

# Analisis tekno-ekonomi penerapan minyak kelapa sawit mentah (crude palm oil) sebagai bahan bakar alternatif mesin diesel putaran rendah = Techno-economic analysis of the application of crude palm oil as alternative fuel for low-speed diesel engines

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## Abstrak

Penelitian analisis tekno-ekonomi Crude Palm Oil (CPO) bertujuan untuk mengetahui karakteristik viskositas dan densitas CPO sebagai bahan bakar mesin diesel serta dampak penggunaan CPO terhadap karakteristik mesin seperti performance, karakteristik parameter pembakaran, keandalan dan emisi gas buang yang dihasilkan.

Penelitian dilakukan dengan metode pengujian operasi (running test) menggunakan 100% CPO selama 375 jam 58 menit pada mesin diesel Type MAK 8M453B dengan 8 cylinder inline dan daya mampu gross 1,200 KW. Suhu pemanasan CPO pada Flow Control Module selama pengujian dijaga pada rentang 77 <sup>0</sup>C s.d 83 <sup>0</sup>C untuk mendapatkan rentang viskositas kinematik CPO di inlet mesin sebesar 11 cSt s.d. 13 cSt. Selama running test, dilakukan uji performance, uji karakteristik pembakaran (engine analyzer), uji emisi gas buang dan pengambilan sampel CPO. Sementara sebelum dan sesudah running test dilakukan uji sampel CPO serta minyak pelumas. Uji Scanning Electron Microscope (SEM) juga dilakukan untuk mengetahui komposisi logam pada deposit.

Hasil penelitian menunjukkan bahwa viskositas kinematik dan densitas CPO cenderung menurun ketika suhu dinaikkan dengan kurva berbentuk parabolic polinomial untuk viskositas kinematik dan cenderung linier untuk densitas. Specific Fuel Consumption (SFC) pada beban maksimum 1.200 kW gross sebesar 0,298 liter/kWh. Persamaan polinomial SFC terhadap beban adalah  $y = 10^{-07}x^2 - 0,0003x + 0,4496$ . Kadar emisi gas buang NO<sub>x</sub> sebesar 2.075,4 mg/Nm<sup>3</sup> s.d. 2797,7 mg/Nm<sup>3</sup>, melebihi batasan standar baku mutu lingkungan (maksimum 1.400 mg/Nm<sup>3</sup>). Terbentuk deposit keras berupa lelehan di permukaan cylinder head, piston dan valve serta nozzle dengan kandungan komposisi logam Calcium (Ca) yang bersifat keras dan sulit dibersihkan. Akumulasi deposit menyebabkan tergoresnya dinding permukaan liner.

Pengoperasian menggunakan bahan bakar CPO menurunkan tekanan pembakaran sebesar 14 % pada beban maksimum dibandingkan beroperasi menggunakan biodiesel/B20; menurunkan Indicated Horse Power (IHP) mesin rata-rata sebesar 7,44 %; memperpendek interval pemeliharaan periodik yang berdampak pada peningkatan signifikan pada kebutuhan biaya fix dan variable O&M dan penurunan capacity factor mesin. Kualitas minyak pelumas mengalami degradasi dengan indikasi kenaikan viskositas minyak pelumas dan terdapat kenaikan kontaminan logam silica (Si) dan besi (Fe).

Berdasarkan hasil perhitungan pada analisis keekonomian, harga keekonomian CPO tahun 2018 sebesar Rp.7.238,11/liter, lebih rendah Rp. 1.142,73/liter terhadap harga indeks pasar rata-rata pada tahun 2018. Sementara pada tahun 2019, harga keekonomian bahan bakar CPO sebesar Rp. 6.515,25/liter, lebih rendah Rp. 1.002,54/liter terhadap harga indeks pasar rata-rata CPO pada tahun 2019 dan lebih rendah Rp. 1.857,42/liter terhadap harga suplier CPO di ULPLTD-MG Bontang.

.....The techno-economic analysis of Crude Palm Oil (CPO) aims to determine the viscosity and density

characteristics of CPO as diesel engine fuel and the impact of CPO use on engine characteristics such as performance, characteristics of combustion parameters, reliability and exhaust emissions produced. The research method was carried out by running test using 100% CPO for 375 hours 58 minutes on a diesel engine MAK Type 8M453B with 8 inline cylinders and a gross capable power of 1,200 kW. CPO heating temperature in the Flow Control Module during testing is maintained in the range of 77 <sup>0</sup>C to 83 <sup>0</sup>C to get the kinematic viscosity range of CPO at the engine inlet of 11 cSt to 13 cSt. During the running test, a performance test, a combustion characteristics test (engine analyzer test), a flue gas emission test and CPO sampling was conducted. While before and after running test CPO and lubricant oil samples were tested. The Scanning Electron Microscope (SEM) test was also carried out to determine the metal composition of the deposit.

The results showed that kinematic viscosity and CPO density tended to decrease when the temperature was raised with a polynomial shaped parabolic curve for kinematic viscosity and tended to be linear for density. Specific Fuel Consumption (SFC) at a maximum load of 1,200 kW gross is 0,298 liters/ kWh. The SFC polynomial equation for load is  $y = 10^{-07}x^2 - 0,0003x + 0,4496$ . NOx exhaust gas emission levels of 2,075.4 mg/Nm<sup>3</sup> s.d. 2,797.7 mg/Nm<sup>3</sup>, exceeding the limits for environmental quality standards (maximum 1,400 mg/Nm<sup>3</sup>). A hard deposit formed in the form of a melt on the surface of the cylinder head, piston and valve as well as a nozzle with a metal composition of Calcium (Ca) which is hard and difficult to clean. Accumulated deposits cause scratching of the liner surface.

Operations using CPO fuel reduce combustion pressure by 14% at maximum load compared to operating using biodiesel/ B20; reduce machine Indicated Horse Power (IHP) by an average of 7.44%; shortening periodic maintenance intervals which results in a significant increase for fix and variable O&M costs and a decrease in engine capacity factor. The quality of the lubricating oil is degraded with an indication of an increase in the viscosity of the lubricating oil and an increase in metal (Si) and iron (Fe) contaminants. Based on economic analysis, the economic price of CPO in 2018 is Rp.7,238.11 /liters, lower Rp. 1,142.73 /liters against the average market index price in 2018. While in 2019, the economic price of CPO fuel is Rp. 6,515.25 / liters, lower Rp. 1,002.54 / liters against the CPO average market index price in 2019 and lower Rp. 1,857.42 / liters of CPO supplier prices in ULPLTD-MG Bontang.