Effect of Storage Time of Boosted Pertalite Fuel on Its Physical Properties to Improve Performance on a Single Cylinder 108.2 cc Petrol Engine

Wardoyo
Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Jakarta

D A Wulandari
Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Jakarta

Firdaus, Rahmat
Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Jakarta

Eko Arif Syaefudin
Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Jakarta

https://doi.org/10.5109/7151763

出版情報：Evergreen. 10 (3), pp.1991-1996, 2023-09. 九州大学グリーンテクノロジー研究教育センター
バージョン：

Effect of Storage Time of Boosted Pertalite Fuel on Its Physical Properties to Improve Performance on a Single Cylinder 108.2 cc Petrol Engine

Wardoyo[1*], D A Wulandari[1], Rahmat Firdaus[1], Eko Arif Syaefudin[1]
[1]Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Jakarta, Jakarta 13220, Indonesia

*Author to whom correspondence should be addressed:
E-mail: wardoyo@unj.ac.id

(Received May 8, 2023; Revised July 10, 2023; accepted September 17, 2023).

Abstract: This study aims to investigate the use of octane booster on pertalite (gasoline with an octane number of 90), analyze the effect of mixed storage time, and compare it with Pertamax (gasoline with an octane number of 92). The selected storage times are 0 weeks, two weeks, and four weeks. This research was started by adding an octane booster to pertalite, and a portion of the pertalite and octane booster mixture was stored for two weeks and four weeks. Samples were characterized by octane number, density, viscosity, torque, and engine power. The results showed that the performance of boosted pertalite increased, then decreased with increasing fuel storage time. The original Pertalite has an octane number of 89.9 and strengthened pertalite at 90.8. Then, after two weeks, it dropped to 90.5, then 90.4 in the fourth week. Pertalite viscosity was 0.630 cP, pertalite boost 0.589 cP, 0.593 cP in the second week, and 0.612 cP in the fourth week. Pure Pertalite 7.54 HP, boosted pertalite increased by 7.80 HP, in the second week 7.69 HP and 7.66 HP in the fourth week.

Keywords: detonation; octane booster; petrol engine; storage time

1. Introduction

To participate in reducing global warming, internal combustion engines (ICE), especially gasoline engines that dominate global transportation engines[1)], are sought to have good efficiency[1,2)]. The use of good quality fuel in a gasoline engine will result in more energy efficient and cleaner combustion. The addition of additives to fuel can contribute to increasing the economic value of fuel, as well as reducing greenhouse gas emissions and other pollutants[3)]. The high-octane number allows it to be used in engines with high compression ratios to increase performance, efficiency and eliminate detonation[4)]. In line with the recent trend of motorcycle manufacturers using new engines with high compression ratios[5–10)].

In the last ten years, the number of motorbikes has grown rapidly in Indonesia[11)]. For convenience and fuel efficiency, users will consider replacing their motorbike with a new one or a used motorbike that is in better condition after six years of use[11)]. Indonesia is currently dependent on fossil energy sources; on the other hand, the increasing number of vehicles has an impact on fuel consumption which also increases[12)]. Circulating liquid fuels based on fossil fuels contribute 95% of all energy sources for transportation[13)].

Gasoline as a fuel is a complex compound containing several hydrocarbons fractions whose main components are olefins, isoolefins, paraffins, isoparfins, naphthenes, and aromatics[6,14–19)]. Additives are added to gasoline to increase the octane number of the fuel[20–24)]. To reduce exhaust emissions into the environment, it is recommended to improve the compression ratio of gasoline engines and improve the physicochemical properties and combustion characteristics[25–31)].

The use of additives in fuel can be effective when used in lower amounts compared to the volume of fuel. The way to increase the octane number by additives is to add high-octane components to gasoline to get high-octane number of fuel, so that the economic value increases, and is environmentally friendly[24)].

There are many choices of fuel types on the Indonesian market, consumers can be trapped in choosing fuel with an octane number that does not match the specifications of the gasoline engine they have, which has an impact on decreasing engine performance and increasing fuel consumption[32)]. One solution is to change the ignition timing to reduce detonation tendencies, but this can reduce torque, power, and fuel efficiency[33)].

