is stable, data can be recorded, including output power, torque and fuel consumption time. Fourth, the engine speed is reduced to several stages, from 9000 rpm to 3000 rpm. Fifth, data is recorded as in point 3 (three) at each stage of decreasing engine speed. Furthermore, it must be remembered that data recording is done when the engine rotation is in a stable condition. Sixth, do the above steps by changing the fuel variations to 7%, 12%, and 18%, as shown in Figure 2. In order for the test to run smoothly, the things that need to be prepared are as follows: checking the physical condition of the engine, lubricating oil, cooling system, fuel intake system, and electrical system; checking the condition of the dyno test chassis, checking the quality of the measuring instrument to be used. Used and the blower is turned on.

3. Result And Discussion

The performance capability of a gasoline engine is determined by the amount of output power produced; the level of fuel and air intake significantly affects the capacity of the combustion process that occurs in the combustion chamber. This background has inspired researchers to focus more on analyzing the use of butanol as an alternative fuel. Figure 3 describes the importance of butanol in increasing SI-engine power. The mixture of fuel and butanol has a LCV, which causes the engine speed and combustion process to increase. Maximum power increase occurs at an engine speed of 8000 rpm of 8.23 kW. The maximum power increase in the 18% butanol mixture variation compared to the use of RON-90.

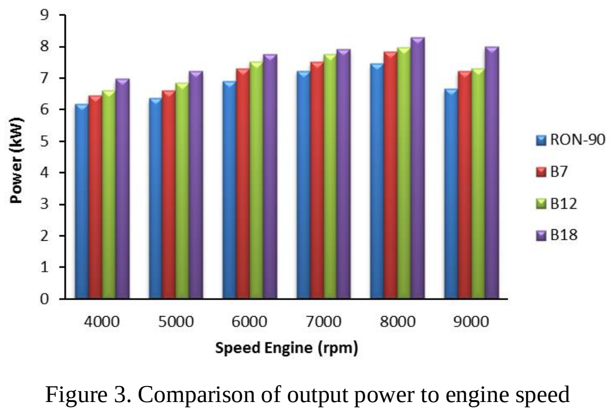

Figure 3. Comparison of output power to engine speed

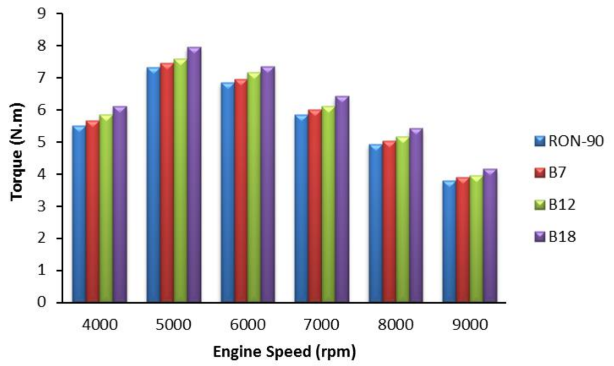

Figure 4. Comparison of torque to engine speed

Torque is a measure of the engine's ability to produce work. In everyday life, torque from the engine is helpful to overcome obstacles on the road or increase the vehicle's speed. Torque increases with engine speed, directly proportional to engine speed. However, when the engine speed reaches the range of 8000 rpm, the torque will decrease because it is affected by several losses, such as friction and high temperature. The increased engine speed causes the combustion chamber's turbulence cycle to increase so that this phenomenon can optimize the air-fuel mixture leading to complete combustion. This phenomenon increases the ignition of the fire in the combustion chamber so that the torque produced will be more optimal at high engine speeds. High friction capacity, fuel-air supply lead time, and incomplete combustion are disadvantages that often occur at high engine speeds [16][13].

Figure 4 shows that the highest maximum torque is produced on B18 fuel, with a maximum torque of 7.95 N.m at 5000 rpm engine speed. On the other hand, the slightest torque is produced by the B7 fuel variation, with a maximum torque of 7.31 N.m at 5000 rpm engine speed. On average, adding B18 butanol to the fuel will increase engine torque by 8% compared to standart fuel. It happens because adding butanol will reduce the fuel calorific. Although, in general, the addition of butanol 7%, 12% and 18% can reduce the fuel calorific, the impact that occurs is that the energy that can be released from the fuel also decreases, so the torque produced also decreases along with the engine speed of 4000-9000 rpm. The increase in torque occurs when the engine speed is 5000 rpm because in the B18 mixture the right chemical reaction occurs to produce good fuel. In addition, it can also be caused by better fuel fogging so that fuel atomization becomes better and results in complete combustion.

