APPLICATION OF LES TECHNIQUE FOR THE CALCULATION OF INTERNAL COMBUSTION ENGINE FLOWS

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LES FOR IC ENGINE SIMULATIONS

- *LES resolves all the turbulent spectrum larger than the grid scale (filter scale) & only the sub grid scale motion (SGS) is to be modelled*
- *SGS scales are isotropic and less sensitive to model parameters*
- *Hence LES provides an accurate way to investigate unsteady effects associated with mixture formation, combustion & cyclic variations in IC engines*
- *Present study aims to develop & validate an LES code for IC engine simulations*

COMPUTATIONAL APPROACH

- *KIVA 4 RANS code was modified to incorporate LES capability*
- *It uses an arbitrary Lagrangian Eularian approach to solve governing equations in unstructured hexahedron grids with moving boundaries*
- *SGS viscosity was modelled using SGS kinetic energy*

$$\mu_{sgs} = C_v \bar{\rho} k_{sgs}^{1/2} \bar{\Delta}$$

k_{sgs} – *SGS kinetic energy*
$\bar{\Delta}$ – *filter width*
ρ – *density*

- *Filter width is taken to be the cubic root of the computational cell volume*

COMPUTATIONAL APPROACH

- *The following transport equation is solved for k_{sgs}*

$$\frac{\partial}{\partial t}\left(\bar{\rho}k_{sgs}\right) + \nabla.\left(\bar{\rho}k_{sgs}\tilde{U}\right)$$

$$= -\left(\nabla \otimes \tilde{U}\right):\bar{\tau}_{sgs} - C_{\varepsilon}\bar{\rho}\,k_{sgs}^{3/2}\Big/_{\bar{\Delta}} + \nabla.\left(\frac{\mu_{sgs}}{Sc_k}\nabla k_{sgs}\right)$$

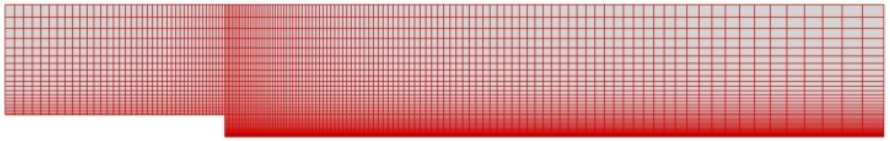
$$+ \overline{\dot{W}^{spary}}$$

$$U - velocity\ vector \quad \bar{\tau}_{sgs} - SGS\ stress\ tensor$$

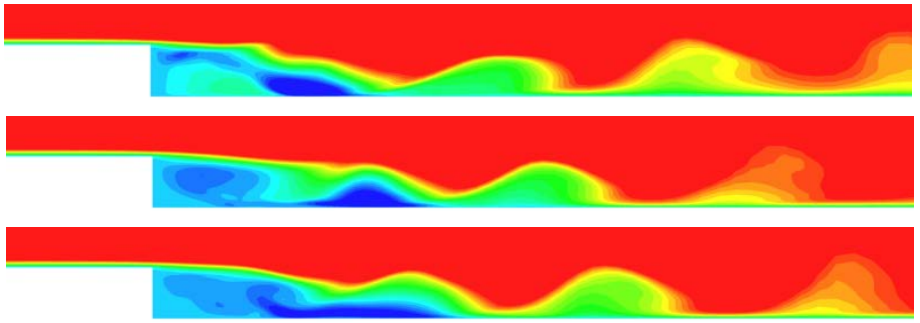
- *No-slip boundary conditions were imposed on solid walls*
- *Piston motion was modelled by removing and addition of cell layers to minimise the deformation of cells, so that the commutation error is minimum*

