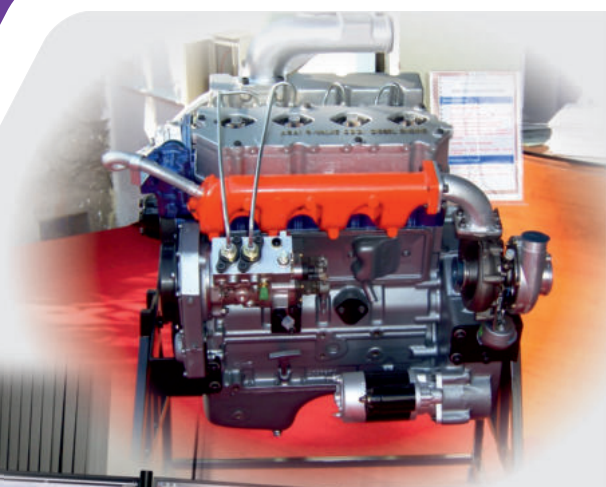
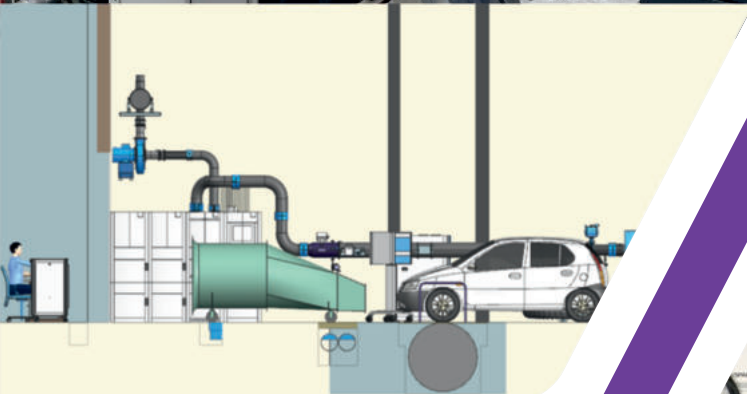


ENGINE DEVELOPMENT LABORATORY

DEVELOPMENT | CALIBRATION | SIMULATION

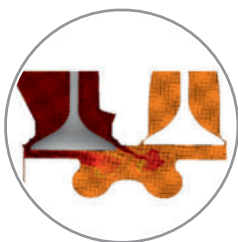
ENGINE - Powering Your Mobility



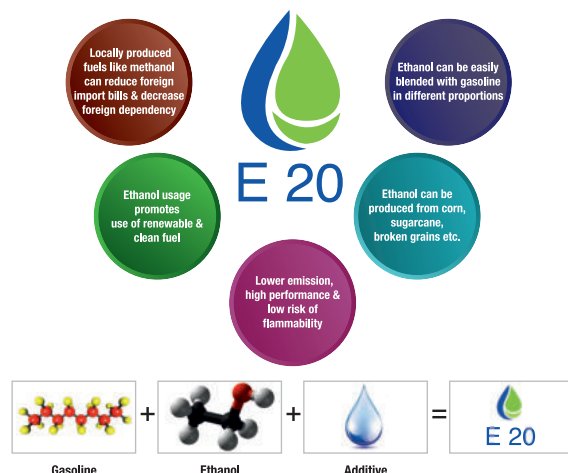
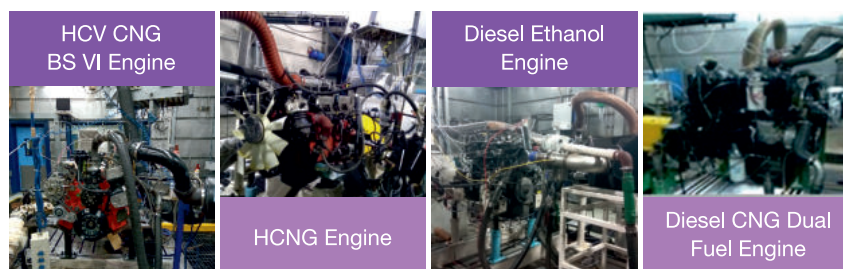
Engine development Lab (EDL) at ARAI is a state of the art R&D centre for engine and vehicle development. EDL is engaged in various research, development and evaluation of all types of IC engines such as diesel, gasoline, CNG, LNG, LPG, HCNG, Hydrogen, Ethanol, Bio-diesel, Methanol, DME and Dual Fuel 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
- Feasibility for Future Emission Road map
- Engine Calibration
- On-Board Diagnostics (OBD) Calibration
- After Treatment Calibration
- Vehicle fuel efficiency improvement & 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:

