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ANALYSIS OF THE PERCENTAGE OF CORN COB BIOETHANOL VOLUME WITH 92 OCTANE FUEL IN GASOLINE ENGINES

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ABSTRACT

One way to improve the performance of gasoline engines is by using bioethanol, which can enhance combustion efficiency. Bioethanol, a renewable fuel derived from the fermentation of plant materials, can be blended with traditional fossil fuels to create a more efficient and environmentally friendly fuel alternative. The combination of fossil fuel and fermentation-derived fuel has a significant impact on the overall performance and emissions of the engine. The aim of this study is to determine the magnitude of changes in torque and power when a gasoline engine is fueled with a mixture of corn cob bioethanol and pertamax. Additionally, specific fuel consumption will be determined to evaluate the fuel efficiency. The engine used in this study is a 150cc gasoline motor, a common size for motorcycles and small vehicles. The testing variables include engine speed variations from 2000 to 9500 rpm using bioethanol blends of 5%, 10%, and 15% with 92 octane fuel. The data collected from these tests is calculated mathematically. The results of the study show the largest increase in power at 0.45 horsepower at 2500 rpm and torque at 2.82 Nm at 2500 rpm when using the BE15% fuel blend, indicating a notable enhancement in engine performance with higher bioethanol content. Furthermore, the smallest decrease in fuel consumption was recorded at 0.1739 kg per horsepower, highlighting the efficiency benefits of bioethanol blends. Overall, the engine performance improves when using a blend of 92 octane fuel with bioethanol compared to pure 92 octane fuel. This suggests that incorporating bioethanol into gasoline can not only improve power and torque but also enhance fuel efficiency, making it a viable option for reducing dependency on fossil fuels and lowering emissions.

Keywords Power; Torque; Fuel Consumption; 92 Octane; Bioethanol
Paper type Research paper

INTRODUCTION

According to information obtained from the Central Statistics Agency (BPS), there was a 75.76% decrease in the value of Indonesia's oil exports in May 2020. This fact can be interpreted as a result of increased public demand for fuel, driven by the high number of vehicles operating on the roads, especially motorcycles. Currently, Indonesia's petroleum stock is only at 3.77 billion barrels, with an estimate that this amount will only be sufficient for approximately nine years ahead. Therefore, the importance of developing alternative fuels becomes increasingly evident [1].

The remaining disposal of organic waste, especially consisting of unused vegetables, leaves, paper, fruit peels, and food leftovers, creates a problem of waste accumulation. One alternative solution to address waste accumulation is through the process of biocorversion. In this method, waste is converted into fuel by involving microorganisms. This process is similar to the production of bioethanol. Bioethanol is ethanol derived from living organisms; in this case, plant-based materials such as corn cobs, wheat, potatoes, and sugarcane are used in the process [2].

The production of bioethanol is carried out through the fermentation process. Bioethanol is highly flammable and has a calorific value of 21 MJ/liter [3], [4]. Bioethanol serves as an octane booster in vehicle engines, improving the combustion process in gasoline engines. The properties of bioethanol as a fuel include lower pollutant emissions, a cooler combustion compared to fossil fuels, and high fuel efficiency. Due to these characteristics, the combustion that occurs can reduce the effects of detonation in gasoline engines. Additionally, bioethanol has a high oxygen content, reaching 35%, and an octane rating of 108, making it capable of producing more complete combustion.

On the other hand, Pertamax is a type of fossil fuel produced through a distillation process with a Research Octane Number (RON) of 92. Therefore, its use is intended for gasoline engines with compression ratios ranging from 9:1 to 10:1. The advantage of using 92 octane fuel is its ability to reduce carbon dioxide (CO2) emissions. Additionally, with the presence of anti-rust content in Pertamax, it can clean the internal parts of the engine and protect the fuel tank from rust [5][6][7]. Research on the use of a blend of bioethanol with premium fuel [8], focusing on motorcycles using bioethanol from sugarcane sap without specifying the engine capacity, concludes that when using premium fuel, the maximum torque occurs at 7000rpm at 5.20Nm, with a power of 4.30hP. When using a blend of 25% bioethanol with premium, it produces a torque of 4.37Nm at 7000rpm and a power of 4.79hP at 9000rpm. The situation is different when using a blend of 50% bioethanol with premium, resulting in a torque of 5.27 Nm at 7000rpm and power of 4.93 Hp at 8000rpm. A blend of 75% bioethanol with premium fuel produces a torque of 4.23 Nm at 7000rpm and a power of 4.97hP at 9000rpm.

