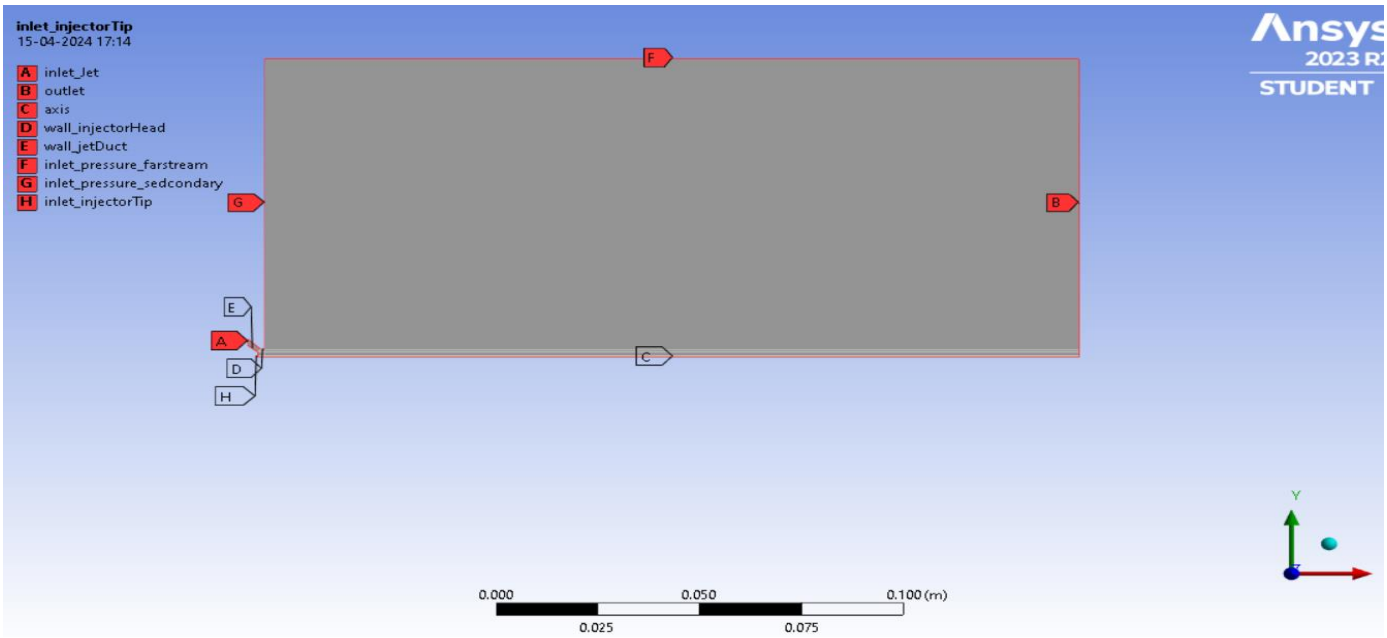
PROJECT : Fuel (methyl alcohol) injection simulation using DPM



Geometry:

Fig. 1 Flow Domain to be analyzed.