From these conditions, it is very important to find replacement fuels or add additives to fuels that can

improve engine performance and reduce exhaust emissions[34,35]. Good energy efficiency will result in less fuel consumption and reduced greenhouse gas effects so that it can support environmental sustainability[13].

This research was conducted to analyze the effect of octane booster on Pertalite fuel for several aspects, namely changes in octane number, density, viscosity, torque, power, and percentage of transmittance of functional groups by FT-IR. In this study, a comparison of the effect on fuel storage with time variables of 0 weeks, two weeks and four weeks was also carried out. All of the above parameters are compared with Pertamax, a fuel on the Indonesian market which has a higher octane number than Pertalite

2. Materials and methods

To test the effect of booster octane on engine performance, octane number, density, viscosity, and torque, and power were tested on pertalite + octane booster-x and booster-y fuels with storage effects of 0 weeks, two weeks and four weeks and compared them with pure pertalite.

The octane number is tested to compare the tested fuel variables to the octane number. Octane number in gasoline indicates its usefulness in avoiding detonation when burning fuel in the combustion chamber, which can cause damage to the vehicle engine[4].

Density testing is carried out to analyze the ratio of the fuel variable to the density, and the density data obtained are used to calculate viscosity. Density can be calculated using the following equation.

$$\rho = \frac{m}{v} \quad (1)$$

With:

ρ = density (kg/m^3)
m = mass (kg)
v = volume me (m^3)

Viscosity testing in this study was conducted to analyze the ratio of fuel to viscosity variables. The low viscosity will result in the fuel entering the combustion chamber becoming smoother and mixing air and fuel more homogeneous, which results in increased pressure in the combustion chamber[5]. Viscosity testing was carried out using an Ostwald viscometer and distilled water as a comparison fluid with a viscosity of 0.8705 cP. Viscosity can be calculated using the following equation.

$$v = \frac{t \times \rho}{ta \times \rho a} \times \eta_a \quad (2)$$

With:

v = viscosity of the liquid sought (cP)
t = fluid time (s)
ρ = density of the liquid sought (g/ml)
ηa = viscosity of reference liquid (cP)
ta = time of reference liquid (s)
ρa = density of the reference liquid (g/ml)

The dyno test was carried out to analyze the ratio of the fuel variable to torque and power. The test results taken are the most considerable torque and power in each test. Each fuel variable was tested three times, and then the average was calculated.

3. Results and discussion

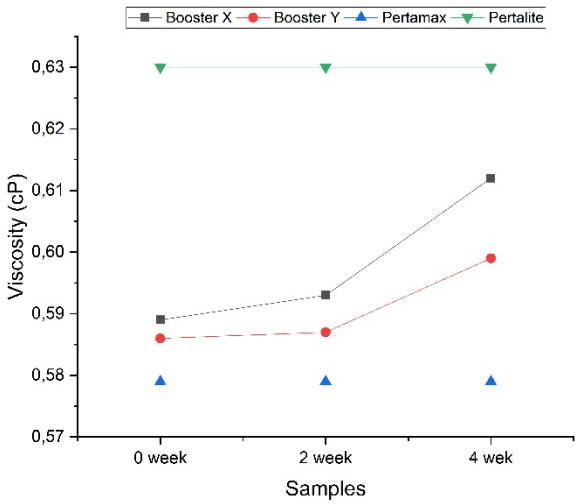

Fig 1: Effect of booster octane and fuel storage time on viscosity

In Pertalite + octane booster-y 0 Weeks, there was a decrease in viscosity compared to Pertalite, which was originally 0.630 cP to 0.586 cP. The Fig 1. shows that the octane booster-y can reduce the viscosity of Pertalite, which causes pressure in the combustion chamber. The decrease in viscosity occurs because the octane booster-y makes the mass and flow time of the Pertalite decrease. The low viscosity will result in the fuel entering the combustion chamber becoming smoother and mixing air and fuel being homogeneous, which results in increased pressure in the combustion chamber. In Pertalite + octane booster-y for two weeks, there was an increase in viscosity to 0.587 cP and continued to increase in Pertalite + octane booster-y for four weeks to 0.599 cP. This increase in viscosity occurred because the density and flow time increased (0 weeks = 0.736 g/ml and 30.9 seconds, 2 weeks = 0.744 g/ml and 30.99 seconds, 4 weeks = 0.748 g/ml and 31.59 second).

