

Advanced Modeling Of Diesel engines Development of a computational tool for simulation of internal combustion engines

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Motivation

- Diesel engines
 - High fuel efficiency than gasoline engines
 - More pollutant emission than gasoline engines
- Oxygenated liquid fuels offer significant reduction in
 - Particulate emission
 - NO_x emission
 from Diesel engines



Objective

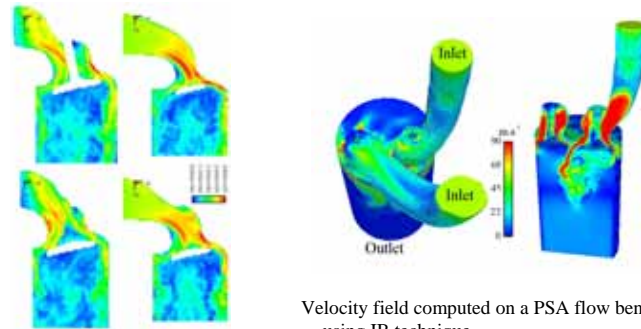
- To systematically study the effectiveness of oxygenated fuels in Diesel engine operating conditions
 - Experimental testing
 - Costly
 - Tedious
 - Computational testing
 - Attractive for parametric study
 - Need a computational tool capable of modeling the flow and combustion in an internal combustion engine.
- To perform three-dimensional numerical simulations of flow and combustion in realistic diesel engine configurations to study pollutant formation processes.

Capabilities of the computation tool

- Large eddy simulation (LES) turbulence modeling technique much more accurate than RANS
- Code capable of performing LES in engines should
 - Have higher order spatial and temporally accurate solvers
 - Accurately represent the geometrical complexities of the Diesel engine
 - Model the motion of the moving parts of an internal combustion engine
 - State of the art combustion models to simulate the turbulent combustion processes
 - Models for spray formation, evaporation and combustion processes in an engine
 - State of the art soot models

Immersed boundary technique

- All pre-existing engine codes based on unstructured grids
- Unstructured grid codes
 - Easy to represent complex geometries
 - Computationally expensive
 - Grid generation cumbersome and tedious
 - Restricted to low order of accuracy
- In this study we are focusing on structured grid codes
 - Easy to implement higher order formulation
 - Computationally inexpensive
 - Easy grid generation
 - Difficult to represent complex geometries
- To facilitate modeling of complex geometries
 - Immersed boundary technique

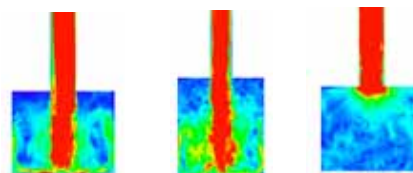


Velocity field computed on a PSA flow bench using IB technique

Velocity field computed on a GM flow bench using IB technique

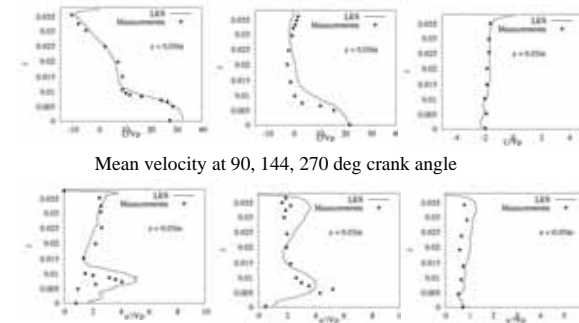
Moving mesh

- Motion of piston is 1 dimensional
- Use moving mesh algorithm to model the motion of piston
 - Computationally inexpensive
 - Less mesh distortion
 - More accurate than IB



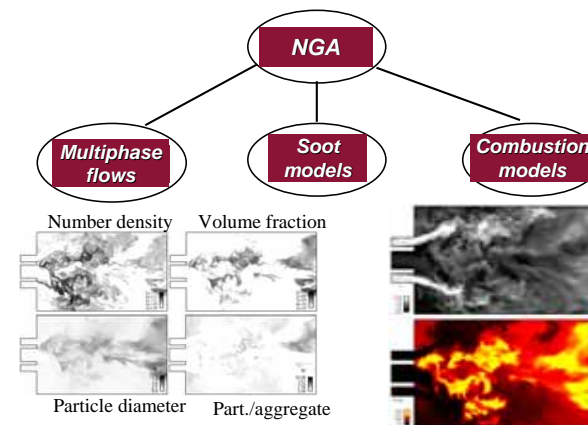
Velocity field computed by LES at 90,140 and 270 deg of a 2 Stroke cycle from simplified piston cylinder assembly

For the same case, quantitative comparison of velocity field with experimental data are shown below



Turbulent velocity fluctuations at 90, 144, 270 deg crank angle

Multi-physics models



Velocity, temperature and soot profiles from a numerical simulation of swirling diffusion flame

Future work

- Full scale simulation of a Diesel engine.
- Study the performance of oxygenated fuels in Diesel engine conditions