BIO Web of Conferences **62**, 04003 (2023) https://doi.org/10.1051/bioconf/20236204003
EREE 2023

Experimental study the effect of diesel engine performance fuelled by waste tire oil- dexlite blends

Khairil[1*], *Muhammad Gamell* Rickansvar[1], *Amir Zaki* Mubarak[1], and *Sarwo Edhy* Sofyan[1]

[1]Department of Mechanical Engineering, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia

Abstract. It well known that tire as a waste from vihicles susch as passengger car, truck and trailller. Indonesia country has enough potensial of tire waste, it was produced of about 11 millions ton per years. This phenomena could be serious environmental problem because tire waste was difficult dissolve by environment. It is needs to solve this issue by convert the waste tire to oil fuels. The main focus of this research to evaluate the performance of diesel engine fuelled by waste tire oil-dexlite blends. The physicochemical properties such as viscosity, density, calorific value and cetane number the waste tire fuel and its blends with dexlite were analysed. The experimental methode to determine engine performance by using the CI engine with variation of speed from 1500 rpm to 2100 rpm and waste tire-dexlite blends ratios at 10% (WTO-10), 20% (WTO-20) and 30% (WTO-30) of waste tire oil (WTO) and dexlite were utilized as a fuels. The CI engine with variation of speed from 1500 rpm to 2100 rpm was selected in order to determine the engine performance. The experimental results showed that the blending of waste tire oil with dexlite from 10% to 30% can operate with CI engine without any engine modifications. The results of this study revealed that maximum power and SFC were found to be 2.3 kW and 0.48 kg/kWh, respectively. Moreover, at the engine speed of 1900 rpm and a fuel blend of WTO-10 were found that to be optimal values of power and thermal efficiency which is similarly by using dexlite as fuel.

1. Introduction

It well known that the global economic and industrial is going to move forward hence caused increased waste tyres and waste plastic are generated every day. However, the landfill and incineration are certainly not the best methods of waste solution as they cause serious environmental pollution. Indonesia's economic growth will experience growth in 2021, increasing by 7.07% [1]. One sector that has a significant contribution is the automotive industry. Indonesia has enough potensial tire waste was produced about 11 millions ton per years since many of vihicles was increased in every years [2]. This

* Corresponding author: khairil@unsyiah.ac.id

phenomena could be serious environmental problem because tire waste was difficult dissolve by environment. On the other hand, Indonesia's oil production over the past 10 years has shown a downward trend in production due to the fact that oil-producing wells have closed, generally old and the production of new wells is relatively limited. To meet the needs of Indonesia to import crude oil so that its dependence on imports reaches 35% [3].
Many studies have been carried out on converting tire waste into fuel using the pyrolysis method, the most of sample tire waste for pyrolysis process was selected on the outer tire oil compare than the inner tire oil. For example, the previous studies of the pyrolysis method has been carried out by using variation temperatures of about 250°C, 300°C, and 350°C and its found that the higher the pyrolysis temperature was increased the yield of oil and the residual gas [4]. Another study was also carried out by examining the characteristics of used tire oil and the results showed that its characteristics were almost similar to diesel fuel oil [5]. In addition, a mixture of diesel fuel with oil from pyrolysis tires on diesel engines was tested. The result was found that the higher the oil mixture from the tires caused the performance of the diesel engine will be decreased [6].
This work attempts to expand the knowledge on the possibility waste tire oil fuel. It is important to address, the waste tire oil-dexlite blends have not been elucidated in-depth on engine power, specific fuel consumption and thermal efficiency in diesel engines. Therefore, the main focus of this study is to perform the suitability of waste tire oil - dexlite blend fuel on the CI engine as a alternative fuel source in the near future energy supply.