In Pertalite + octane booster-x (0 weeks), viscosity decreased compared to Pertalite from 0.630 cP to 0.589 cP. This shows that octane booster-x can reduce the viscosity of Pertalite, which causes the pressure in the combustion chamber to increase. The decrease in viscosity occurs because the octane booster-x decreases the mass and flow time of Pertalite. The low viscosity will result in the fuel entering the combustion chamber becoming smoother, and the mixing of air and fuel is more homogeneous, which results in increased pressure in the combustion chamber. In Pertalite + octane booster-x (2 weeks), there was an increase in viscosity to 0.593 cP and continued to increase in Pertalite + octane booster-x (4 weeks) to 0.612

cP. This increase in viscosity occurred because the density and flow time increased (0 weeks = 0.736 g/ml and 30.72 seconds, 2 weeks = 0.740 g/ml and 30.79 seconds, 4 weeks = 0.744 g/ml and 31.57 second). The Fig. 2 shows that the longer the storage time will increase the density.

It causes an increase in viscosity which causes the pressure in the combustion chamber to decrease. The increase in viscosity occurs because the fuel undergoes precipitation during storage, resulting in decreased fuel quality.

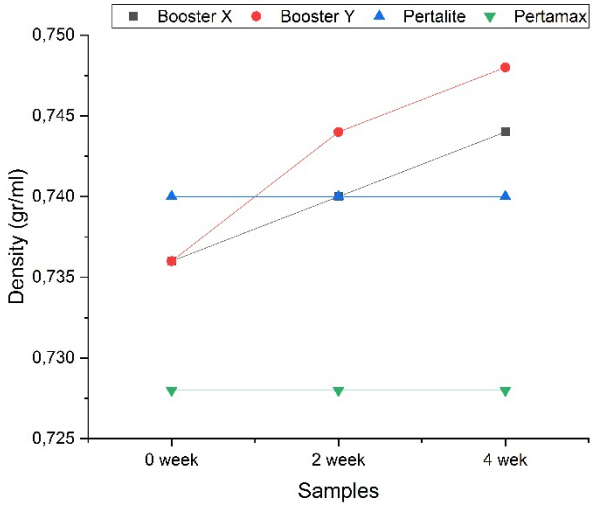

Fig 2: Effect of booster octane and fuel storage time on density

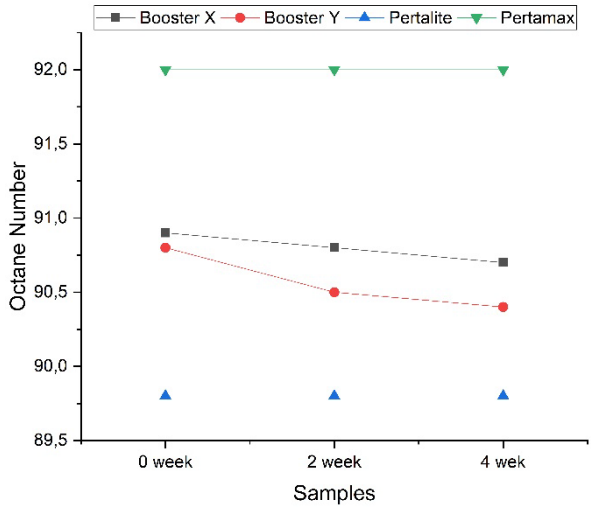

Fig 3: Effect of booster octane and fuel storage time on octane number

In Pertalite + octane booster-x (2 weeks), the octane number decreased to 90.8 as shown in Fig.3. It continued to decrease in Pertalite + octane booster-x (4 weeks) to 90.7. That shows that the longer storage time in pertalite + octane booster-x causes a decrease in the octane number, which makes it more susceptible to knocking. This decrease in octane number occurs because the fuel undergoes oxidation during storage, resulting in decreased fuel quality.

