

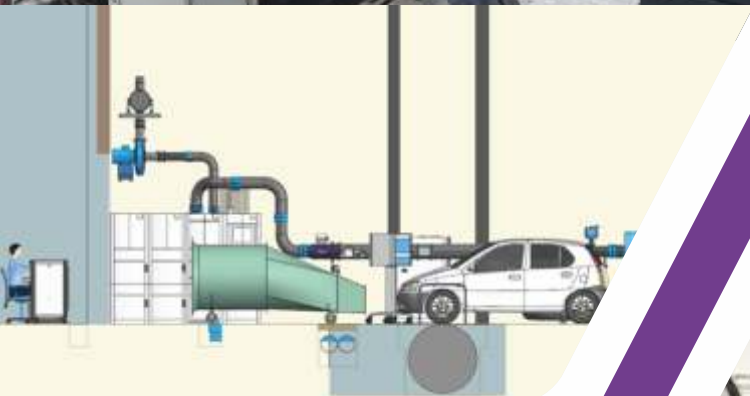


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**ARAI**  
Progress through Research

# ENGINE DEVELOPMENT LABORATORY

DEVELOPMENT | CALIBRATION | SIMULATION

ENGINE - Powering Your Mobility

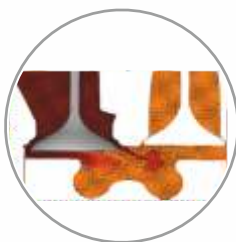


THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA

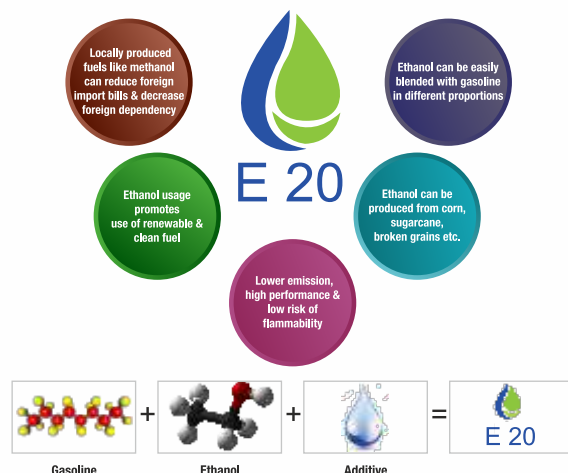
Engine development Lab (EDL) at ARAI is a state of the art R&D centre for engine and vehicle development. EDL is engaged in various research, development and evaluation of all types of IC engines such as diesel, gasoline, CNG, LNG, LPG, HCNG, Hydrogen, Ethanol, Bio-diesel, Methanol, DME and Dual Fuel 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

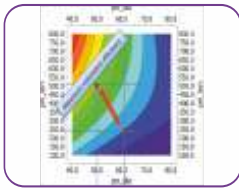
ARAI has been identified as a center of excellence in “Green Hydrogen” & “Flex Fuel”



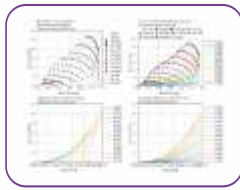


## 1D Air Handling & Gas Exchange Analysis

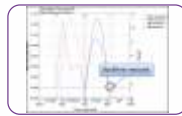
### Air Handling System



Intake & Exhaust System Tuning



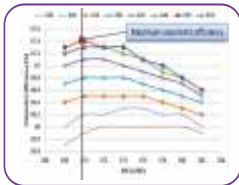
TC Matching



Gas Exchange



Measurements before & after modifications



Valve Timings, Profile & port flow Coefficient



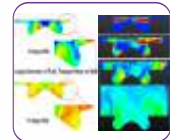
Comparison of Predicted & Measured results



