DIGITAL SIMULATION OF FOUR STROKE HIGH SPEED DIESEL ENGINE WITH TURBOCHARGER FOR WIDE RANGE MATCHING AND OPTIMISATION

by

RISHI RAJ GAUR

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A B S T R A C T

Matching and optimisation of automotive turbocharged diesel engines and other more complex variants of this category necessitate wide-range performance evaluation, with different combinations of components. Experimental matching procedures hitherto applied more commonly, prove to be cumbersome and costly. The work reported in this thesis was under-taken with an objective to develop a simple and versatile simulation procedure using digital computer for wide-range performance prediction of such systems.

The system considered in particular, was a four stroke, high speed automotive diesel engine with a radial turbocharger. A general 'system-oriented' approach was followed in this simulation. It consisted of the following steps.

1. Cycle simulation of the processes in the component control volumes, namely, the engine cylinder and the exhaust manifold. This step is to predict the performance of above components analytically. For turbine and compressor, the experimental steady state performance data was used. When experimental data for these components is not available, simple analytical performance prediction methods developed by Wallace can be used.
2. The performance data of components (as obtained by Step 1) was analysed in order to represent the performance characteristics of individual components in form of simple

polynomial functions using linear regression technique.

3. The overall simulation was then attained by simultaneous solution of the equations representing component performance characteristics and the necessary compatibility conditions.

A review of the available simulation techniques and process models has been presented to put into perspective the current status of turbocharged diesel engine simulation and to evaluate their suitability for the present simulation.

For cycle process simulation, the simpler assumptions e.g., the 'quasi-steady' model for gas-exchange and gas-property data neglecting dissociation have been used. Similarly, simple semi-empirical models have been used for heat release, heat transfer and engine friction. Consequently, the simulation is suitable for rapid performance prediction without elaborate input data.

Three main computer programs have been developed in FORTRAN-IV. Using these programs the cycle process data as well as the overall performance data can be conveniently predicted over a wide-range of operating conditions.

An experimental rig has also been developed in the course of the present work for wide-range testing of automotive engines. It incorporates the arrangement to simulate variable ambient pressure conditions. This test rig was used to obtain the experimental information needed in the simulation and to obtain performance data for validation.

Typical computed results including cycle process data and overall performance data for a number of operating conditions have been given to show the general predictive capability of the simulation. The overall performance results have also been compared with the corresponding experimental data at certain operating points for the naturally aspirated, and turbocharged engine. Despite the use of simple process models, the overall performance results show a close agreement with the test data.

This simulation will not only be useful for performance evaluation of engine-turbocharger combinations for wide-range matching but will also expedite the development of systematic optimisation procedures for these systems.

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C E R T I F I C A T E

This is to certify that the thesis entitled 'Digital Simulation of Four Stroke High Speed Diesel Engine with Turbocharger for Wide Range Matching and Optimisation' being submitted by Shri Rishi Raj Gaur to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy in Mechanical Engineering, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other University for any degree or diploma.

RDGarg

(Dr. R.D. Garg)
Assistant Professor,
Department of Mechanical Engineering,
Indian Institute of Technology, Delhi,
New Delhi-110029.

A C K N O W L E D G E M E N T S

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PAGE

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