In Pertalite + octane booster-y two weeks, there was a decrease in octane number to 90.5 and continued to experience a decrease in Pertalite + octane booster-y four weeks to 90.4. That shows that the longer storage time of pertalite + octane booster-y causes a decrease in the octane number, which makes it more susceptible to knocking. This decrease in octane number occurs because the fuel undergoes oxidation during storage, resulting in decreased fuel quality.

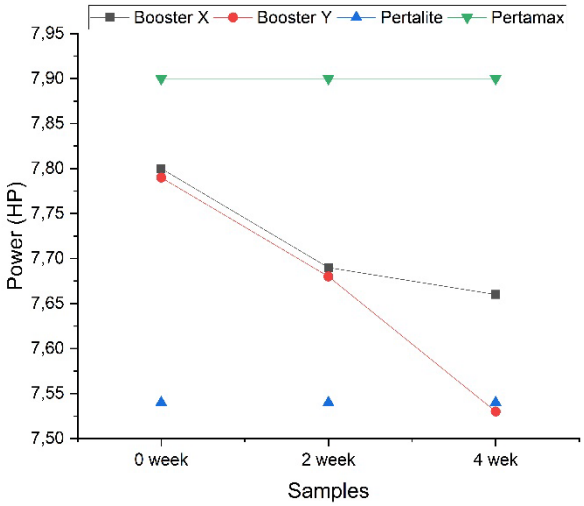

Fig 4: Effect of booster octane and fuel storage time on engine power

As shown in Fig 4. the Pertalite + octane booster-Y 0 weeks, there is an increase in power compared to Pertalite, which was originally 7.54 HP to 7.79 HP. This increase in power occurs because pertalite + octane booster-Y has a lower transmittance percentage (fig 6), higher octane number, lower density, and lower viscosity than Pertalite. Pertalite + octane booster-Y for two weeks experienced a decrease in power to 7.68 HP and continued to experience a decrease in Pertalite + octane booster-Y for four weeks to 7.53 HP. This shows that the longer the storage time causes, the more power decreases. This decrease in power occurs because the fuel quality decreases during storage, resulting in an increase in transmittance percentage, a decrease in octane number, an increase in density, and an increase in viscosity.

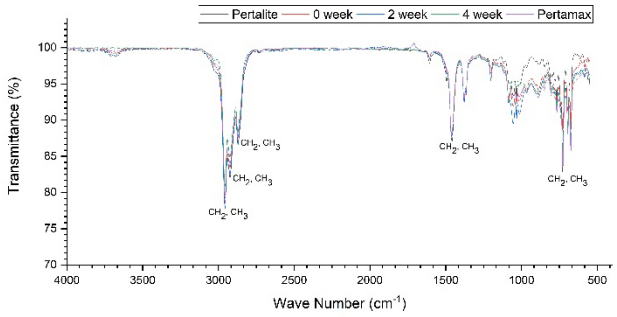

Fig 5: FT-IR characterization of octane booster X

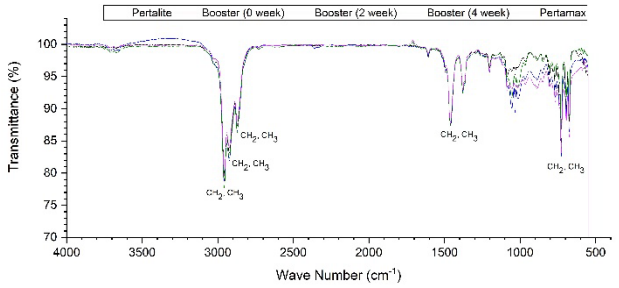

Fig 6: FT-IR characterization of octane booster Y

Fig.4 also shows that Pertalite + octane Booster-X (0 weeks) increases power compared to Pertalite from 7.54 HP to 7.80 HP. That show the octane Booster-X can increase the power of Pertalite even though it does not exceed Pertamax. This increase in power occurs because Pertalite + octane Booster-X has a lower transmittance percentage (fig 5), higher octane number, lower density, and lower viscosity than Pertalite. Pertalite + octane Booster-X (2 weeks) experienced a decrease in power to 7.69 HP and continued to experience a decrease in Pertalite + octane Booster Booster-X (4 weeks) to 7.66 HP. That shows that the more prolonged the storage time causes, the more power decreases. This decrease in power occurs because the fuel quality decreases during storage, resulting in an increase in transmittance percentage, a decrease in octane number, an increase in density, and an increase in viscosity.