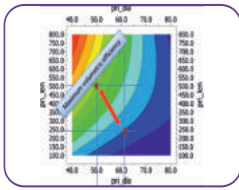
- Rich calibration experience of more than 25 years +
- Experience of various fuel system technologies Carburation to injection
- Experience of various types of engines Single Cylinder to Multiple cylinder
- Experience of different types of vehicles 2 Wheeler to HCV, Off Highway, Agriculture, Genset, 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”

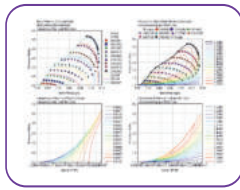


1D Air Handling & Gas Exchange Analysis

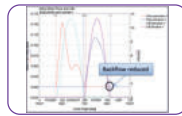
Air Handling System



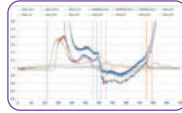
Intake & Exhaust System Tuning



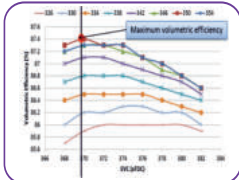
TC Matching



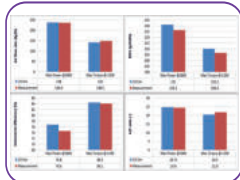
Gas Exchange



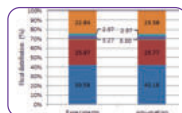
Measurements before & after modifications



Valve Timings, Profile & port flow Coefficient



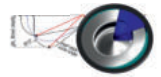
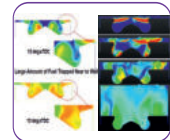
Comparison of Predicted & Measured results



Energy Audit

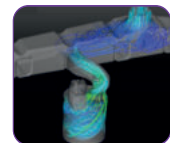
3D Combustion Simulation

- Bowl Geometry
- Spray Bowl Interaction
- Compression Ratio
- Injector Spray Angle
- Number of Nozzle Holes
- Nozzle Tip Protrusion
- Injection Timing
- Injection Duration
- Injection Pressure
- Boost Pressure
- Swirl
- EGR Ratio
- Port Design effect
- Combined Manifold-Port effect

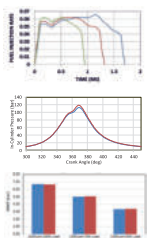


Combustion Chamber For CNG/H2 ICE Design

Soot-in Oil Analysis Air Utilization Study

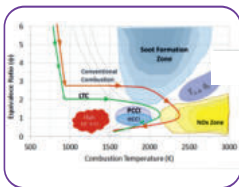


Effect of Manifold design on Swirl and Combustion

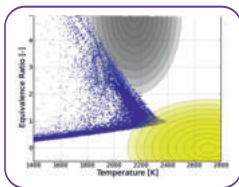


Case Study Validation

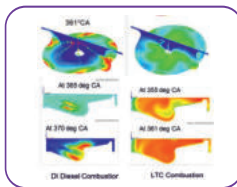
Advanced combustion Strategies for BS VI and BS VII



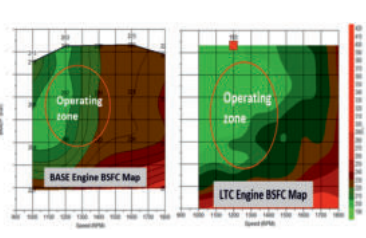
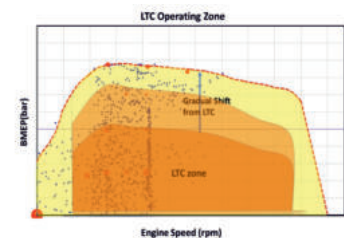
LTC Concept