2. Materials and methods

Waste tires is a type of synthetic polymer (Polystyrene). The polystyrene cracking process is one way to minimize polystyrene waste by using pirolysis method in order to produces waste tire oil (WTO). Dexlite is a variant of diesel fuel which has a minimum cetane number and it is a type of diesel fuel that produces is an economical in use. In this study waste tire oil and dexlite fuels are used as a samples. The characteristics of waste tire oil and dexlite are used is shown in Table 1. To obtain the physicochemical properties of the oil mixture of WTO–dexlite blends (WTO-10, WTO-20 and WTO-30), such as viscosity, density, and heating value, the equation of mixture-oil properties was used as follows [7]:

$$HV_{blend} = X_1 * HV_{WTO} + X_2 * HV_{dexlite} \quad (1)$$

Where HV_{blend} is heating value of fuel blends, X_1 is fraction volume of WTO, X_2 is fraction volume of pure dexlite, HV_{WTO} is heating value of WTO and $HV_{dexlite}$ is heating value of pure dexlite.

Table 1. The characteristics of waste tire oil and dexlite are used.

No	Spesifications	Unit	WTO	Dexlite
1	Cetane number	-	78.9	48
2	Heating Value	kJ/kg	43.491	58.088
3	Density	kg/m^3	897.86	842,5
4	Viscosity	mm^2/s	4.351	3.25

The engine that was used for the experiment is an Yanmar engine TF65R type. The specifications of the engine are power of 6.5 HP, CI-engine of 382 cc, maximum rotation was about 2200 rpm. The engine is mated to a generator with maximum load 3 kW and operates at 220 V – 50 Hz and connected to 6 (six) lamp (250 watts each) that used as a load bank to control the load of the engine during the engine performance test. The generator operates at 220 V and speeds 1500 rpm. The function of the generator emits the voltage and electric current to power the 1500-watt from 6 lamps when the engine consumes the fuel at varying speeds. The schematic diagram of the engine experimental setup was shown [7,8]

3. Results and discussion.

3.1. The effect of waste tire oil blends on engine power.

The engine power produced by an engine connected to a single-phase a-c generator can be calculated by the equation [7],

$$N_b = \frac{E.I.pf}{746\ eg} \qquad (2)$$

Where Nb is engine Power (HP), E is voltage generated (Volt), I is curent meter Reader (Ampere), pf is power factor for one single phase = 1 and eg is fficiency of electric generators for engines under 50 kVA = 87% - 89%, for generators using V belts, the power generated is divided by ηb = 0.96.
The engine power produced from waste tire oil - dexlite blends and compare to pure dexlite are shown in **Figure 1**. The result shows that the increasing of the engine rotation value may affect to the higher the engine power value. In case of using fuel blends of WTO-30 obtained as the lowest engine power at 1500 rpm. The highest power produced at 1500 rpm and 2100 rpm engine speed was obtained 1.12 kW and 2.32 kW uses dexlite fuel, respectively. Besides, the lowest power has shown that 1.12 kW and 2.12 kW uses WTO-30. The dexlite fuel obtained highest engine power is 2.32 kW at 2100 rpm engine speed, while the waste tire oil - dexlite blends obtained WTO-10 (2.28 kW), WTO-20 (2.22 kW) and WTO-30 (2.2 kW). The WTO-30 blends give the lowest result of engine power, but WTO-10 at each engine speed show, that was not too significantly different compare to dexlite result.

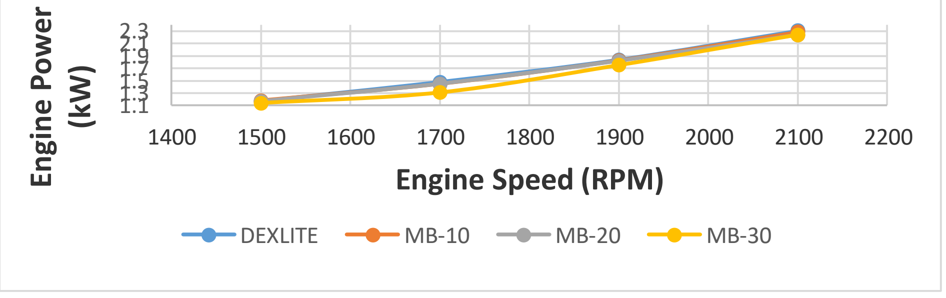

Figure 1. The effect of waste tire oil-dexlite blends on engine power

3.2. The effect of waste tire oil blends on specific fuel consumption

The specific fuel consumption (sfc) is defined as the amount of fuel consumed by the engine to produce power in kW/h. This specific fuel consumption measurement of fuel consumption by an engine, which is usually measured in the mass of fuel from the output power. The specific fuel consumption can be calculated by the equation below [8]:

$$sfc = \frac{mf}{N_b} \tag{3}$$

Where sfc is specific fuel consumption (kg/kWh), mf is total fuel consumption (kg/hour) and N_b is engine power (HP).