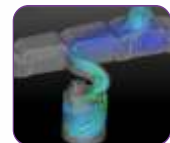
Energy Audit

## 3D Combustion Simulation

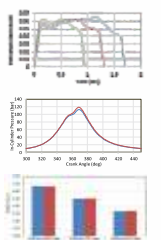
- Bowl Geometry
- Spray Bowl Interaction
- Compression Ratio
- Injector Spray Angle
- Number of Nozzle Holes
- Nozzle Tip Protrusion
- Injection Timing
- Injection Duration
- Injection Pressure
- Boost Pressure
- Swirl
- EGR Ratio
- Port Design effect
- Combined Manifold-Port effect



Soot-in Oil Analysis Air Utilization Study

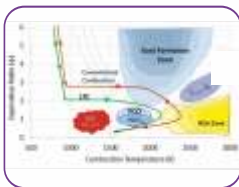


Effect of Manifold design on Swirl and Combustion

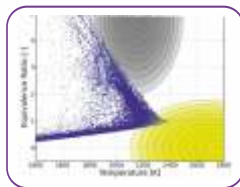


Case Study Validation

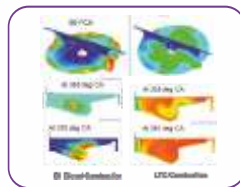
## Advanced combustion Strategies for BS VI and BS VII



LTC Concept



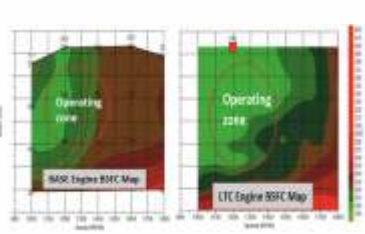
T - φ Analysis



Spray Bowl Interaction



LTC Operating Zone



Operating Zone

Operating Zone

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

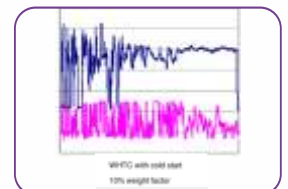
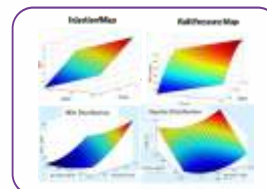
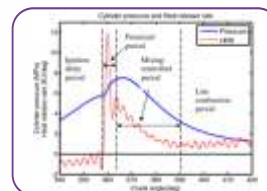
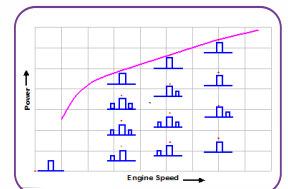
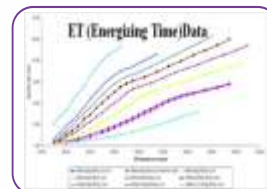
- Hardware Screening – Nozzle, Bowl, Swirl etc
- Full Load Performance
- Steady State Cycle Emission Calibration
- Transient Cycle Emission Calibration
- DPF Calibration
- SCR Calibration
- Thermal Management for aftertreatment
- RDE & Off Cycle Emission Calibration
- Vehicular Calibration
- Environmental Corrections
- OBD & Diagnostic Calibration



Exhaust After Treatment Calibration



HD Diesel -Common Rail Engine



## Existing State-of-the-art Facility

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 Measurement Systems

Durability Test Cells

Flow Calibration Facility Accredited to  
ISO/IEC 17025:2005

Virtual Test Bed (VTB)

**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.

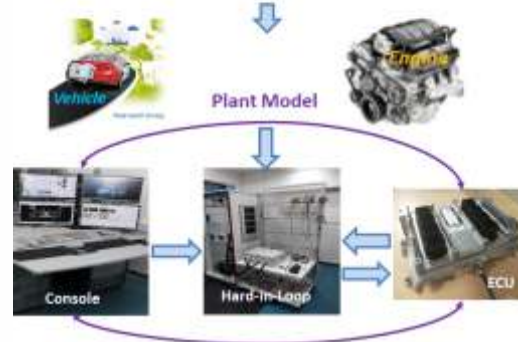
### EAT Calibration for Low Temperature Combustion Concept

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



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

