

# Optimasi Unjuk Kerja dan Emisi Mesin Otto 150cc Berbahan Bakar Campuran Bensin RON 90 dan Fuel Grade Bioetanol E40, E50, dan E60 dengan Pengaturan Ignition Timing dan Injection Duration Menggunakan Engine Control Module (ECM) = Performance and Emission Optimization of 150cc Otto Engine with RON 90 Gasoline and E40, E50, and E60 Fuel Grade Bioethanol by Changing Ignition Timing and Injection Duration Settings Using Engine Control Module (ECM)

Ahmad Hamzah Syafiq, author

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## Abstrak

Dalam rangka mengurangi ketergantungan terhadap BBM, pemerintah melalui Peraturan Menteri Energi dan Sumber Daya Mineral, mengeluarkan Permen ESDM No.12/2015 mengenai pemanfaatan Bioetanol (E100) sebagai campuran BBM diproyeksikan akan mencapai 5% pada tahun 2020 dan 20% pada tahun 2025 khususnya pada bidang transportasi. Pencampuran fuel grade bioetanol dengan bahan bakar minyak akan meningkatkan nilai Research Octane Number (RON) dari bahan bakar. Namun, bahan bakar campuran tersebut akan memiliki total nilai kalor yang lebih rendah. Sehingga, diperlukan adanya modifikasi dari mesin agar dapat berfungsi dengan optimal. Engine Control Module digunakan untuk mengubah pengaturan pada mesin khususnya dari segi ignition timing dan injection duration. Melalui penelitian ini, akan dicari nilai Research Octane Number (RON) yang paling optimal sebagai dasar untuk menentukan kombinasi persentase fuel grade bioetanol dengan bahan bakar yang telah tersedia di pasaran. Selain itu, penelitian ini akan memberikan pengaturan Engine Control Module yang paling optimal sehingga didapatkan unjuk kerja mesin yang terbaik dengan kadar emisi yang memenuhi standar. Sebelum melakukan pengujian unjuk kerja dan emisi, bahan bakar campuran akan diuji karakterisasi yaitu Research Octane Number (RON) dan densitas berdasarkan standar ASTM D 2699 dan ASTM D 4052. Pengujian unjuk kerja dilakukan dengan menggunakan AVL Engine Dynamometer untuk mengetahui besaran torsi, daya, dan specific fuel consumption yang dihasilkan pada kecepatan putar mesin 3500, 5000, 6500, dan 8000 RPM. Mesin dioperasikan dalam keadaan bukaan throttle penuh (wide-open throttle) untuk mendapatkan unjuk kerja maksimum yang dihasilkan mesin. Pengujian emisi gas buang yang dihasilkan juga diperhatikan agar tetap memenuhi kriteria Euro-4 yang telah diterapkan di Indonesia. Pengujian emisi dilakukan menggunakan AVL Compact Diagnostic System. Pengaturan ignition timing dan injection duration memengaruhi unjuk kerja dan emisi yang dihasilkan oleh mesin. Hal tersebut berpengaruh terhadap proses pembakaran dan perbandingan campuran udara dengan bahan bakar. Efek yang dihasilkan yaitu peningkatan unjuk kerja mesin (torsi, daya, dan specific fuel consumption). Sedangkan hasil pengujian emisi menunjukkan pembakaran yang mendekati stoikiometri yaitu ketika kadar karbon dioksida dan nitrogen oksida maksimum, sedangkan kadar karbon monoksida dan hidrokarbon minimum. Berdasarkan hasil penelitian, bahan bakar campuran yang menghasilkan torsi dan daya maksimum yaitu Bensin RON 90 E40 dengan pengaturan pengaturan ignition timing  $28^{\circ}$ BTDC dan injection duration -10%. Specific fuel consumption mencapai minimum pada bahan bakar Bensin RON 90 E60 dengan pengaturan ignition timing  $28^{\circ}$ BTDC dan injection duration -10%. Kadar karbon dioksida mencapai maksimum pada bahan bakar Bensin RON 90

E50 dengan pengaturan ignition timing  $28^{\circ}$ bTDC dan injection duration -15%. Kadar karbon monoksida dan nitrogen oksida mencapai optimum pada Bensin RON 90 E60 pengaturan ignition timing  $28^{\circ}$ bTDC serta injection duration -10% serta pada Bensin RON 90 E40 dengan pengaturan ignition timing  $28^{\circ}$ bTDC dan injection duration -15%. Sedangkan kadar hidrokarbon mencapai minimum pada Bensin RON 90 E50 dengan pengaturan ignition timing  $24^{\circ}$ bTDC dan injection duration -10%.

.....In order to reduce dependence on gasoline fuel, the government, through the Minister of Energy and Mineral Resources Regulation, issued ESDM Regulation No.12 / 2015 regarding the use of Bioethanol (E100) as a gasoline fuel mixture is projected to reach 5% in 2020 and 20% in 2025 especially in the transportation sector. Mixing fuel grade bioethanol with gasoline fuel will increase the Research Octane Number (RON) value. However, the gasoline-bioethanol fuel mixture will have a lower total heating value. Thus, modifications are needed from the engine to function optimally. Engine Control Module is used to change parameters on the engine especially in terms of ignition timing and injection duration. Through this research, the most optimal Research Octane Number (RON) value will be sought as a basis for determining the percentage combination of fuel grade bioethanol with gasoline fuels that are already available on the market. Besides, this research will provide the most optimal Engine Control Module parameters so that the best engine performance with emission levels that meet the standards is obtained. Before conducting performance and emission testing, the sample of gasoline-bioethanol fuel mixture will be tested for characterization in terms of Research Octane Number (RON) and density based on ASTM D 2699 and ASTM D 4052. Performance tests are carried out using the AVL Engine Dynamometer to determine the amount of torque, power, and specific fuel consumption resulting in engine rotational speeds of 3500, 5000, 6500 and 8000 RPM. The engine is operated in wide-open throttle to get the maximum performance generated by the engine. Examination of the resulting exhaust emissions is also considered to continue to meet the Euro-4 criteria that have been applied in Indonesia. Emission testing is carried out using the AVL Compact Diagnostic System. The ignition timing and injection duration settings affect the engine's performance and emissions. This affects the combustion process and the air-fuel ratio (AFR). The effect is an increase in engine performance (torque, power, and specific fuel consumption). The results of emission tests show that the combustion approaching stoichiometry is when the levels of carbon dioxide and nitrogen oxides are maximum, while the levels of carbon monoxide and hydrocarbons are minimum. Based on the results of the research, a gasolinebioethanol fuel mixture that produces maximum torque and power is RON 90 E40 Gasoline with ignition timing  $28^{\circ}$ bTDC and injection duration of -10%. Specific fuel consumption reaches a minimum in RON 90 E60 Gasoline with ignition timing  $28^{\circ}$ bTDC and -10% injection duration. The levels of carbon dioxide reach maximum in RON 90 E50 Gasoline with ignition timing  $28^{\circ}$ bTDC and injection duration -15%. The levels of carbon monoxide and nitrogen oxide reach optimum in RON 90 E60 Gasoline with ignition timing  $28^{\circ}$ bTDC and injection duration -10% and in RON 90 E40 Gasoline with ignition timing  $28^{\circ}$  bTDC and injection duration -15%. While the levels of hydrocarbon reach minimum in RON 90 E50 Gasoline with ignition timing  $24^{\circ}$ bTDC and injection duration -10%.