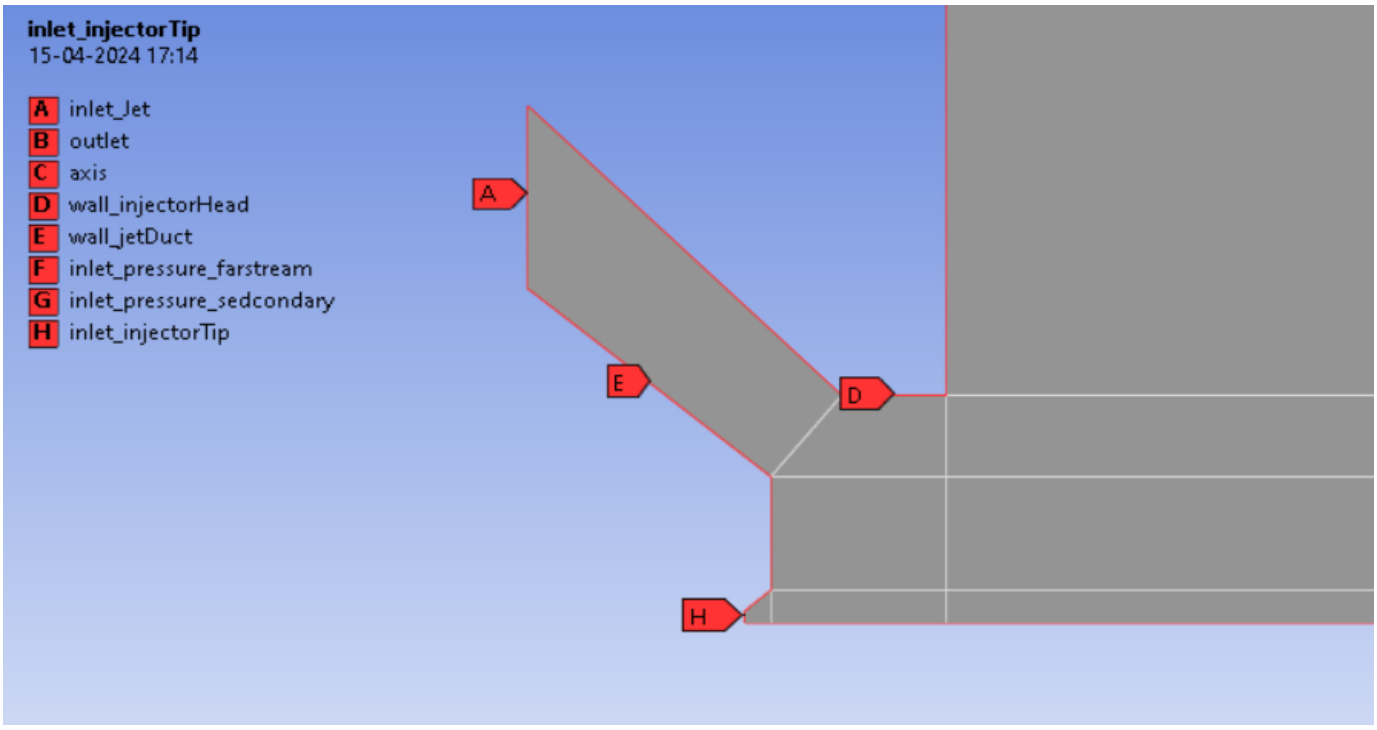


Fig. 2 Axis-symmetric model of injector.

Meshing:

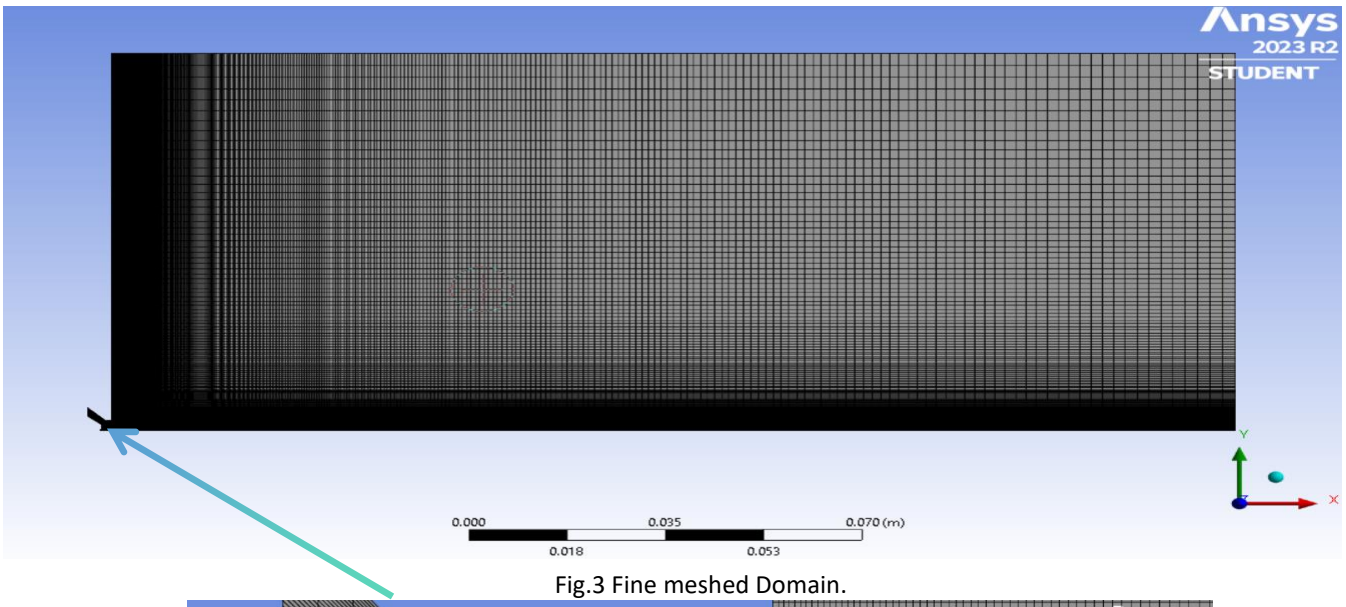


Fig.3 Fine meshed Domain.

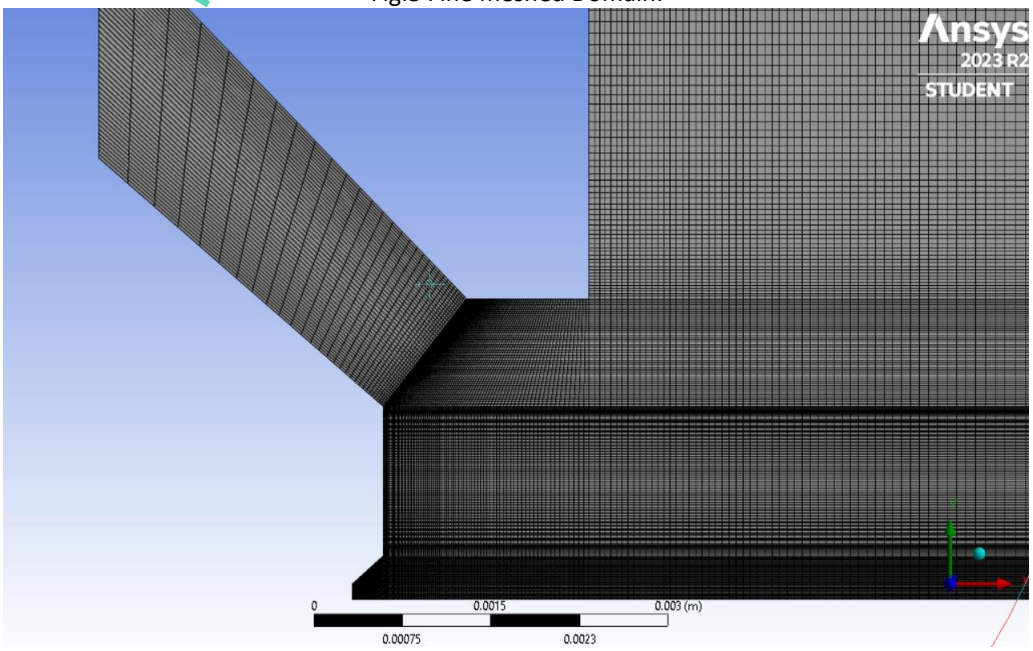


Fig. 4 injector part meshing.

Air flow model without injection(but species activated):

Mixture and Boundary condition specification:

In model section the species tab was turned on and methyl-alcohol air mixture was selected. In the Boundary condition of the species transport, only ch3oh and o2 was chosen. In the injector_tip inlet, 20m/s velocity was given with temperature of 300K,and in jet_inlet 20m/s velocity was given with temperature of 800K. Rest other inlets were pressure fed with 0 gauge pressure. In species mass fraction tab, all inlets have o2 as 0.21 and ch3oh as 0.