4. Conclusion

The results showed an increase in the performance of boosted pertalite. The power produced by pure pertalite is 7.54 HP and boosted pertalite (3.38%) is higher than pure petalite. Pertalite has an octane number of 89.8, and boosted pertalite is 1.17% higher than pure pertalite. The viscosity value of pure pertalite is 0.630 cP, boosted pertalite is 6.75% lower than the original fuel. The density of pertalite is 0.740 g/ml, and the boosted pertalite is 0.54% lower than pure pertalite.

Acknowledgements

This research received financial support from the Institute for Research and Community Service, Universitas Negeri Jakarta, on the Faculty's Basic Research grant scheme with contract number 365/N39/HK.02/2022, and number of Dean Assignment Agreement Letter of the Faculty of Engineering 023/UN39.5.FT/PP/IV/2022.

References

1) F. Duronio, A. De Vita, A. Montanaro, and C. Villante, "Gasoline direct injection engines – a review of latest technologies and trends. part 2," *Fuel*, **265** (2020). doi:10.1016/j.fuel.2019.116947.
2) F. Zhao, M.-C. Lai, and D.L. Harrington, "Automotive spark-ignited direct-injection gasoline engines," 1999. www.elsevier.com/locate/pecs.
3) J.M. Herreros, F. Oliva, S. Zeraati-Rezaei, A. Tsolakis, and J. Delgado, "Effects of high octane additivated gasoline fuel on three way catalysts performance under an accelerated catalyst ageing procedure," *Fuel*, **312** (2022). doi:10.1016/j.fuel.2021.122970.
4) D. Valdenaire, and H. Hamje, "High-octane petrol (HOP) study: making gasoline relevant for the future of road transport," 2019. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0088:0113:EN:PDF.
5) C.K. Westbrook, M. Mehl, W.J. Pitz, and M. Sjöberg, "Chemical kinetics of octane sensitivity in a spark-ignition engine," *Combust Flame*, **175** 2–15 (2017). doi:10.1016/j.combustflame.2016.05.022.
6) T.M.M. Abdellatief, M.A. Ershov, V.M. Kapustin, M. Ali Abdelkareem, M. Kamil, and A.G. Olabi, "Recent trends for introducing promising fuel components to enhance the anti-knock quality of gasoline: a systematic review," *Fuel*, **291** (2021). doi:10.1016/j.fuel.2020.120112.
7) M.A. Ershov, E. V. Grigorieva, T.M.M. Abdellatief, E.A. Chernysheva, D.Y. Makhin, and V.M. Kapustin, "A new approach for producing mid-ethanol fuels e30 based on low-octane hydrocarbon surrogate blends," *Fuel Processing Technology*, **213** (2021). doi:10.1016/j.fuproc.2020.106688.
8) J. Wang, X. Duan, Y. Liu, W. Wang, J. Liu, M.C. Lai, Y. Li, and G. Guo, "Numerical investigation of water injection quantity and water injection timing on the thermodynamics, combustion and emissions in a hydrogen enriched lean-burn natural gas si engine," *Int J Hydrogen Energy*, **45** (*35*) 17935–17952 (2020). doi:10.1016/j.ijhydene.2020.04.146.
9) R.R. Gabdulkhakov, V.A. Rudko, and I.N. Pyagay, "Methods for modifying needle coke raw materials by introducing additives of various origin (review)," *Fuel*, **310** (2022). doi:10.1016/j.fuel.2021.122265.
10) M.A. Ershov, V.D. Savelenko, U.A. Makhova, V.M. Kapustin, T.M.M. Abdellatief, N. V. Karpov, E. V. Dutlov, and D. V. Borisanov, "Perspective towards a gasoline-property-first approach exhibiting octane hyperboosting based on isoolefinic hydrocarbons," *Fuel*, **321** (2022). doi:10.1016/j.fuel.2022.124016.
11) A. Habibie, M. Hisjam, W. Sutopo, and M. Nizam, "Sustainability evaluation of internal combustion engine motorcycle to electric motorcycle conversion," *Evergreen*, **8**(*2*) 469–476 (2021). doi:10.5109/4480731.
12) I. Yamin, B. Sugiarto, and S. Abikusna, "Indonesia recent research of bioethanol for internal combustion engine," *Evergreen*, **8**(*4*) 850–854 (2021). doi:10.5109/4742131.
13) Abdelgader A.S. Gheidan, Mazlan Bin Abdul Wahid,