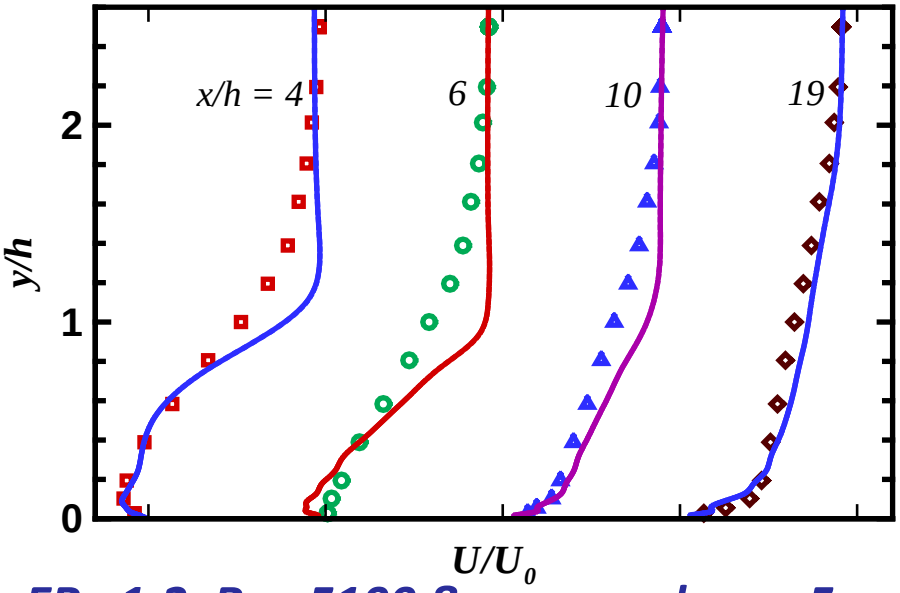
VALIDATION OF KIVA4:LES

❑ FLOW OVER A BACKWARD FACING STEP

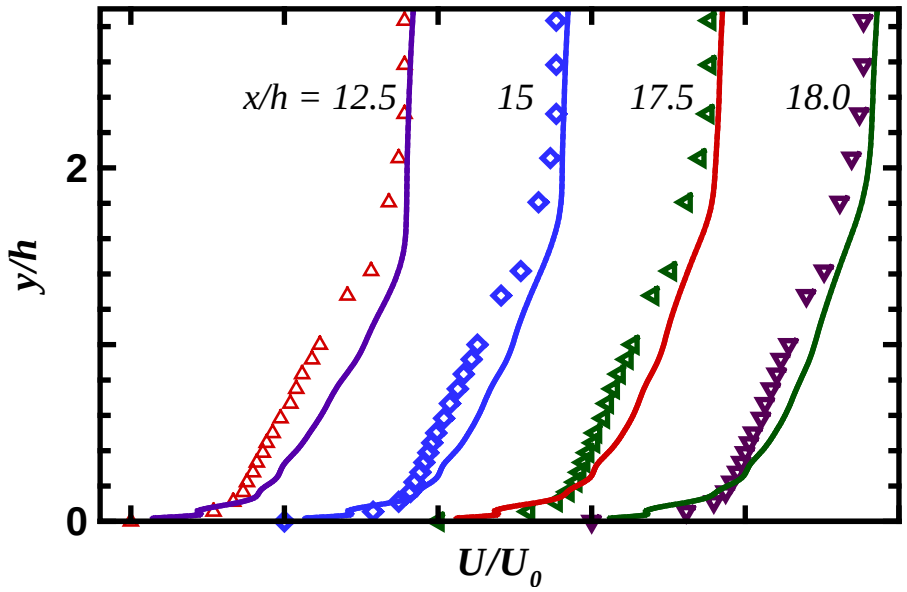


Computational mesh & instantaneous U velocity contour snaps at three instances





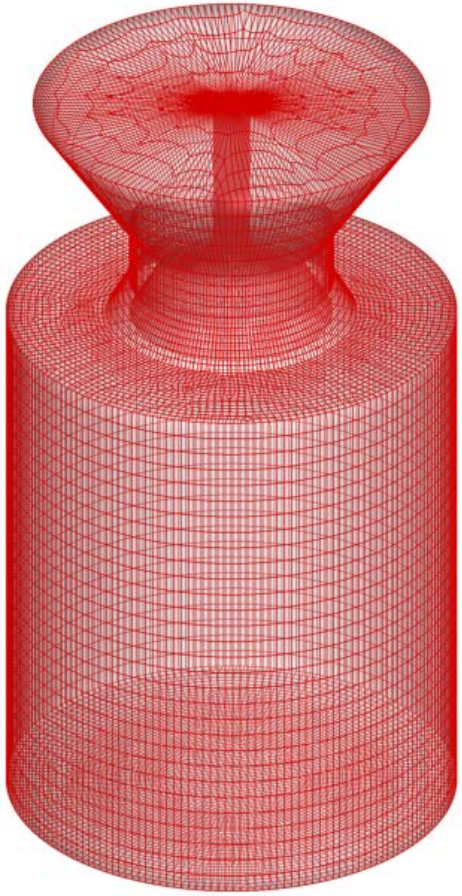
ER =1.2, Re= 5100 & averaged over 5 flow through times