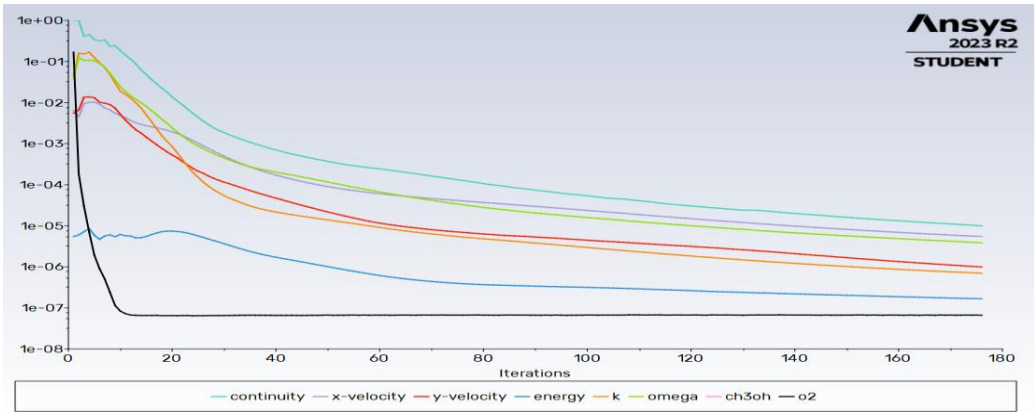


Fig 5 Convergence plot .

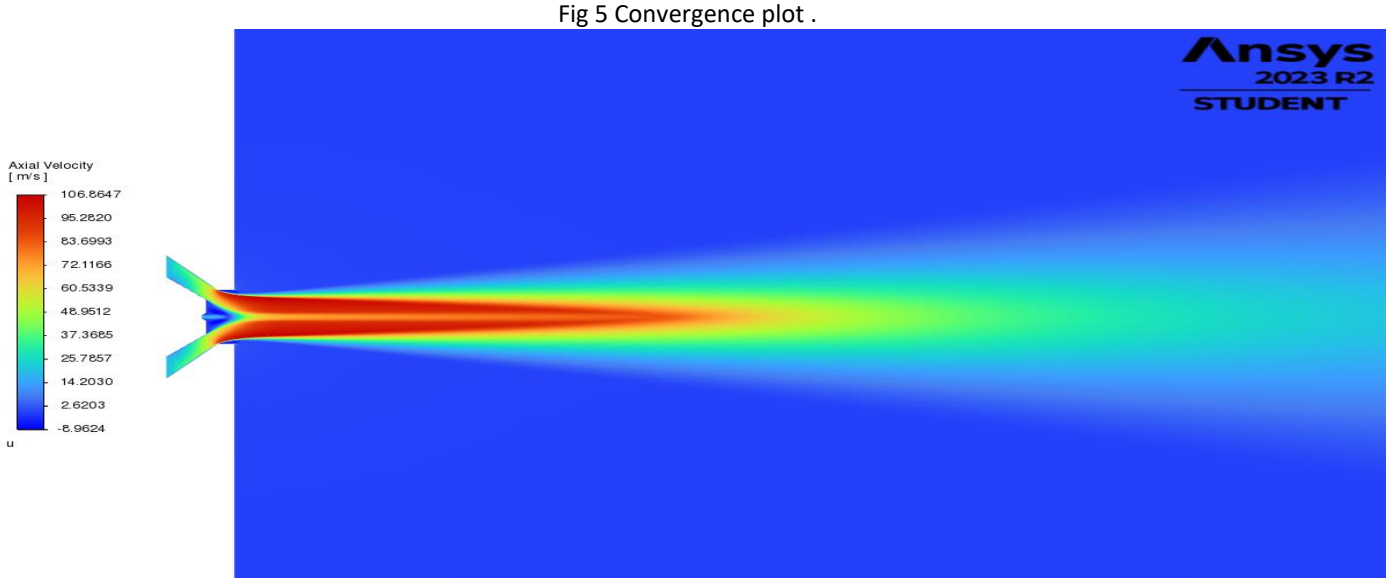


Fig. 6 Axial velocity contour.

