



ENGINE DEVELOPMENT LABORATORY

DEVELOPMENT | CALIBRATION | SIMULATIONENGINE - Powering Your Mobility



Engine development Lab (EDL) at ARAI is a state of the art R&D centre for engine and vehicle development. EDL is engaged in various research, development and evaluation of all types of IC engines such as diesel, gasoline, CNG, LNG, LPG, HCNG, Hydrogen, Ethanol, Bio-diesel, Methanol, DME and Dual Fuel systems. EDL has capabilities to develop BS-VI, Stage-IV, Stage-V and IGES IV+ norms.

Service Areas

- Engine Upgradation
- Engine Performance & Durability Assessment
- Emission & Combustion Development Engine Cycle / Combustion Simulation
- · Automotive, off-highway, Gensets
- Alternate Fuel Engines
- Blow-by Calibration Facility
- Benchmarking
- Engine Calibration

- On-Board Diagnostics (OBD) Calibration
- After Treatment Calibration
- Vehicle fuel efficiency improvement & • Feasibility for Future Emission Road map energy audit projects (Conventional & EV's)
 - Vehicle Calibration

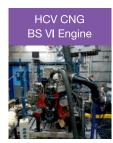




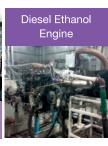




Alternate Fuel Engine Development























ARAI is a hub for alternate fueled engine development for various applications - On-road, Off-road, Genset

Core Competency of Alternate Fuel Team:

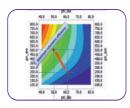
- Rich calibration experience of more than 25 years +
- Experience of various fuel system technologies Carburation to injection
- Experience of various types of engines Single Cylinder to Multiple cylinder
- Experience of different types of vehicles 2 Wheeler to HCV, Off Highway, Agriculture, Genset, etc.
- Worked for various emission norms BS II to BSVI, Trem norms for Off-highway and CPCB for Gensets.
- Knowledge of legislation and decoding of clauses as active member of various government notification committees
- · Experience of various fuel system suppliers and their calibration software
- OBD logics and demonstration capabilities
- More than 25 international papers, journal articles published
- More than 6 patents in the field of alternate fuels

ARAI has been identified as a center of excellence in "Green Hydrogen" & "Flex Fuel"

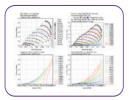


1D Air Handling & Gas Exchange Analysis

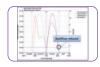
Air Handling System



Intake & Exhaust System Tuning



TC Matching



Gas Exchange



Measurements before & after modifications



Energy Audit

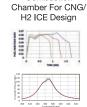
Soot-in Oil Analysis



Air Utilization Study



Effect of Manifold design on Swirl and Combustion

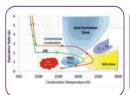


Combustion

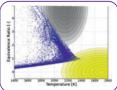
Case Study Validation

Advanced combustion Strategies for BS VI and BS VII

Valve Timings, Profile Comparison of Predicted



& port flow Coefficient

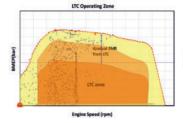


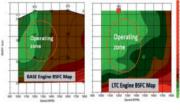
&Measured results

LTC Concept

T - øAnalysis

Spray Bowl Interaction





Combustion Hardware Selected by Simulation

Engine Level Calibration

Engine Out Emissions Performance & Efficiency Aftertreatment & OBD

Complete Solution for BS VI/TREM V/CPCB IV + Concept to Vehicular, RDE & OBD trials

EGT

3D Combustion Simulation

Bowl Geometry

Injection Timing

Injection Duration

• Injection Pressure

Port Design effect

Combined Manifold-Port

Boost Pressure

Swirl EGR Ratio

effect

 Spray Bowl Interaction Compression Ratio Injector Spray Angle

 Number of Nozzle Holes Nozzle Tip Protrusion

> Selection & Integration **DPF** Calibration SCR Calibration

Vehicular & **OBD**

Vehicular, field & Environmental trials OBD Calibration

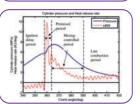
Emission Optimization & Calibration

- Hardware Screening Nozzle, Bowl, Swirl etc
- Full Load Performance
- Steady State Cycle Emission Calibration
- Transient Cycle Emission Calibration
- DPF Calibration
- SCR Calibration

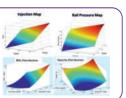
- Thermal Management for aftertreatment
- RDE & Off Cycle Emission Calibration
- Vehicular Calibration
- Environmental Corrections
- OBD & Diagnostic Calibration

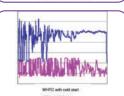
ET (Energizing Time)Data













Exhaust After Treatment Calibration



HD Diesel -Common Rail Engine

Existing State-of-the-art Facility

Steady State upto 560kW and Transient upto 600kW Test Beds

Pre - Post Emission Measurement Systems FTIR Emission systems,

Partial Flow PM & PN systems, with HSDA Systems

Vehicle Chassis Dynamometer with Emission Mesurment Systems

Durability Test Cells

Flow Calibration Facility Accredited to ISO/IEC 17025:2005

Transient Test Facility up to 600 kW- capacity to measure Emission and Performance of Automotive and Non-Automotive Engines (BS-VI / CEV/Tractor Engines) Suitable for Engine operating on fuel types- Diesel, Gasoline, CNG, Biodiesel, Ethanol ED95, Methanol.



Test Facilities





Virtual Test Bed (VTB)

Blow- by and Air flow meter calibration rig

Virtual calibration of Engine & Vehicle

HD RDE Calibration

HD commercial application Reproducing vehicle data measured using PEMS Engine and EAT calibration for variation in parameters such as ambient, driver, vehicle platforms etc.

EAT Calibration for Low Temperature Combustion Concept

HD commercial application DOC-DPF-SCR sizing & Calibration for steady state & Transient Thermal management comparison with ITV, ETV, post injection strategies Fault code checking

Vehicle fuel efficiency improvement & Energy audit projects for conventional & Electric vehicle



Vehicle Fuel efficiency improvement & energy audit by Simulation



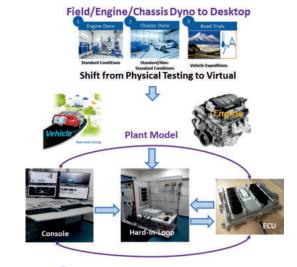
Electric vehicle range estimation by assessment of battery and motor characteristics



Simulation Reduces-Time Cost / Manpower Variant build & testing



Identifying the potential areas for fuel efficiency improvement



- Duty Cycle/ Mission **Profile**
- Vehicle Speed
- Traffic density
- GPS Co-ordinates,
- Driver Behavior
- Vehicle Testing
- Drag Area Calculation (Cd*A) by VECTO Procedure



Component Testing/ **EV Testing**

- Engine Maps
- Transmission efficiency
- Auxiliary Power
- Tyre RRC Test
- Motor Testing
- Battery Testing

Chassis Dyno Trials

Drivetrain Loss Measurement

Sensitivity Analysis

- Air drag
- Transmission ratios
- Auxiliary power
- Tyre RRC
- Gear Shift Optimization





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