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Trends in Mechanical Engineering Research

THE IMPACT OF DIFFERENT CONVERTER KIT TYPES ON THE PERFORMANCE OF A DIESEL ENGINE UTILIZING BIOSOLAR AND LPG FUEL

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Graphical abstract

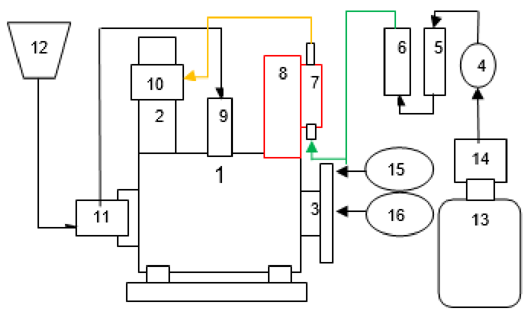

Figure 1. Experiment setup tools

Caption :
Diesel Engine, 2. Intake manifold, 3. Output Shaft, 4. Pressure Gauge, 5. Thermometer, 6. Gas Flowmeter, 7. Gas Heater Kit, 8. Exhaust Channel, 9. Fuel Injector Nozzle, 10. Air/LPG Mixing Chamber, 11. Injector Pump, 12. Measuring Cup, 13. Gas Tank, 14. High-Pressure Gas Regulator..

Article history
Received
11 December 2023
Received in revised form
13 December 2023
Accepted
20 December 2023
Published
25 December 2023

Abstract

The impact of the converter kit type on the performance of diesel engines using biodiesel and LPG fuel has been explored. Converter kits play a vital role in transforming the fuel supply system, and experiments have been conducted to assess their influence on various engine performance parameters. The findings of the study indicate that the selection of a converter kit significantly affects the performance of dual-fuel diesel engines (biodiesel and LPG). Gas Heater converter kits, including type 1, type 2, and type 3 variations, were scrutinized in this research. Testing revealed variations in LPG-Biodiesel fuel mixing ratios depending on the type of converter kit employed. For instance, Gas Heater type 3 achieves the highest value with a mixing ratio of 14.4. Furthermore, the performance of the engine in terms of power and torque is also impacted by the type of converter kit utilized. Gas Heater type 1 exhibits peak performance, with power reaching 5.4 kW and torque measuring 34.81 Nm. Despite the operational costs of dual-fuel diesel engines tending to be higher than those using pure biodiesel, the research concludes that the choice of the converter kit type can have a substantial effect on engine performance, particularly regarding fuel efficiency.

Keywords: Converter Kit, performance, diesel engine, Lpg, biodiesel

Abstrak

Pengaruh jenis konverter kit terhadap kinerja mesin diesel yang menggunakan bahan bakar biosolar dan LPG telah diinvestigasi. Konverter kit memainkan peran krusial dalam mengubah sistem suplai bahan bakar, dan pengujian dilakukan untuk mengevaluasi dampaknya terhadap beberapa parameter kinerja mesin. Hasil penelitian menunjukkan bahwa pilihan konverter kit memiliki pengaruh yang signifikan terhadap performa mesin diesel dengan bahan bakar dual (biosolar dan LPG). Dalam penelitian ini, konverter kit Gas Heater dengan variasi tipe 1, tipe 2, dan tipe 3 dievaluasi. Pengujian mengungkapkan perbedaan dalam rasio pencampuran bahan bakar LPG-Biosolar berdasarkan jenis konverter kit. Sebagai contoh, Gas Heater tipe 3 mencapai nilai tertinggi pada rasio pencampuran sebesar 14,4. Selain itu, performa mesin dalam hal daya dan torsi juga dipengaruhi oleh jenis konverter kit yang digunakan. Gas Heater tipe 1 menunjukkan hasil puncak dengan daya mencapai 5,4 kW dan torsi sebesar 34,81 Nm.Meskipun biaya operasional mesin diesel dual fuel cenderung lebih tinggi daripada mesin yang menggunakan biosolar murni, kesimpulan dari penelitian ini menyoroti bahwa pemilihan jenis konverter kit dapat memiliki dampak yang substansial pada kinerja mesin, terutama dalam hal efisiensi bahan bakar..