The specific fuel consumption of waste tire oil - dexlite blends WTO-10, WTO-20 and WTO-30 are shown in **Figure 2** and compared to pure dexlite fuel. Based on Figure 3, the specific fuel consumption of WTO-30 was the highest compared to WTO-10, WTO-20 and dexlite. The sfc of WTO-30 at 1500 rpm was obtained 0.481 kg/kWh compared to WTO-10, WTO-20 and dexlite which is 0.423 kg/kWh, 0.445 kg/kWh, and 0.421 kg/kWh, respectively. Furthermore, the experimental results for the WTO-10 showed the results a litte bit higher to the value of dexlite at 1500 rpm and 2100 rpm, which is 0.423 kg/kWh and 0.416 kg/kWh, respectively. Generally, the result has shown that the value of sfc from waste tire oil-dexlite blends still in line with fuel standard, this can be a reference for further development in future research.

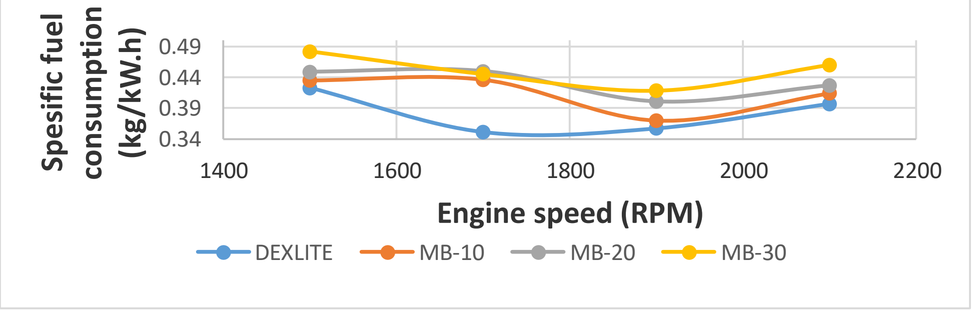

Figure 2. The effect of waste tire oil-dexlite blend on specific fuel consumption.

3.3. The effect of waste tire oil blends on thermal efficiency

Thermal efficiency is defined as the utilization efficiency of heat from fuel to be converted into mechanical work. the thermal efficiency (ηth) can be calculated using the equation [8]:

$$\eta th = \frac{N_b \times 632{,}5}{mf \times LHV} \tag{4}$$

Where ηth is thermal efficiency (%), N_b is engine Power (HP), mf is fuel consumption (kg / hour) and LHV is fuel calorific value (kcal / kg).

Thermal efficiency is the ratio between work output and the heat available introduced through fuel injection. The variation of thermal efficiencies using waste tire oil – dexlite fuel blends fuel is shown in **Figure 3**.

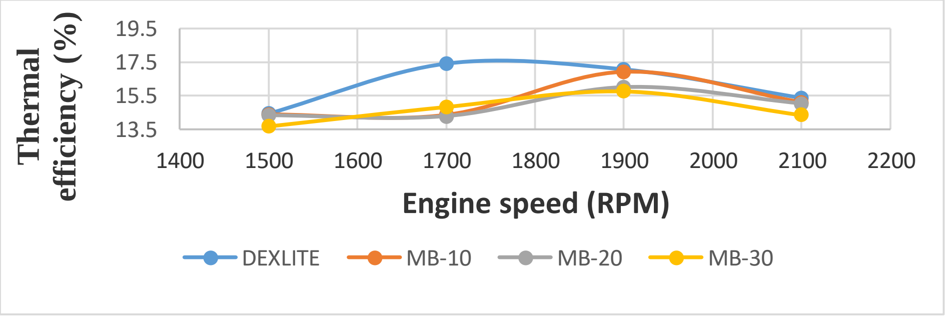

Figure 3. The effect of waste tire oil-dexlite blend on thermal efficiency

It can be seen that the thermal efficiency for WTO-10, WTO-20, WTO-30 were 14.4 %, 14.3 %, and 13.6 % compared to gasoline fuel dexlite which is about 14.5 % at engine speed 1500 rpm. Based on the result of experiments conducted, it can be concluded that the higher engine speed will a litle bit higher the thermal efficiency of all types of fuel. This due to the combustion process faster at higher engine speed and required more fuel than at lower engine speed. This has a delay effect on thermal efficiency WTO-30 due to the time needed to burn in the engine is longer than dexlite, WTO-10 and WTO-20.

