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An Experimental Study on Influence of Injection Timing Variations on Diesel Engine Performance Using Dexlite and Cooking Oil Blends

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A B S T R A C T

This study aims to analyze the effect of firing point variations on the performance of the S195 type diesel engine using a mixture of Dexlite fuel and cooking oil. The firing point variations used were 17°, 18°, and 19° before TDC, with the fuel mixture containing 30% cooking oil. Tests were conducted to measure thermal efficiency, specific fuel consumption (SFC), and engine output power. The results showed that proper firing point settings can increase thermal efficiency and decrease SFC, especially at an angle of 18°, where the highest thermal efficiency was 24.80% and the lowest SFC was 0.342 kg/kWh. In addition, the use of this mixed fuel was able to provide more perfect combustion than pure Dexlite fuel. The conclusion of this study suggests the need for good engine maintenance and proper injection timing to improve the performance of diesel engines based on mixed fuel, as well as an effort to utilize cooking oil as a renewable energy source.

Keywords: Firing point, Diesel engine, Thermal efficiency, SFC, Engine performance

Article History
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1. Introduction

The rapid development of railways has made this mode of transportation the primary choice. This led to coal-fired locomotives being phased out and replaced by diesel-powered locomotives. The history of diesel engines in railways began in the early 20th century as a solution to improve efficiency and reduce dependence on coal-fired locomotives, which had previously dominated the industry. Diesel engine is a type of internal combustion engine that uses diesel fuel as its main fuel supply. Diesel fuel is a refined petroleum product that boils at around 175-370°C and is used as fuel for diesel engines [1-3], meanwhile Dexlite is a type of diesel fuel with a minimum cetane number of 51 and a maximum sulfur content of 1200 ppm.

In Indonesia, not everyone can buy diesel fuel due to restrictions on its purchase, so dexlite has become the primary choice even though it is much more expensive. The cetane number affects the price of dexlite, which is more expensive than diesel fuel, because the cetane number greatly affects the quality of diesel fuel. The higher the cetane number of a diesel fuel, the more expensive it is.

To overcome this problem, a mixture is needed to reduce the cost of using dexlite. One of them is by using cooking oil as a mixture for dexlite because Indonesia has abundant palm oil reserves, resulting in cheap and easily available cooking oil. Cooking oil itself is oil derived from purified vegetable or animal fat in liquid form, which is commonly used for frying [4].

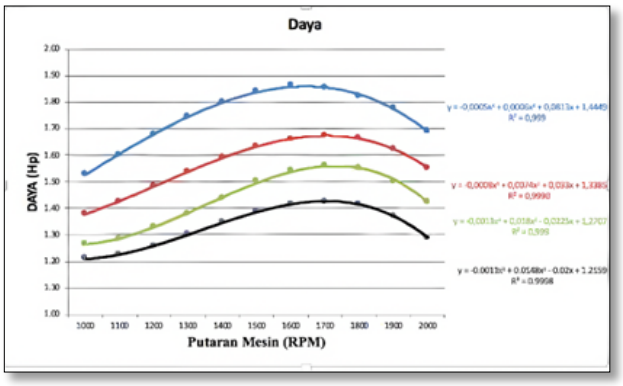
In engine performance testing, several aspects influence the operation of a diesel engine in order to produce optimal diesel engine performance. One of them is about fuel injection duration (Timing injection). The duration of fuel injection greatly affects combustion quality, resulting in maximum engine power and

optimal fuel economy. Injecting fuel too early causes combustion to be slow due to the low air temperature at this point. The diesel engine will run roughly and noisily due to delayed combustion, resulting in wasted fuel and excessive smoke in the exhaust. A delayed fuel injection cycle causes combustion to occur in some of the fuel when the piston has far exceeded TMA and the engine loses power. As a result, the motor will not generate maximum power, but fuel consumption will become wasteful [5-6].