Kata kunci: Konverter Kit, kinerja, mesin diesel, Lpg, biosolar

DOI: http://dx.doi.org/10.62870/timer.v1i2

1.0 INTRODUCTION

Biosolar Diesel engines, also known as compression-ignition engines, are internal combustion engines that use heat generated through compression to ignite and combust fuel injected into the combustion chamber. Biosolar [1], fundamentally falls into the category of alternative fuels created or produced through a combination of fossil fuel, namely diesel fuel, and organic materials referred to as biomass. This biomass can include palm oil, plant waste, or organic waste [2]. Recent restrictions on oil fuel subsidies have led to various issues, particularly concerning diesel fuel, which is now subject to sales limitations. This situation has a significant impact on society. The fuel consumption value (fc), an economic parameter measuring the fuel usage per hour by the engine, becomes crucial. Lower fc prices indicate higher efficiency levels [3], [4].

Dual-fuel diesel or Diesel Dual Fuel engines are conventional diesel engines with an additional fuel supply in the air intake, and fuel ignition is carried out by a fuel injector [5]. In simple terms, the use of liquid or gas fuel can be regulated by opening holes in the diesel engine's air intake manifold [5], [6].

The principle behind the Gas Heater converter kit is to utilize the heat generated by the engine through the exhaust gas channel. The temperature increase in the Gas Heater kit leads to a rise in the temperature of the LPG gas flowing through the Gas Heater channel. This facilitates the optimal combustion of LPG gas. The Gas Heater temperature follows the exhaust gas temperature of the engine [7].

Therefore, researchers are working to explore the potential of alternative energy development by employing a dual-fuel diesel system equipped with a simple Gas Heater converter kit. With this dual-fuel system, it is expected to provide alternatives that help address fuel-related issues, especially those triggered by subsidy restrictions and oil fuel sales. Thermal efficiency is measured as a parameter to evaluate the effectiveness of utilizing heat to generate power after the combustion process..

2.0 METHODOLOGY

2,1, Materials

The instruments used in the experiment involve a 7 hp Dong Feng diesel engine with a speed of 2600 rpm, a single-block brake instrument for stopping, a load cell unit with its display as a braking load indicator, a digital tachometer, a gas flow meter, and a thermometer equipped with a measuring cup. Additionally, for the completeness of the converter unit, it includes gas hoses, a regulator, and connecting clamps.

2,2, Experiment Setup

The initial step of the research begins with the fabrication of a Gas Heater using copper pipes and copper fibers, along with red bricks as the main materials for the Gas Heater. This process is then followed by modifications to the engine's suction channels to create a space for air and gas mixture. All instruments are assembled into a unified system, following the scheme outlined below ;

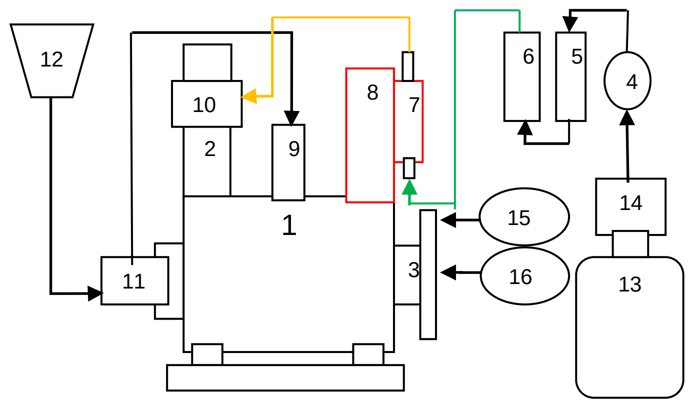

Figure 1. Experiment setup tools

Caption :

Diesel Engine, 2. Intake manifold, 3. Output Shaft, 4. Pressure Gauge, 5. Thermometer, 6. Gas Flowmeter, 7. Gas Heater Kit, 8. Exhaust Channel, 9. Fuel Injector Nozzle, 10. Air/LPG Mixing Chamber, 11. Injector Pump, 12. Measuring Cup, 13. Gas Tank, 14. High-Pressure Gas Regulator..