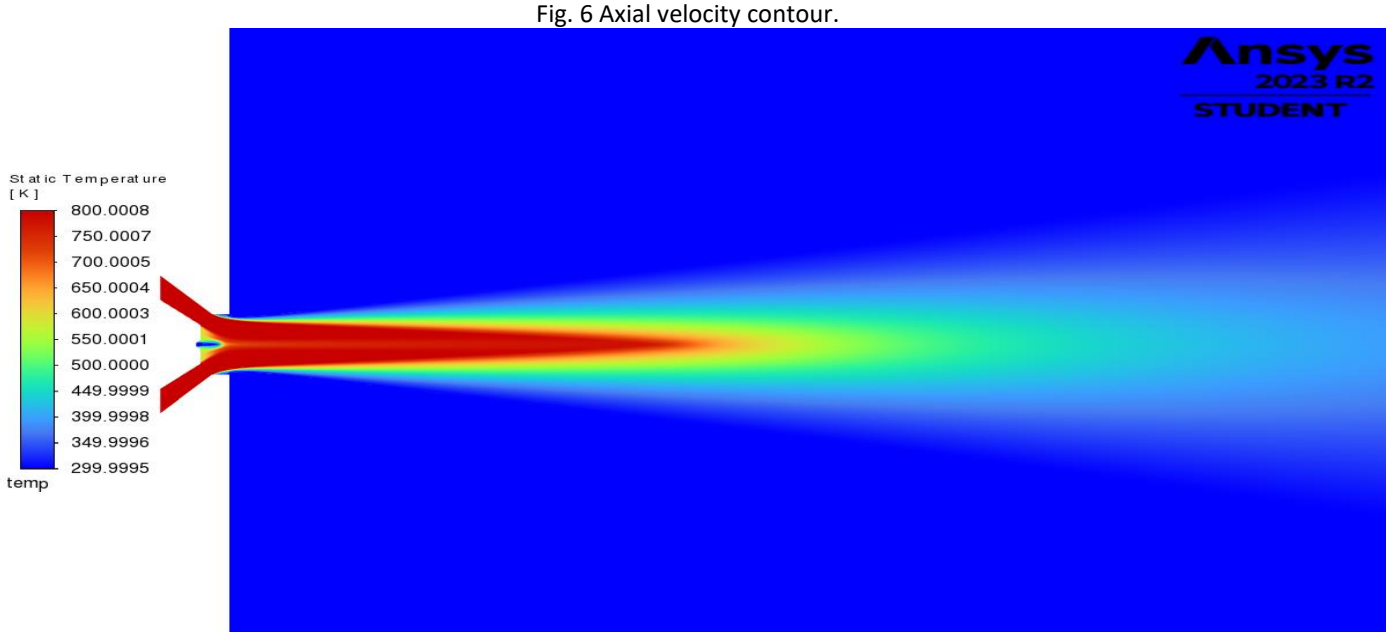


Fig. 7 Static Temperature contour.