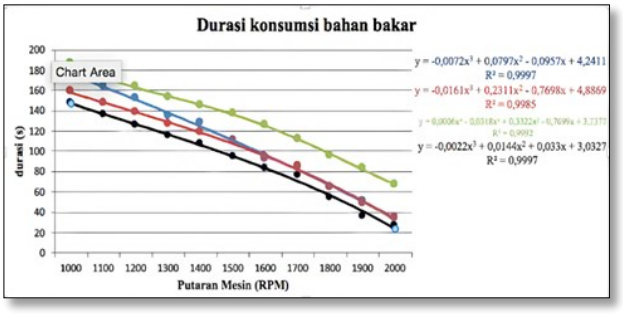
Researched by [7] the effect of changes in fuel injection angle on the performance of diesel engines for generators. Various injection angle tests were conducted using 65°, 55°, 45° (original diesel engine variation), and 35°, with each test using 50 ml of fuel. The injection angle parameter was created to obtain different results in terms of power, RPM, and fuel consumption. The results of the test showed that the highest power output was 1.86 HP at variation 1 at 1600 RPM. The lowest power output is 1.27 HP at variation 3 at 1000 RPM. The longest fuel consumption was 187 s at variation 3 at 1000 RPM. Then, fuel consumption with the fastest duration was 27 seconds in variation 4 at 2000 RPM (can be seen in Figure 1.).

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(a)



(b)

Figure 1. (a) Power comparison. (b) Fuel consumption duration comparison.

Based on the above description, an experimental study will be conducted on the effect of changes in the firing point on an S195 diesel engine fueled by a mixture of dexlite and cooking oil. This experimental study aims to determine the engine performance, particularly in terms of SFC and thermal efficiency, produced by variations of 17°, 18°, and 19° before Top Dead Center.

2. Experimental Methods

The method used in this study was experimental research aimed at finding the best firing point change from a mixture of dexlite fuel and cooking oil. The experiment was conducted in a laboratory with appropriate material mixture conditions. This study used quantitative descriptive analysis to provide an overview of the results of the comparison of changes in firing point against SFC and thermal efficiency.

2.1 Fuel blending

This process is carried out by mixing dexlite fuel and untreated cooking oil in a ratio of 30% cooking oil to 70% dexlite. Cooking oil to be used as a mixture, namely the Sunco brand. This test was conducted at Building D of the Madiun State Polytechnic.

2.2 Fuel Testing

This stage involves testing the properties of dexlite and cooking oil fuel blends, including viscosity values, which will be tested at the Combustion Engine Laboratory, Brawijaya University, and calorific values at the Integrated Laboratory, Diponegoro University.

2.3 Machine Performance Testing

The tests were conducted by changing the firing point by 17°, 18°, and 19° before TMA. metode yang digunakan untuk mengubah firing point dengan menggunakan kertas packing yang dibentuk sesuai dengan mesin yang berada di boshpump.

3. Results and Discussion

3.1 Fuel Mixing Results

Visual observation of Figure 2 shows no specific color differences compared to pure dexlite itself.. Then there is no dividing line between the two materials, or it can be said that they are perfectly mixed even though the mixing process was done without treatment.



Figure 2. Mixture of dexlite and cooking oil

3.2 Fuel Mixing Results

The fuel to be tested for data properties is only a mixture of dexlite and cooking oil. The data to be tested includes kinematic viscosity, density, and heat value, which can be seen in Figure 3.



(a)

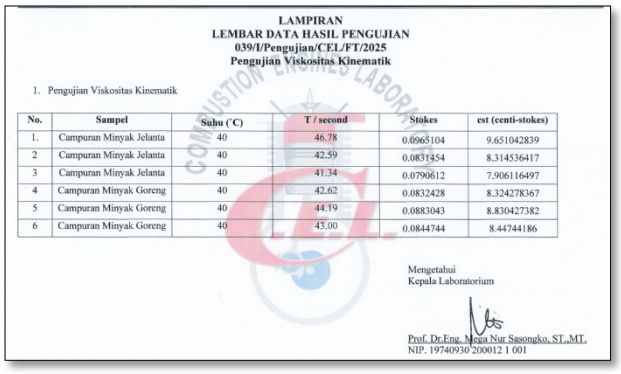


LAPORAN HASIL UJI (LHU)
No. Seri : 2025 – 0731

No	Nama Sampel Uji	Parameter	Satuan	Nilai Hasil Analisis	Metode Uji (SNI)/Alat	Keterangan
1.	SP 25-0888-18-01-1 (Dex-Minyak goreng)	Nilai Kalor	Cal/g	10.132,00	Parr Bomb Calorimeter 6400	-
2.	SP 25-0888-18-01-2 (Dex-jelantah)			10.068,00		

(b)

Figure 3. (a) Mixture of dexlite and cooking oil. (b) Calorific value test results



LAMPIRAN
LEMBAR DATA HASIL PENGUJIAN
039/I/Pengujian/CEL/FT/2025
Pengujian Viskositas Kinematik