The testing begins by starting the engine with a 15-minute warm-up period. Then, observe the initial engine speed before adding LPG. The addition of LPG is done gradually with a pressure of 6 Psi until the maximum speed is reached without knocking. Next, observe the increase in speed that occurs and monitor the flow rate of LPG on the flow meter. Perform a gradual shutdown until the engine stops operating. Observe the magnitude of the load achieved on the load cell display. Continue the test by running the engine for 5 minutes to measure the consumption of biodiesel fuel in dual-fuel conditions.

3.0 RESULTS AND DISCUSSION

3.1 Dual Fuel Mass Ratio

From the research data, the highest ratio value was achieved utilizing a Gas Heater Converter Type 3. The values recorded were 2.75 at 700 rpm, 6.38 at 1000 rpm, and 14.4 at 1300 rpm. This ratio indicates the proportion of LPG gas fuel consumption to biodiesel fuel. A higher ratio implies a larger percentage of LPG that can be incorporated. Consequently, a greater ratio signifies a reduced utilization of biodiesel. The test result data is illustrated in Figure 2 below.

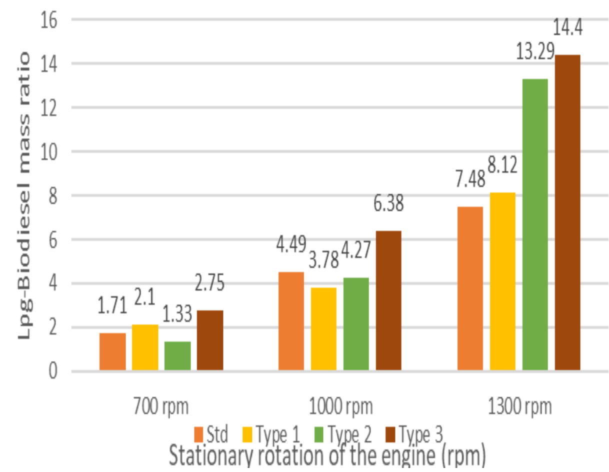

Figure 2. . Lpg-Biodiesel mass ratio

3.2 Torque Achievement

The engine's torque is determined by calculating the loading force parameters on the single block brake system. Figure 3 illustrates the torque values attained by the engine when the dual fuel function is employed with the Gas Heater converter.

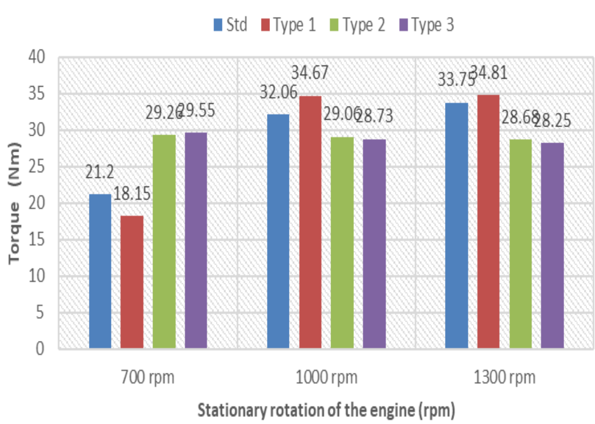

Figure 3. Torque values attained with each Gas Heater konverter kit

The maximum torque is attained by employing a Gas Heater Converter Type 1, registering at 34.81 Nm at a rotational speed of 1300 rpm. Conversely, at a lower speed variation of 700 rpm, Gas Heater Type 1 yields the minimum torque of 18.15 Nm. The highest torque at 700 rpm is reached with a Gas Heater Type 3, recording a value of 29.55 Nm.

Upon reviewing the preceding data, particularly graph 1 at high revolutions, Gas Heater Type 1 exhibits a lower fuel usage ratio compared to Gas Heater Type 3 and Type 2. Nevertheless, Gas Heater Type 1 yields higher torque. Thus, it can be inferred that the mass-to-fuel usage ratio can impact the torque achievable by the engine.

3.3 Engine Power

The engine's power is calculated based on the torque achieved parameter. The torque amount is determined by the engine's maximum rotation after the addition of LPG gas. The test result data is represented graphically in Figure 4.