Opia A. Chukwunonso, and Mohd Fairus Yasin, "Impact of internal combustion engine on energy supplyand its emission reduction via sustainable fuel source," *Evergreen*, **9**(*3*) 830–844 (2022). doi:10.5109/4843114.

14) X. Sun, H. Liu, X. Duan, H. Guo, Y. Li, J. Qiao, Q. Liu, and J. Liu, "Effect of hydrogen enrichment on the flame propagation, emissions formation and energy balance of the natural gas spark ignition engine," *Fuel*, **307** (2022). doi:10.1016/j.fuel.2021.121843.
15) C. Chen, N. Lu, L. Wang, and Y. Xing, "Intelligent selection and optimization method of feature variables in fluid catalytic cracking gasoline refining process," *Comput Chem Eng*, **150** (2021). doi:10.1016/j.compchemeng.2021.107336.
16) A. Verma, N.S. Dugala, and S. Singh, "Experimental investigations on the performance of SI engine with Ethanol-Premium gasoline blends," in: Mater Today Proc, Elsevier Ltd, 2021: pp. 1224–1231. doi:10.1016/j.matpr.2021.08.255.
17) M. Dehhaghi, H. Kazemi Shariat Panahi, M. Aghbashlo, S.S. Lam, and M. Tabatabaei, "The effects of nanoadditives on the performance and emission characteristics of spark-ignition gasoline engines: a critical review with a focus on health impacts," *Energy*, **225** (2021). doi:10.1016/j.energy.2021.120259.
18) C. Wang, W. Fang, L. Wang, and F.S. Xiao, "Fischer-tropsch reaction within zeolite crystals for selective formation of gasoline-ranged hydrocarbons," *Journal of Energy Chemistry*, **54** 429–433 (2021). doi:10.1016/j.jechem.2020.06.006.
19) Y.L. Calvin, P.A.T. Hariyanto, A.I. Usman, M. Masuku, C.S. Wibowo, Maymuchar, R. Anggarani, N.A. Fathurrahman, and B. Sugiarto, "Volatility and physicochemical properties of gasoline-ethanol blends with gasoline ron-based 88, 90, and 92," *Fuel*, **307** (2022). doi:10.1016/j.fuel.2021.121850.
20) B.Q. He, S.P. Xu, X.Q. Fu, and H. Zhao, "Combustion and emission characteristics of an ultra-lean burn gasoline engine with dimethyl ether auto-ignition," *Energy*, **209** (2020). doi:10.1016/j.energy.2020.118437.
21) Z. Cao, X. Zhang, C. Xu, X. Huang, Z. Wu, C. Peng, and A. Duan, "Selective hydrocracking of light cycle oil into high-octane gasoline over bi-functional catalysts," *Journal of Energy Chemistry*, **52** 41–50 (2021). doi:10.1016/j.jechem.2020.04.055.
22) A.-M.A. El-Bassiouny, T.M. Aboul-Fotouh, and T.M.M. Abdellatief, "Maximize the production of environmental, clean and high octane number gasoline-ethanol blends by using refinery products maximizing the production of an environmental high-octane reformulated gasoline view project process integration view project see profile maximize the production of environmental, clean and high octane number gasoline-ethanol blends by using refinery products," *Article in International Journal of Scientific and Engineering Research*, **6** (*7*) (2015). http://www.ijser.org.
23) M.S. El-Sawy, S.A. Hanafi, F. Ashour, and T.M. Aboul-Fotouh, "Co-hydroprocessing and hydrocracking of alternative feed mixture (vacuum gas oil/waste lubricating oil/waste cooking oil) with the aim of producing high quality fuels," *Fuel*, **269** (2020). doi:10.1016/j.fuel.2020.117437.