In another study [6], [9], the research focused on mixtures such as 930ml Pertalite with 70ml bioethanol, 880ml Pertalite with 120ml bioethanol, 830ml Pertalite with 170ml bioethanol, and 780ml Pertalite with 220ml bioethanol. The conclusion was that the highest torque, 8.61Nm at 1000rpm, was achieved using a 12% bioethanol fuel blend. The highest power was obtained with Pertalite fuel at 6.97 hP, and when using a 12% bioethanol blend with Pertalite, the power reached 7.60 hP standard. Research on mixtures of Pertalite fuel with added bioethanol in a 2011 injection engine resulted in the highest and most stable torque when using a blend of E15 or 85% Pertalite, producing 15.08 Nm at 7500 rpm. The highest power occurred at 8500rpm with a power output of 17.14 kW [1].

The content of corn cobs consists of 48% cellulose, 36% pentosan, 10% lignin, 4% ash, and 2% water. It is an agricultural waste with the potential to be converted into glucose through the fermentation process, capable of producing bioethanol [4], [10]. Research on the mixture of fossil fuels with bioethanol derived from various raw materials is continuously being developed. However, the use of bioethanol derived from corn cobs remains an interesting subject of study due to the high starch and cellulose content in corn cobs. Additionally, there is still limited literature showing the results of bioethanol mixtures with Pertamax fuel, which has a higher octane rating. The purpose of this study is threefold. First, corn cobs are an abundant agricultural waste in Indonesia, yet they are still not fully utilized. By converting this waste into bioethanol, we can reduce agricultural waste and create added value from previously unutilized resources. Second, this research is important for understanding the potential of corn cob bioethanol as an environmentally friendly and sustainable alternative fuel. By increasing knowledge about the performance of this mixture, we can develop more sustainable energy solutions for the future. Third, this research can provide insights into the economic, social, and environmental impacts of using corn cob bioethanol on a larger scale. Thus, research on the mixture of Pertamax with bioethanol from corn cobs is crucial for expanding our understanding of renewable energy potential and steering us towards more sustainable energy solutions. This research focuses on finding a blend of 92-octane fuel with bioethanol derived from corn cobs that can yield optimal performance in gasoline engines. The performance of a gasoline engine includes power, torque, fuel consumption, average effective pressure, efficiency, and exhaust gas emissions. However, in this discussion, the focus is limited to power, torque, and fuel consumption [5], [11].

METHOD

The parameters of this research are power, torque, and specific fuel consumption. Power is the energy produced by the engine during one cycle per unit of time. Specific fuel consumption is the amount of fuel required by the engine to operate for one hour for a mass of one kilogram [5], [12]. The energy used comes from 92-octane fuel (standard) and a mixture of 92-octane fuel with a volume percentage of 95% and 5% corn cob bioethanol (BE 5). This means that in 1000ml of the mixture, there are 950ml of 92-octane fuel and 50ml of corn cob bioethanol. The other mixtures include a blend of 92-octane fuel with a volume percentage of 90% and 10% corn cob bioethanol (BE 10), and a blend of 92-octane fuel with a volume percentage of 85% and 15% corn cob bioethanol (BE 15).

The performance testing was conducted on a 4-stroke, single-cylinder, 150cc gasoline engine with the full valve opening method following ISO 1585 testing standards to obtain engine rotation data. Torque measurement was performed using a chassis dynamometer. The research was carried out at Politeknik Negeri Malang. The data was mathematically calculated and analyzed using analysis of variance (one-way ANOVA) with a 95% confidence level.

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There are two variables in the research: independent variables consisting of power, torque, and fuel consumption, and dependent variables including 92-octane fuel with bioethanol mixtures of 5%, 10%, and 15%, as well as engine rotations controlled at 2000, 2500, 3000, up to 9500 rpm [5], [12].