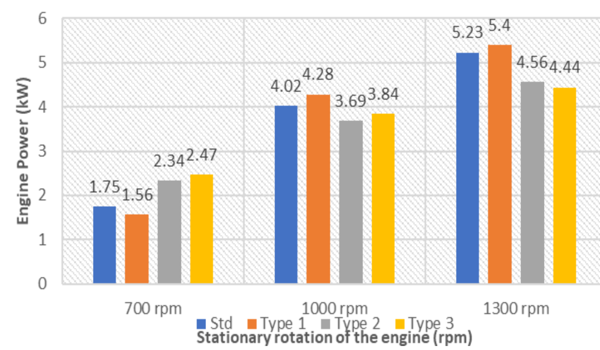

Figure 4. Achievement of dual fuel engine power

The engine's highest power output is achieved by employing Gas Heater Type 1 at 1300 rpm, recording a value of 5.4 kW. Conversely, at 700 rpm, the maximum power is attained using Gas Heater Type 3, with a measurement of 2.47 kW. Analyzing the preceding data, power is directly influenced by the torque generated by the engine, which, in turn, is affected by the mass ratio of the fuel in use. Consequently, it can be deduced that the ratio of LPG-biodiesel usage plays a significant role in determining the engine's power output. Thus, a higher LPG-biodiesel ratio results in a decreased power output from the engine. However, achieving a higher ratio indicates a greater substitution of biodiesel with LPG gas.

3.4 Thermal Efficiency

Thermal efficiency is computed by taking the thermal power that should be attained, derived from the use of fuel, and then multiplying it by the fuel's heat value. The achieved power is then compared to the thermal power. Figure 5 illustrates the engine efficiency accomplishments for each Gas Heater.

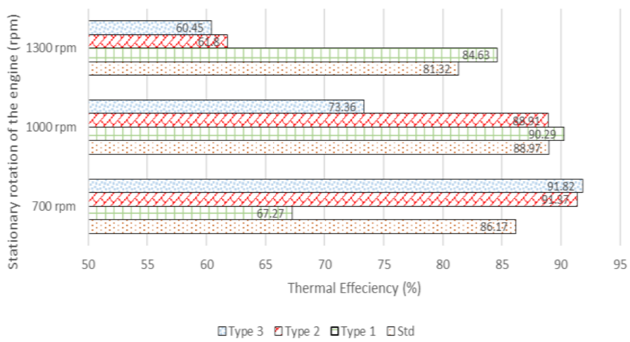

Figure 5. Engine thermal effeciency vs rpm

In the depicted graph, it is evident that the highest efficiency is achieved by employing Gas Heater Type 3 at 700 rpm, reaching a value of 91.82%. At a rotation of 1000 rpm, the highest efficiency is obtained with Gas Heater Type 1, registering at 90.29%. Similarly, for a rotation of 1300 rpm, Gas Heater Type 1 yields an efficiency of 84.63%. Examining the specific fuel consumption (SFC) data, it can be concluded that SFC directly influences efficiency. A higher SFC value corresponds to lower engine efficiency..

3.5 Economic perspective

To evaluate the economic implications arising from the engine's dual-fuel usage, calculations are conducted by taking into account fuel consumption while considering the fuel price factor. The data is computed under the assumption of the machine operating for 24 hours. Specifics of the calculation outcomes are presented in Figure 6.

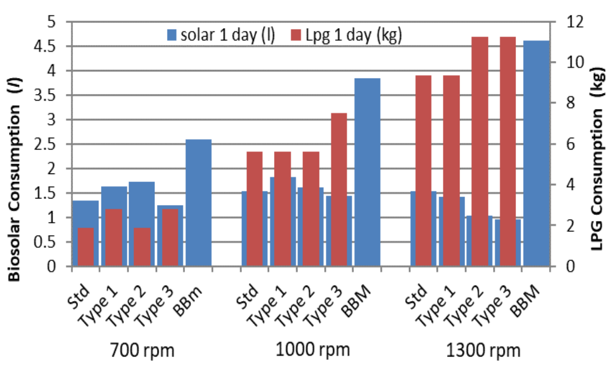

Figure 6. Achievement of Fuel consunption for 24 hours

From figure 6 above, it can be seen that the addition of LPG gas can reduce the use of biodiesel fuel. So the more gas that can be added, the less biodiesel is used. if the data is calculated with the economic value of each fuel. Then the total operational costs for dual fuel in one day can be known.