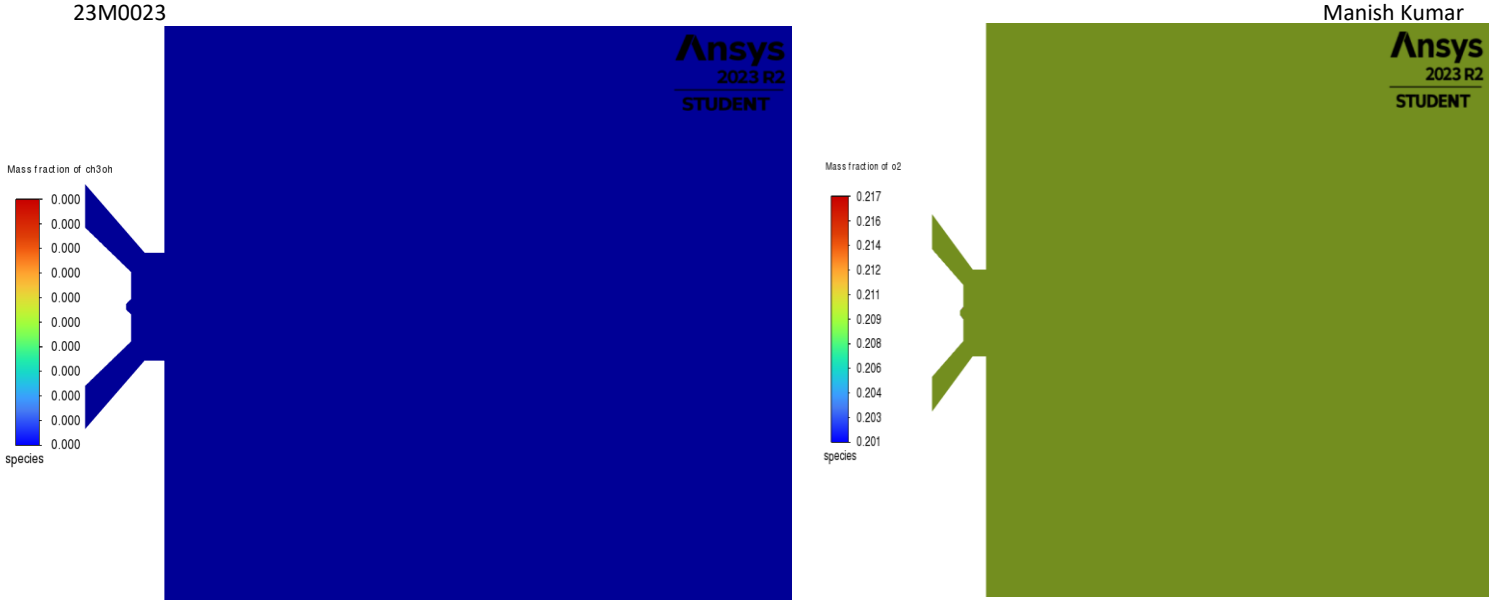


Fig 8. Mass fraction Contours of Ch3oh and o2 without injection.

