Improving Diesel Engine Performance and Exhaust Emission by Optimizing Various Parameters of Air Supplied from Turbocharger

ABSTRACT

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KEYWORDS: Diesel Engine, Taguchi Analysis, Grey Relational Analysis, TOPSIS, MOORA, Polanga Biodiesel, Performance Parameters and Emission Parameters.

ABSTRACT: Present work aims at optimizing input parameters of diesel engine, especially temperature of turbocharged air along with other parameters namely, air pressure, fuel injection timing and compression ratio, to improve performance and to lower exhaust emissions. Performance parameters of diesel engine selected for optimization are brake thermal efficiency, indicated thermal efficiency, brake specific fuel consumption, mechanical efficiency and brake mean effective pressure. The selected emission parameters are hydrocarbon emission, carbon monoxide and carbon dioxide emission, smoke opacity and NO_x emission.

The optimization techniques used in the present work are Taguchi method, analysis of variance, analysis of means, grey relational analysis, principal component analysis, technique for order of preference by similarity to ideal solution (TOPSIS), entropy weight method, multi-objective optimization by ratio analysis (MOORA), standard deviation weight method and regression analysis. Results of different single-objective and multi-objective optimization techniques are compared and validated through confirmatory tests.

After finding the optimum temperature and pressure of turbocharged air, different blends of Polanga biodiesel are prepared and tested for its compatibility. Fuel injection timing, fuel injection pressure, load and biodiesel blend are optimized using different optimization techniques for better performance and exhaust emissions of diesel engine at obtained optimum compression ratio, air temperature and pressure of

turbocharged air. On the basis of results obtained from different analyses, the following conclusions are drawn-

i. In single-objective optimization, compression ratio found to be the most significant and fuel injection timing to be the least significant parameters that affect the performance and exhaust emissions of diesel engine. Whereas, the significance of charge air temperature and pressure is found in between that of compression ratio and fuel injection timing.

ii. The optimum levels of selected input parameters for most of the performance and emission parameters found to be as:

- Compression Ratio – 17 and 18
- Fuel Injection Timing – 23 and 25° bTDC
- Air Temperature – 30 and 40°C
- Air Pressure – 149 and 165 kPa

Therefore, the optimum working ranges of input parameters can be varied in between the above two obtained levels of each corresponding input parameter to attain better performance and low exhaust emission.

iii. In multi-objective optimization, compression ratio found to be the most significant and air temperature to be the least significant parameters that affect the selected combinations of performance and emission parameters. While the significance of fuel injection timing and air pressure found in between the other two.

iv. The optimum working range of input parameters for various combinations of performance and emission parameters found to be as:

- Compression Ratio – 17 to 18
- Fuel Injection Timing – 21 to 23° bTDC

- Air temperature – 30 to 40°C
- Air Pressure – 117 to 133 kPa

v. While running the engine on Polanga biodiesel, fuel injection timing found to be the most significant parameter when NO_x emission is considered. But when NO_x emission is not considered, the most significant parameter is engine load.

Similarly, fuel injection pressure found to be the least significant when NO_x emission is considered and fuel injection timing when NO_x emission is not considered.

vi. The optimum working range of input parameters of engine running on Polanga biodiesel found to be as:

- Fuel Injection Timing – 23 to 27° bTDC
- Engine Load – 60 to 100%

Whereas the optimum values of fuel injection pressure and biodiesel blend are-

- Fuel Injection Pressure – 220 bar
- Biodiesel Blend – B40 (40% Polanga oil and 60% diesel – by weight)

vii. In confirmatory tests, a good relation is found between the predicted and experimental values of output parameters at obtained optimum levels of input parameters.

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