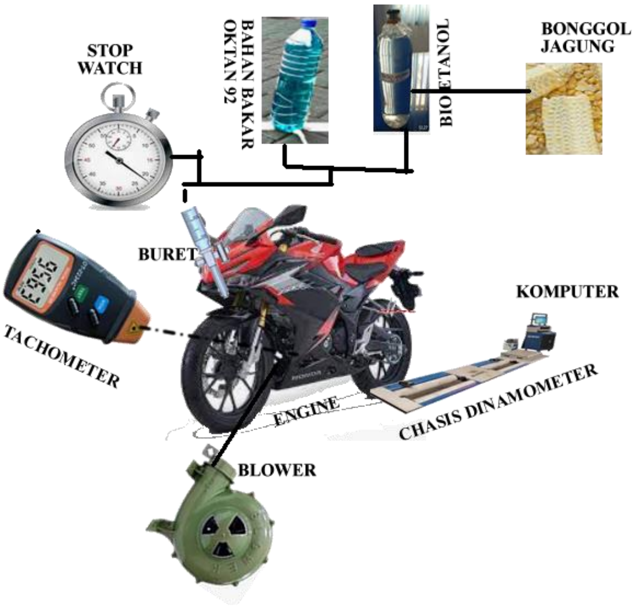

Figure 1. Research data scheme

TABLE I. ENGINE SPECIFICATION

Engine Type	4 stroke, SOHC
Bore	57,0 mm
Stroke	58,7 mm
Compression Ratio	9,3 : 1
Maximum Power	11,39 kW / 8500 rpm
Maximum Torque	13,80 Nm / 7000 rpm
Transmission	6 kecepatan

TABLE II. GASOLINE CHARACTERISTIC

Characteristic	Unit	Pertamax	Bioethanol
Research octane number	-	92	108.6
Stoichiometric air-fuel ratio by mass	-	14.6	9.00
Formula (liquid)	-	C_8H_{18}	C_2H_5OH
Molecular weight	kg/kmol	114.15	46.07
Specific heat (liquid)	kJ/kg.K	2.4	1.7
Specific heat (vapour)	kJ/kg.K	2.5	1.93
Density	kg/m^3	765	785
Lower heating value	kJ/kg	44.000	26.900
Heat of vaporization	kJ/kg	305	840

DISCUSSION

The magnitude of power changes for each variation of engine speed is presented in Table 3 when using a blend of 92-octane fuel with corn cob bioethanol at 5% (BE 5), 10% (BE 10), and 15% (BE 15).

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TABLE III. TEST RESULTS

RPM	RON 92		BE 5		BE 10		BE 15	
	HP	Nm	HP	Nm	HP	Nm	HP	Nm
2000	1,36	9,33	1,44	9,98	1,39	9,38	1,56	11,37
2500	4,33	10,66	4,51	11,51	4,35	11,37	4,68	13,48
3500	5,79	10,93	5,81	11,89	5,42	11,94	5,72	13,54
4500	7,45	11,56	7,61	12,27	7,20	11,74	7,45	13,00
5500	8,92	11,42	9,17	12,23	8,28	11,33	9,10	12,26
6500	10,26	10,62	10,38	10,96	9,67	10,06	10,71	11,59
7500	10,57	9,77	10,57	10,15	9,62	9,50	10,57	10,55
8500	9,49	8,87	10,02	9,97	9,12	9,22	10,17	10,05
9500	9,44	8,12	9,65	9,34	8,59	8,63	9,22	9,72

In general, based on the obtained data, the addition of bioethanol can result in higher power and torque compared to using pure 92-octane fuel (8)-(11). This condition is influenced by the increased combustion energy, leading to a more complete combustion. The data obtained is discussed separately for power, torque, brake mean effective pressure (BMEP), and specific fuel consumption (SFC).