T - φ Analysis



Spray Bowl Interaction



Combustion Hardware Selected by Simulation

Engine Level Calibration

Engine Out Emissions
Performance & Efficiency
Aftertreatment & OBD

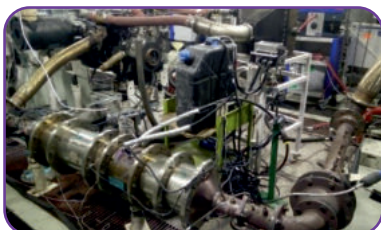
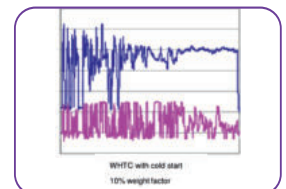
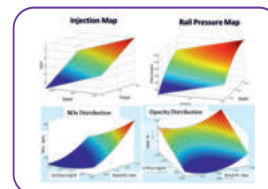
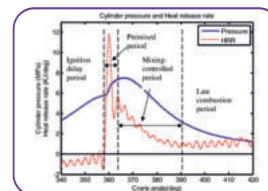
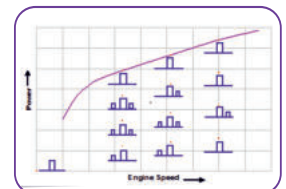
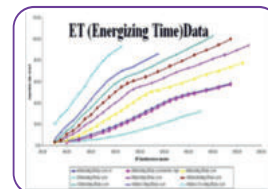
Complete Solution for
BS VI/TREM V/CPCB IV +
Concept to
Vehicular, RDE
& OBD trials

EGT
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

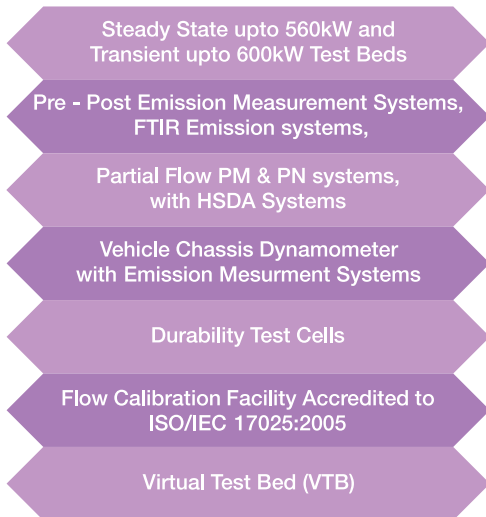


Exhaust After Treatment Calibration



HD Diesel -Common Rail Engine

Existing State-of-the-art Facility



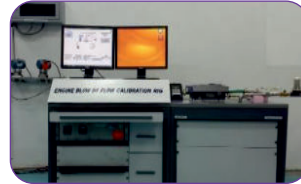
Transient Test Facility up to 600 kW- capacity to measure Emission and Performance of Automotive and Non-Automotive Engines (BS-VI / CEV/Tractor Engines) Suitable for Engine operating on fuel types– Diesel, Gasoline, CNG, Biodiesel, Ethanol ED95, Methanol.



Test Facilities



Virtual Test Bed (VTB)



Blow-by and Air flow meter calibration rig

Virtual calibration of Engine & Vehicle

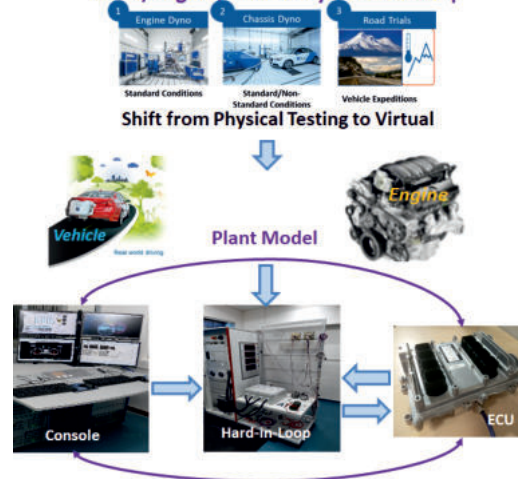
HD RDE Calibration

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

Field/Engine/Chassis Dyno to Desktop



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