The amount of pressure experienced by the piston varies throughout the piston stroke. If we take a constant value pressure that acts on the piston and produces the same work, that pressure is the average adequate pressure of the piston. The torque of an engine is affected by the MEP, so the graph of the MEP is identical to the torque; with the increase in rotation, the greater the MEP. It happens because the pressure in the combustion chamber will increase with the amount of combustion. However, after reaching a certain peak point, it will decrease because the explosion produced by combustion helps generate power and is also used to overcome losses that occur [14][3].

Figure 5 shows a trend of increasing the average adequate pressure from low rpm to reaching the maximum average adequate pressure at a certain speed and then decreasing at higher engine speeds. The highest maximum adequate pressure is produced on engines that use B18 fuel with a maximum average adequate pressure of 923.95 KPa at an engine speed of 5000 rpm. The most negligible average adequate pressure produced on B7 fuel is 892.41 kPa. The addition of butanol concentrations of 7%, 12% and 18% had a decreasing average adequate pressure. It can be seen that the average effective engine pressure is the smallest on B7 fuel. The decrease in the average adequate pressure is caused by adding butanol, which reduces the calorific value. With this decrease in calorific value, the energy that can be released from the fuel also decreases, so the resulting pressure is also lower. On average, adding 7%, 12% and 18% butanol to RON-90 fuel will increase the MEP by 21% compared to standard gasoline.