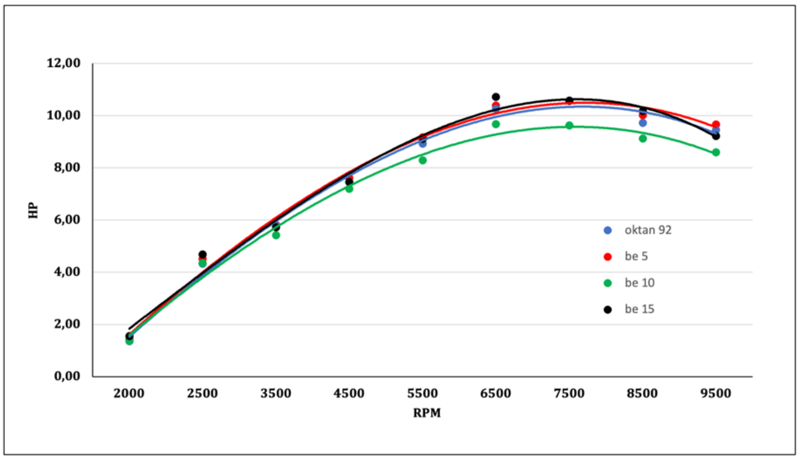

Figure 2. Showing power vs RPM

From figure 2, the comparison between Power and RPM reveals that the highest power values occur at 6500 rpm for all types of fuel mixture variants. When using a 10% and 5% bioethanol mixture, the respective power outputs are 9.67 hp and 10.38 hp. Meanwhile, for fuel without mixture, the power output is 10.26 hp. The highest power is generated when using a 15% bioethanol mixture at 10.71 hp. This is because there is an increase in the octane value in the fuel mixture, effectively increasing the overall average power at various engine speeds.

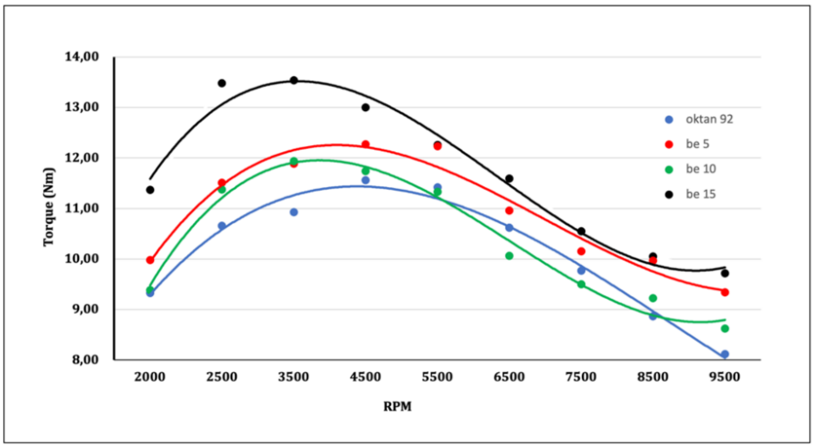

Figure 3. Showing torque vs RPM

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From figure 3, the comparison between Torque and RPM yields more diverse data. When using pure Pertamax, the peak torque is obtained at 4500 rpm with a torque of 11.56 Nm. At the same rpm, the torque values obtained for 5%, 10%, and 15% BE are 12.27 Nm, 11.74 Nm, and 13 Nm, respectively. This is due to the increase in the octane value when mixed with Pertamax, consistent with the theory that an increase in octane value will result in greater torque. The torque characteristics of this fuel mixture show different results regarding peak torque values. The maximum torque value for 5% BE is obtained at 4500 rpm with 12.27 Nm, for 10% BE it is obtained at 3500 rpm with 11.94 Nm, while for 15% BE it is obtained at 3500 rpm with 13.54 Nm. These characteristics are due to bioethanol's cooler combustion effect, reducing knocking at lower rpms and improving combustion at lower rpms. Overall, the torque values generated when using a bioethanol fuel mixture experience an increase.