4. Conclusion

Experimental the effect of diesel engine fuelled by waste tire oil- dexlite blends was performed in this study. From the results of this study, the following conclusions are drawn:

1. The blending ratio of WTO with dexlite was varied from WTO-10, WTO-20, WTO-30 and 100% dexlite. It was shown that the effect of WTO - dexlite blends on engine power close to engine power of pure dexlite. The thermal efficiency found that the pure dexlite fuels used was a litle bit incresed of the thermal efficiency compare to WTO-dexlite blends at high speed rotation.
2. The blending of waste tire oil with dexlite (WTO-30) can reduce the engine's output power slightly. In addition, the WTO-30 obtained satisfactory results at the maximum engine speed 2100 rpm, which has resulted a litle bit decrease to engine power fuelled of pure dexlite.
3. The engine power, specific fuel consumption, and thermal efficiency were showed a litle bit closed phenomena by using WTO-10, WTO-20 compare to dexlite pure.

References

1. Pertumbuhan Ekonomi Triwulan II-2021 Menembus Zona Ekspansif - Kementerian Koordinator Bidang Perekonomian Republik Indonesia, 2022, https://ekon.go.id/publikasi.
2. Agency for the Assessment and Application of Technology. OUTLOOK ENERGI INDONESIA, 2022, Perspektif Teknologi Energi Indonesia: Tenaga Surya Untuk Penyediaan Energi Charging Station.

3. Kemenperin: Menperin: Industri Otomotif Jadi Sektor Andalan Ekonomi Nasional, 2022, https://www.kemenperin.go.id/artikel/22297/Menperin:-Industri-Otomotif-Jadi-Sektor-Andalan-Ekonomi-Nasional.
4. Syamsiro, M. Sulistiawati, W., 2016, "Studi Pirolisis Sampah Ban Untuk Produksi Bahan Bakar Minyak Alternatif Bagi Industri Kecil Dan Menengah." Jurnal Riset Daerah, vol. XV.
5. H. Aydin and C. Ilkiliç, 2012, "Optimization of fuel production from waste vehicle tires by pyrolysis and resembling to diesel fuel by various desulfurization methods," Fuel, vol.102,pp. 605–612, doi: 10.1016/j.fuel.2012.06.067.
6. W. C. Wang, C. J. Bai, C. T. Lin, and S. Prakash, 2016, "Alternative fuel produced from thermal pyrolysis of waste tires and its use ina di diesel engine," Appl. Therm. Eng., vol. 93, pp. 330–338, doi: 10.1016/j.applthermaleng.2015.09.056.
7. Khairil, Teuku Meurah Indra Riayatsyah, Samsul Bahri, Sarwo Edhy Sofyan, Jalaluddin Jalaluddin, Fitranto Kusumo, Arridina Susan Silitonga, Yanti Padli, Muhammad Jihad and Abd Halim Shamsuddin, 2020, "Experimental study on the performance of an si engine fueled by waste plastic pyrolysis oil–gasoline blends," *Energies*, vol. 13, no. 6, doi: 10.3390/en13164196.
8. Muhammad Rikhwan Siregar, Khairil, and Sarwo Edhy Sofyan, 2023, "Experimental Study of Waste Plastic Oil - Pertamax (RON 92) Blend on Spark Ignition Engine Performance at High-Speed Rotation," Lecture Notes in Mechanical Engineering, pp 319 – 327.

Acknowledgment

This research was funded by the Universitas Syiah Kuala, Minister of national education through the Research Professor Program No.: 2/UN11.2.1/PT.01.03/PNBP/2023. The authors would like to appreciate many thanks to bachelor students (Yandi F., Aji Fatah and M Hafizd) in the combustion Laboratory of Mechanical Engineering Department who has supported to conducting of the research.