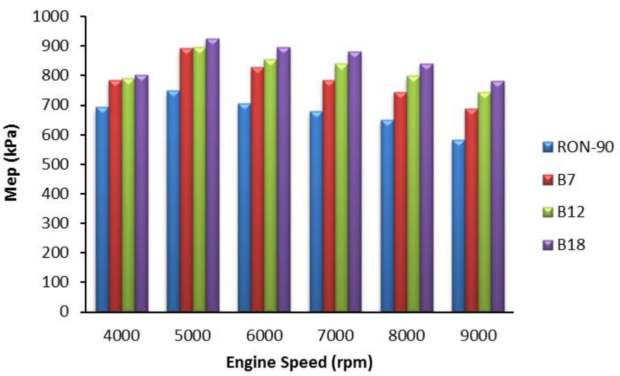

Figure 5. Comparison of MEP to engine speed

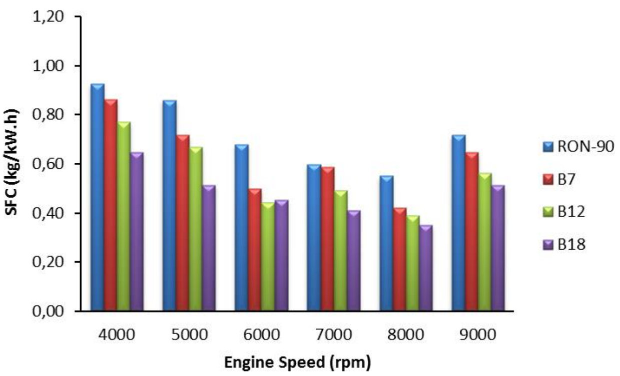

Figure 6. Comparison of SFC to engine speed

The SFC indicates the fuel-air flow capacity of the energy supply that occurs at the combustion chamber inlet. The composition of the inlet energy depends on how much fuel-air enters the combustion chamber. So the factor affecting the specific fuel consumption is the amount of power generated. In general, specific fuel consumption from low engine speed to high engine speed will decrease until it increases again at a certain engine speed [2][6]. Figure 6 shows the decreasing trend of SFC starting from low speed to reaching the optimum point at a certain speed, then when the engine speed starts to increase, and the SFC also increases in direct proportion. It is because the higher the engine speed, the higher the turbulence of the flow entering the combustion chamber, which causes the mixing of air with fuel to be better, and the fire propagation is also faster so that the SFC will decrease. Once the speed is higher, the greater the losses that occur, some of the losses that may occur at high rpm include friction and incomplete combustion. In addition, the combustion of a mixture of fuel and air in the combustion chamber also takes time. When the speed is high, it is possible that the combustion that occurs is not fast enough to burn all the fuel in the combustion chamber; in other words, more fuel is left that has not been burned in the combustion chamber (unburnt fuel). This unburnt fuel is wasted and does not become helpful energy, causing an increase in specific fuel consumption. So with the addition of butanol 7%, 12%, and 18%, the SFC produced by the engine is higher than the SFC that is capable of being produced by the engine using standard fuel. The engine's optimum SFC occurs when B18 fuel is 0.35 kg/KW.hour at 8000 rpm engine speed. On average, adding B18 to Premium fuel will reduce SFC by 57% compared to standard fuel.

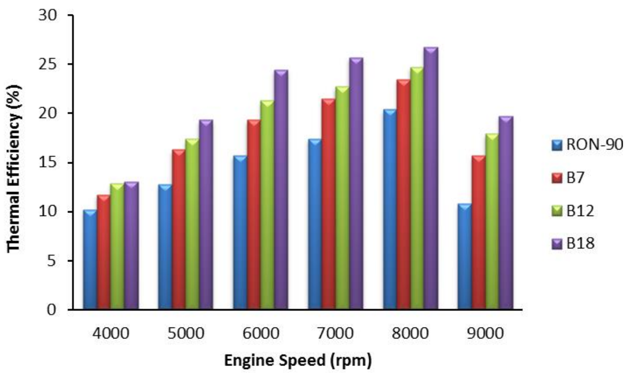

Figure 7. Comparison of thermal efficiency to engine speed

The heat stored in the fuel is converted into output power in the combustion process, which is the concept of thermal efficiency. The thermal efficiency value depends on whether or not the mixture of air and fuel is burned in the combustion chamber [11][16]. In Figure 7, the thermal efficiency of the engine speed function has a graph trend that increases from low speed to the optimum point and then decreases with increasing engine speed. At low speeds, the fuel mixing takes place less than optimally, so the combustion that occurs is less than perfect. At the optimum point, fuel turbulence and combustion time reach the best conditions for the highest efficiency. However, with the addition of engine speed that is too high, the turbulence that occurs is quite significant, so the mixing of fuel and air is good, but the combustion time is very fast, so much fuel is wasted.

The highest thermal efficiency is obtained when the engine uses standart fuel with the addition of B18 butanol by 24% at an engine speed of 8000 rpm, while the lowest thermal efficiency is obtained when the engine uses fuel with the addition of B7 butanol by 13% at an engine speed of 8000 rpm. On average, compared to using a standard fuel engine, the increase in thermal efficiency when B18 is added is 32%, while the decrease in efficiency due to the addition of B7 is 19.5%. In general, the thermal efficiency tends to decrease with the addition of 7%, 12% and 18% butanol. It is because adding butanol with this concentration can reduce the fuel calorific so that the fuel used for complete combustion is more than using gasoline. With a low calorific value, the energy released from fuel tends to decrease, so the resulting performance also tends to decrease. With a decrease in performance, efficiency will also decrease. Adding butanol with this concentration will produce the correct chemical mixture. In addition, it can also be caused by better fuel fogging so that fuel atomization becomes better and produces better combustion.

4. Conclusion

Butanol is an alternative fuel to replace gasoline for SI engines. The addition of butanol to a balanced fuel has an optimal impact on engine performance. This research concluded several essential things. The engine performance increased by using variations in B18 fuel with an engine speed of 8000 rpm; the output power and thermal efficiency increased by 10% and 24% compared to standard gasoline. Torque and average adequate pressure (MEP) increased at 5000 rpm engine speed with B18 consumption of 8% and 19% compared to standard gasoline. Specific fuel consumption (SFC) has decreased at an engine speed of 8000 rpm with the use of B18 by 57% compared to standard gasoline. Future research can analyze the high butanol variation, the use of large compression ratios, multi-cylinder engines and larger engine capacities.

Acknowledgments

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