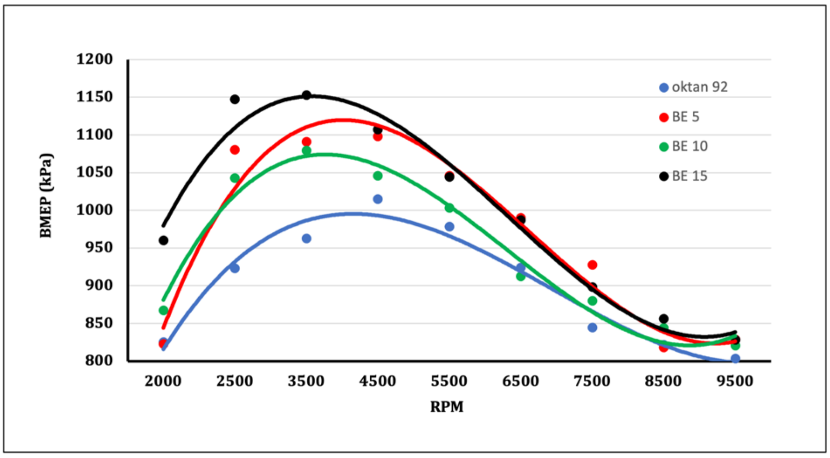

Figure 4. Showing BMEP (brake mean effective pressure) vs RPM

From figure 4, the comparison between BMEP and RPM reveals that the BMEP values exhibit characteristics similar to the torque values shown in figure 3. The highest BMEP for pure fuel occurs at 4500 rpm, measuring 1015 kPa. When using 5% BE, the highest BMEP obtained is 1098 kPa at 4500 rpm. The use of a fuel mixture with 10% BE is able to produce the highest BMEP of 1079 kPa at 3500 rpm. Meanwhile, when using a fuel mixture with 15% BE, the highest BMEP obtained is 1153 kPa at 3500 rpm. Overall, the BMEP values obtained when using a bioethanol fuel mixture are higher. Additionally, BMEP has a strong correlation with torque values because BMEP mathematically derives from torque values, thus its characteristics are similar to torque testing.

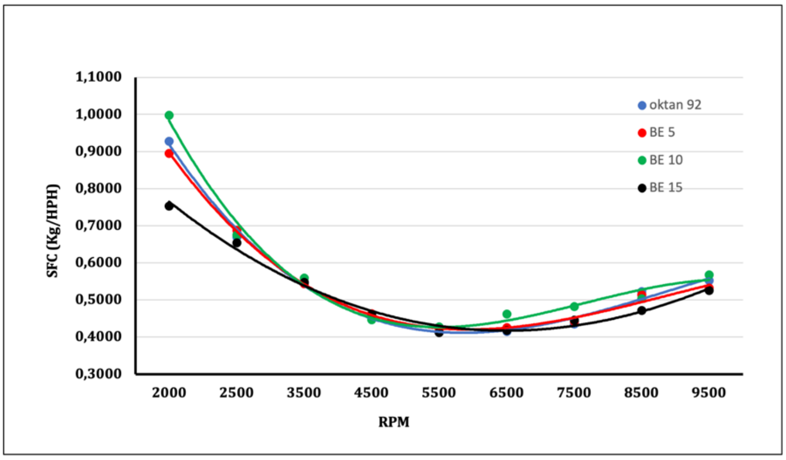

Figure 5. Showing SFC (spesific fuel consumption) vs RPM

From figure 5, the comparison between SFC and RPM shows that at 2000 rpm, the lowest SFC value occurs when using a fuel with a 15% BE mixture, at 0.75 Kg/hP.H. At the same rpm, the SFC values for pure Pertamax, 5% BE, and 10% BE are 0.92 Kg/hP.H, 0.89 Kg/hP.H, and 0.99 Kg/hP.H,

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respectively. The lowest SFC values produced by all fuel mixture variations occur at 5500 rpm, with values for Pertamax, 5% BE, 10% BE, and 15% BE being 0.4129 Kg/hP.H, 0.4167 Kg/hP.H, 0.4271 Kg/hP.H, and 0.4124 Kg/hP.H, respectively. At this rpm, the lowest value occurs when using 15% BE. At 2000 rpm, the engine speed is still slow, so combustion efficiency has not been achieved. Combustion efficiency is achieved at 5500 rpm, which can produce the lowest overall SFC value. Consistent with the increase in octane value, it results in better SFC values compared to using pure Pertamax.

Conclusion

The overall test results indicate that a fuel mixture consisting of Pertamax with an octane number of 92 and bioethanol shows varying outcomes. The best results are obtained when using a 15% bioethanol mixture. The optimal power is 10.71 hp, torque is 13.54 Nm, BMEP is 1153 kPa, and SFC is 0.4124 Kg/hP.H. This is because a 15% volume ratio of bioethanol is capable of increasing the octane value of the fuel mixture overall, resulting in an octane rating of 95. Furthermore, tests conducted using an engine with a compression ratio of 9.3:1, where theoretically the fuel used should have a minimum octane rating of 90. This study demonstrates that a bioethanol blend with Pertamax is effective in increasing power, torque, average pressure, and specific fuel consumption due to the increased octane value of the fuel mixture. Additionally, bioethanol has the characteristic of easy ignition, so even though the engine used has a compression ratio of 9,3 : 1, the use of this fuel mixture does not diminish the ability to ignite.

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