1. Pengujian Viskositas Kinematik

No.	Sampel	Suhu (°C)	T / second	Stokes	cst (centi-stokes)
1.	Campuran Minyak Jelanta	40	46.78	0.0965104	9.651042839
2	Campuran Minyak Jelanta	40	42.59	0.0831454	8.314536417
3	Campuran Minyak Jelanta	40	41.34	0.0790612	7.906116497
4	Campuran Minyak Goreng	40	42.62	0.0832428	8.324278367
5	Campuran Minyak Goreng	40	44.19	0.0883043	8.830427382
6	Campuran Minyak Goreng	40	43.00	0.0844744	8.44744186

Mengetahui
Kepala Laboratorium

Prof. Dr.Eng. Mega Nur Sasongko, ST.,MT.
NIP. 19740930 200012 1 001

(c)

Figure 3. (a) Density test results (b) Kinematic viscosity test results (c) Heat value test results

3.3 Performance Results of Diesel Engines Running on a Mixture of Dexlite Fuel and Cooking Oil

This stage involves testing the diesel engine by changing the firing point to 17˚, 18˚, and 19˚. Then, calculating data such as thermal efficiency and SFC.

3.3.1 Thermal Efficiency Comparison Results (%)

The trend line from the graph in Figure 4 shows that the thermal efficiency of all variations tends to increase as the load on the engine increases. It can be seen that the highest thermal efficiency is found in the firing point variation of 18˚ for a mixture of dexlite fuel and cooking oil with a load of 3000 watts, amounting to 25.12%.

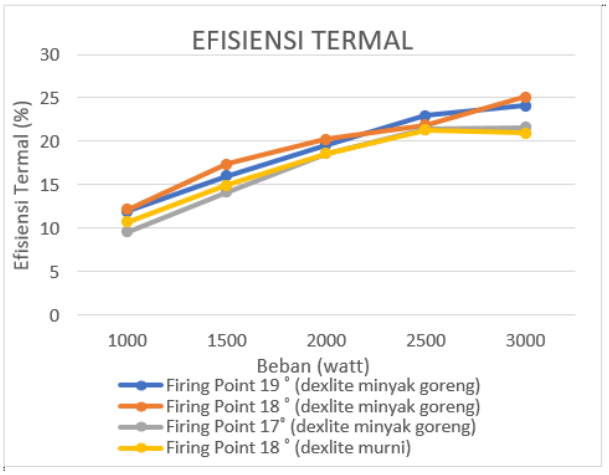
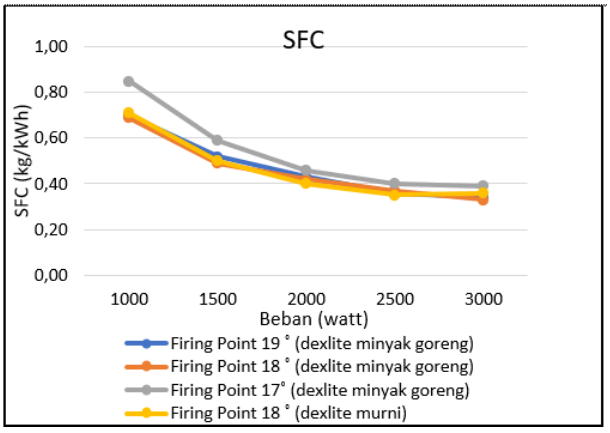


Figure 4. Thermal Efficiency Comparison Chart

3.3.2 SFC Comparison Results (kg/kWh)

The trend line from the graph in Figure 5 shows that SFC for all variations tends to decrease as the load on the engine increases. It can be seen that the lowest SFC is found in the firing point variation of 18˚ for a mixture of dexlite fuel and cooking oil with a load of 3000 watts of 0.33 kg/kWh.

Figure 5. SFC Comparison Chart



4. Conclusion

Based on the results of the study, it can be concluded that the standard firing point or firing point 18˚ produces the highest thermal efficiency of 25.12% and the lowest SFC of 0.33 kg/kWh at a load of 3000 watts, which is the most optimal firing point among the others. The use of cooking oil in dexlite mixtures can also produce better combustion compared to pure dexlite. In addition, proper firing point settings greatly affect engine efficiency, so that proper injection timing settings can result in optimal engine performance and the use of cooking oil as a fuel efficiency enhancer for dexlite.

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