

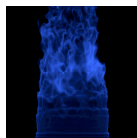
Shashank, Prahalad Iyengar, Liangyu Wang, Heinz Pitsch

## Motivation

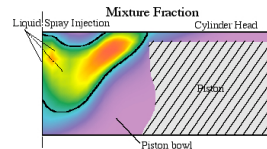
- Assess the fuel structure on emissions in diesel engine combustion and possible fuel optimization

## Objective

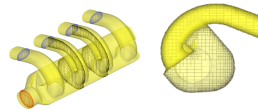
- Develop a computational facility
  - Large Eddy Simulation (LES)
  - Reynolds Averaged Navier Stokes (RANS) approach
  - Advanced combustion models
  - Advanced soot models
  - Advanced spray models
  - Surrogate fuels
- Immersed Boundary (IB) method



LES



RANS



Intake Manifold

## Challenges

- Complex geometry
- Moving parts
- Multiphysics interaction
- Chemistry
- Accuracy and efficiency

## Strategy

Based on the existing LES code

- Structured grid
- Accurate Navier Stokes solver
- Advanced numerical methods
- Multiphysics models

New Techniques implemented

- Immersed boundary (IB) method
  - Complex geometrical like valves
- Arbitrary Lagrangian Eulerian (ALE) approach
  - Moving piston

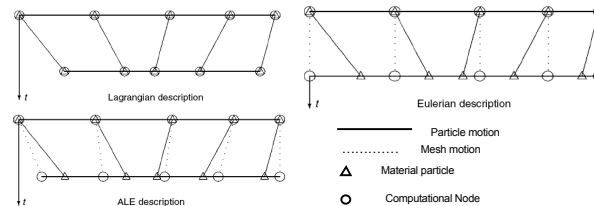
## Status of the Code

- ALE algorithm implemented in the structured grid solver
- IB technique implemented in the structured grid solver

## Arbitrary Lagrangian Eulerian Approach

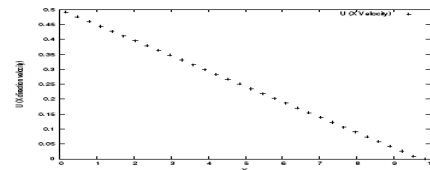
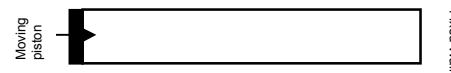
The computational nodes in this algorithm can be either

- Fixed as in Eulerian description of motion
- Following the material as in Lagrangian description of motion
- Moving in an arbitrary manner depending the resolution required



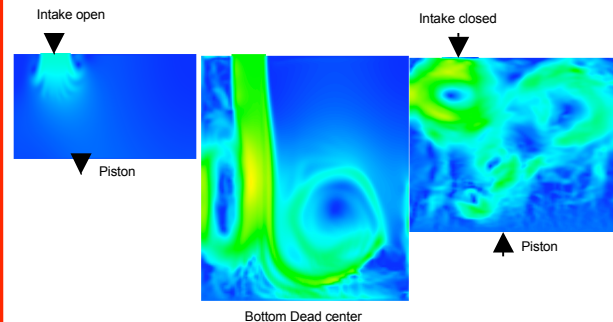
### Verification

Uniformly accelerated piston



### Results

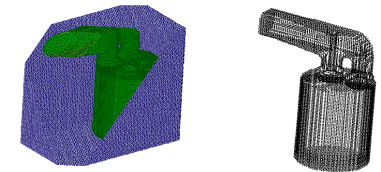
Flow in a simplified piston cylinder assembly



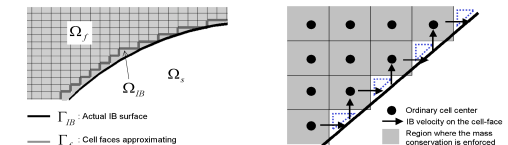
Velocity field at three different time steps in an expansion compression cycle

## Immersed Boundary (IB) Technique

- Maps complex geometry and moving parts onto structured grid
- Uses exact surface reconstruction technique on non-body conforming meshes
- Generate computational mesh easily even for complex geometry



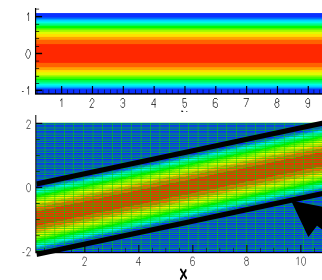
Complex geometry immersed in structured grid and the resulting grid



Representation of immersed boundary

### Verification and Validation

Channel flows: parallel and inclined



For 32 x 32 Grid  
 $L_x = 5.00E-03$   
 $L_z = 1.41E-02$

Walls, represented only by special reconstruction technique

## Future work

- Interfacing IB with STL files
- Coupling IB with ALE in the structured solver
- Towards realistic reciprocating engine simulations