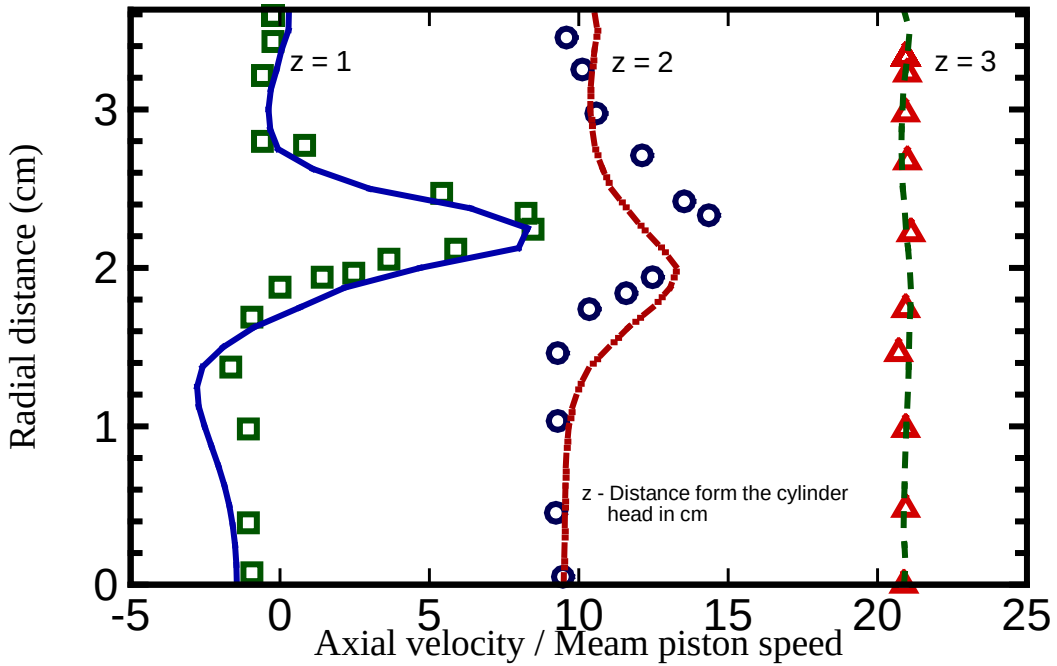


Symbols show measured values & lines show simulated results

VALIDATION OF KIVA4:LES

❑ FLOW IN AN AXISYMMETRIC ENGINE

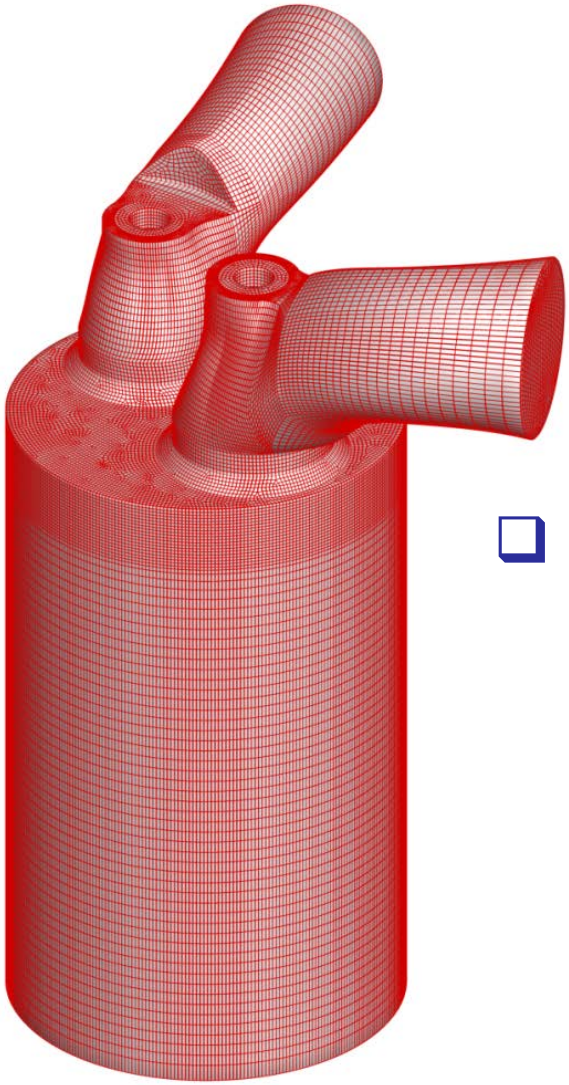




RPM= 200 & averaged over 5 cycles

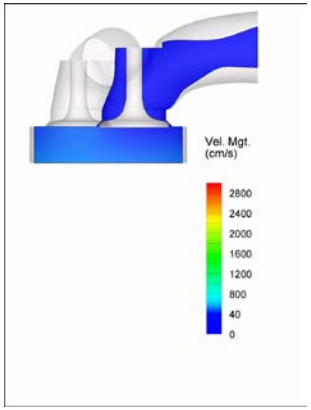
Crank position = 36 ATDC

APPLICATION TO SI ENGINE FLOWS

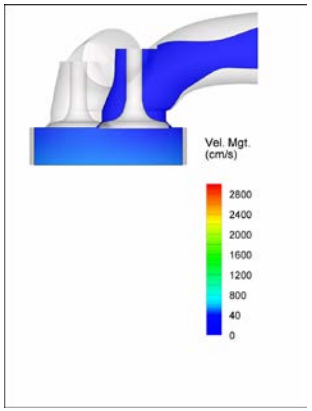


RICARDO E6 ENGINE	
BORE	7.62 cm
STROKE	11.11 cm
RPM	1800
NO. OF CELLS	0.8M

❑ *RANS RESULTS*



❑ *LES PREDICTIONS*



CONCLUDING REMARKS

- KIVA4:LES is only 2nd order accurate but predictions are in good agreement with experimental measurements
- Present LES formulation has been able to resolve most of the energy containing large scale motion
- Accuracy of the predictions are quite satisfactory compared to the relative low mesh densities used

Thank you very much for your cooperation !