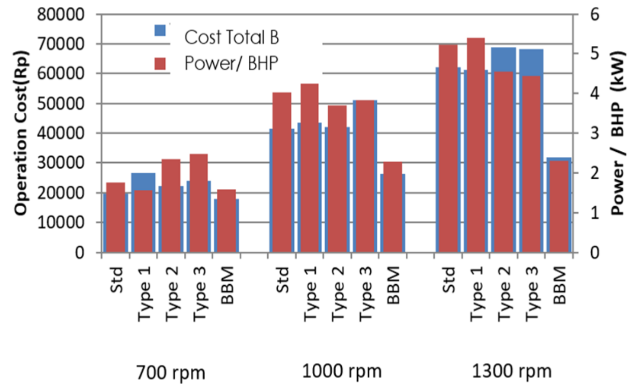

Figure 7. Achievement of operating costs for 24 hours

Figure 7 illustrates that the utilization of dual fuel has the potential to elevate operational expenses compared to employing pure biodiesel at stationary points of 700, 1000, and 1300 rpm. However, it is important to note that the use of dual fuel can substantially enhance power output. The author collected diesel consumption data at the mentioned stationary points of 700, 1000, and 1300 rpm for this study.

From all the test data, it can be deduced that the dual fuel system with a Gas Heater converter has the propensity to increase operational costs. This rise in costs is attributed to the heightened consumption of LPG gas, as the testing method involves maximizing LPG flow at optimal rotations without encountering knocking. This approach is employed to assess the capabilities of the tested Gas Heater kit. The escalated usage of LPG demonstrates an inverse relationship with biodiesel consumption.

4.0 CONCLUSION

Upon examining the data derived from the test results of the heat exchanger (gas heater) on this dual-fuel diesel engine converter kit unit, several conclusions can be drawn:

1. Gas Heater Type 3 exhibits the capability to yield the highest LPG-biodiesel mass ratio compared to the standard Gas Heater Types 1 and 2.
2. Gas Heater Type 1 demonstrates superior overall performance, specifically in terms of power, torque, and efficiency.
3. The operational costs associated with a dual-fuel system surpass those of a pure system (using only diesel fuel).

Acknowledgement

This research is supported by independent funding, and the authors extend their gratitude to colleagues, the research team, and all individuals who contributed to this study. Their efforts and support have been instrumental in generating

research that is both valuable and meaningful for publication.

References

[1] MAN Diesel, "Two-stroke Low Speed Diesel Engines," pp. 1–15, 2009.

[2] R. K. Saluja, V. Kumar, and R. Sham, "Stability of biodiesel – A review," Renew. Sustain. Energy Rev., vol. 62, pp. 866–881, 2016, doi: 10.1016/j.rser.2016.05.001.

[3] N. Kara Togun and S. Baysec, "Prediction of torque and specific fuel consumption of a gasoline engine by using artificial neural networks," Appl. Energy, vol. 87, no. 1, pp. 349–355, 2010, doi: 10.1016/j.apenergy.2009.08.016.

[4] S. Barwe and Y. R. Suple, "EFFECT OF EXHAUST GAS RECIRCULATION (EGR) ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE .pdf," no. 2, pp. 30–37, 2014.

[5] L. Wei and P. Geng, "A review on natural gas/diesel dual fuel combustion, emissions and performance," Fuel Process. Technol., vol. 142, pp. 264–278, 2016, doi: 10.1016/j.fuproc.2015.09.018.

[6] B. Ashok, S. Denis Ashok, and C. Ramesh Kumar, "LPG diesel dual fuel engine - A critical review," Alexandria Eng. J., vol. 54, no. 2, pp. 105–126, 2015, doi: 10.1016/j.aej.2015.03.002.

[7] A. Nugroho, N. Sinaga, and I. Haryanto, "Performance of a compression ignition engine four strokes four cylinders on dual fuel (diesel-LPG)," AIP Conf. Proc., vol. 2014, 2018, doi: 10.1063/1.5054570.