24) D. Panda, F. Bayu, and M. Ramteke, "Discrete time reactive scheduling of gasoline blending and product delivery in presence of demand and component uncertainties using graphical genetic algorithm," *Comput Chem Eng*, **143** (2020). doi:10.1016/j.compchemeng.2020.107100.
25) D.D. Nguyen, H. Moghaddam, V. Pirouzfar, A. Fayyazbakhsh, and C.H. Su, "Improving the gasoline properties by blending butanol-al2o3 to optimize the engine performance and reduce air pollution," *Energy*, **218** (2021). doi:10.1016/j.energy.2020.119442.
26) A. Yakın, and R. Behçet, "Effect of different types of fuels tested in a gasoline engine on engine performance and emissions," *Int J Hydrogen Energy*, **46** (*66*) 33325–33338 (2021). doi:10.1016/j.ijhydene.2021.07.133.
27) S. Yu, B. Yin, Q. Bi, H. Jia, and C. Chen, "Effects of gasoline and ethanol on inner flows and swallowtail-like spray behaviors of elliptical gdi injector," *Fuel*, **294** (2021). doi:10.1016/j.fuel.2021.120543.
28) W. Abdelmoez, and A. Mustafa, "Oleochemical industry future through biotechnology," *J Oleo Sci*, **63** (*6*) 545–554 (2014). doi:10.5650/jos.ess14022.
29) Z. He, W. Zhao, G. Liu, Y. Qian, and X. Lu, "Effects of short chain aromatics in gasoline on gdi engine combustion and emissions," *Fuel*, **297** (2021). doi:10.1016/j.fuel.2021.120725.
30) F. Salek, M. Babaie, S.V. Hosseini, and O.A. Bég, "Multi-objective optimization of the engine performance and emissions for a hydrogen/gasoline dual-fuel engine equipped with the port water injection system," *Int J Hydrogen Energy*, **46** (*17*) 10535–10547 (2021). doi:10.1016/j.ijhydene.2020.12.139.
31) W. Abdelmoez, A.M. Tayeb, A. Mustafa, and M. Abdelhamid, "Green approach for biodiesel production from jojoba oil supported by process modeling and simulation," *International Journal of Chemical Reactor Engineering*, **14** (*1*) 185–193 (2016). doi:10.1515/ijcre-2015-0070.
32) C. Wibowo, F. Adian, Y. Nugroho, and B. Sugiarto, "The optimization of the relationship between octane number of gasoline-ethanol blend fuels in various settings of the engine control module," *Evergreen*, **7**(*4*) 587–592 (2020). doi:10.5109/4150510.
33) P. Mello, F. Wildner, G.S. De Andrade, R. Cataluña, and R. Da Silva, "Combustion time of the oxygenated and non-oxygenated fuels in an otto cycle engine," *Journal of the Brazilian Society of Mechanical*

Sciences and Engineering, **36** (*2*) 403–410 (2014). doi:10.1007/s40430-013-0094-y.

34) S. Abikusna, B. Sugiarto, and I. Yamin, "Utilization analysis of bioethanol (low grade) and oxygenated additive to cov and gas emissions on si engine," *Evergreen*, **7**(*1*) 43–50 (2020). doi:10.5109/2740940.
35) Y. Furutani, K. Norinaga, S. Kudo, J.I. Hayashi, and T. Watanabe, "Current situation and future scope of biomass gasification in japan," *Evergreen*, **4**(*4*) 24–29 (2017). doi:10.5109/1929681.