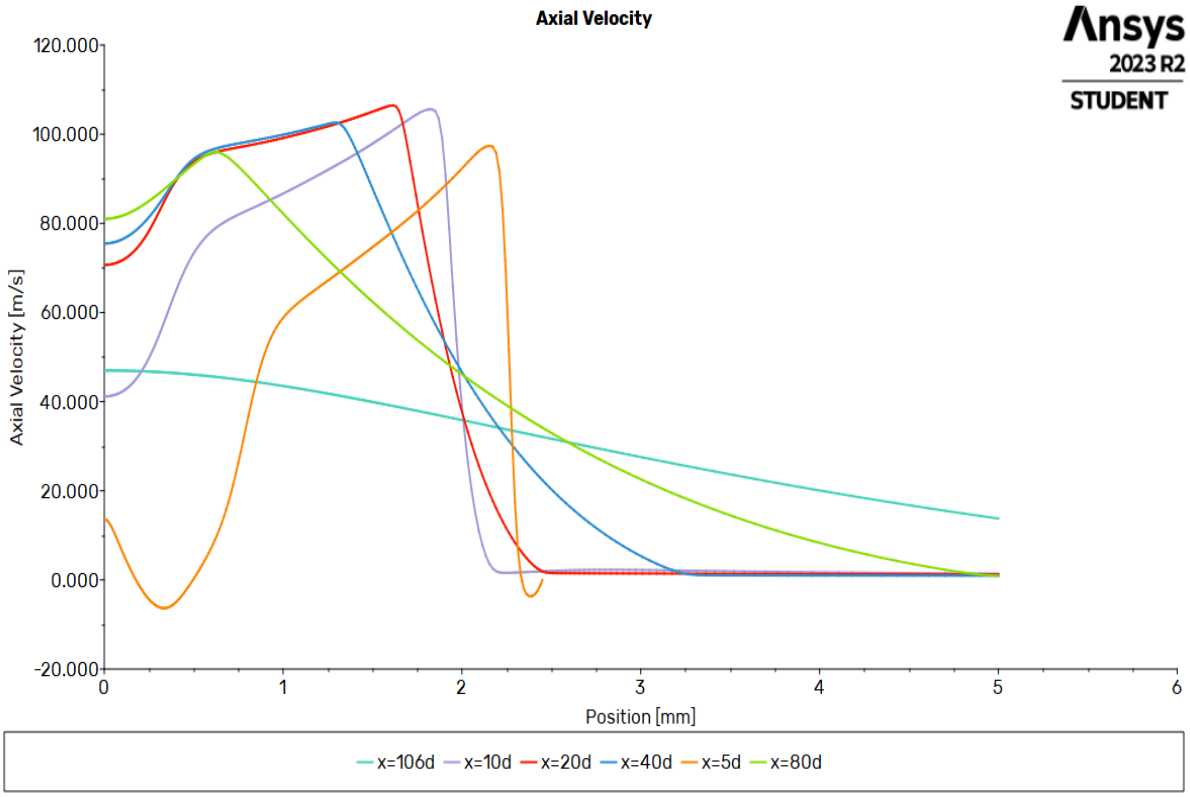


Fig. 9 comparison of axial velocity along radial direction at different locations.

Model with droplet injection.

In this the discrete phase model was turned of with continuous phase interaction, and a injector of surface injection type was created at the inlet of injector tip. Various other parameters are shown in fig 10.

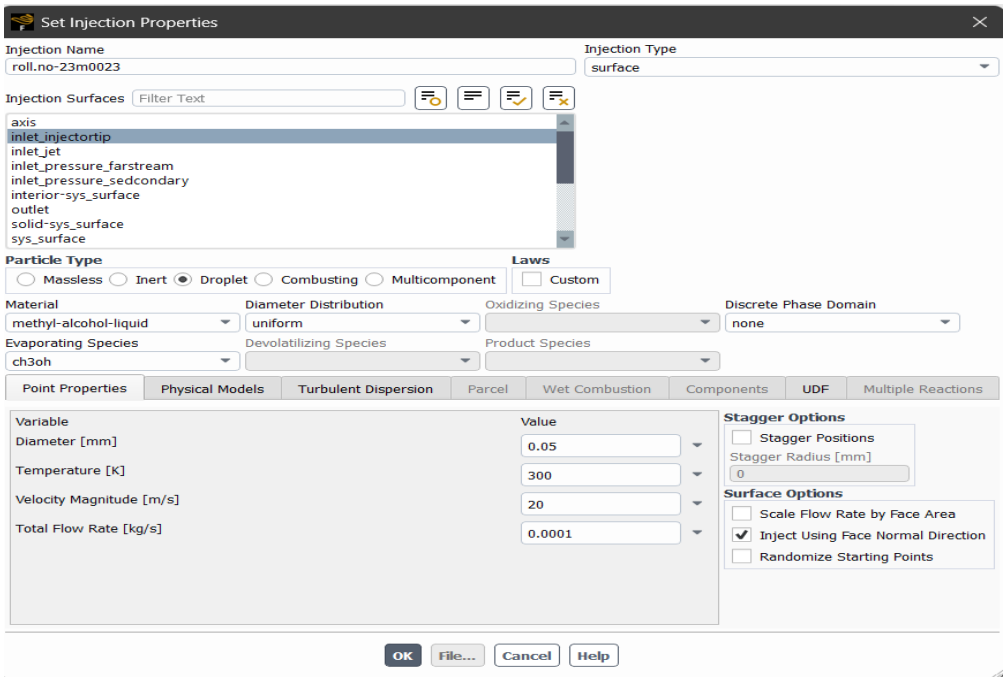


Fig.10 Injector specifications.

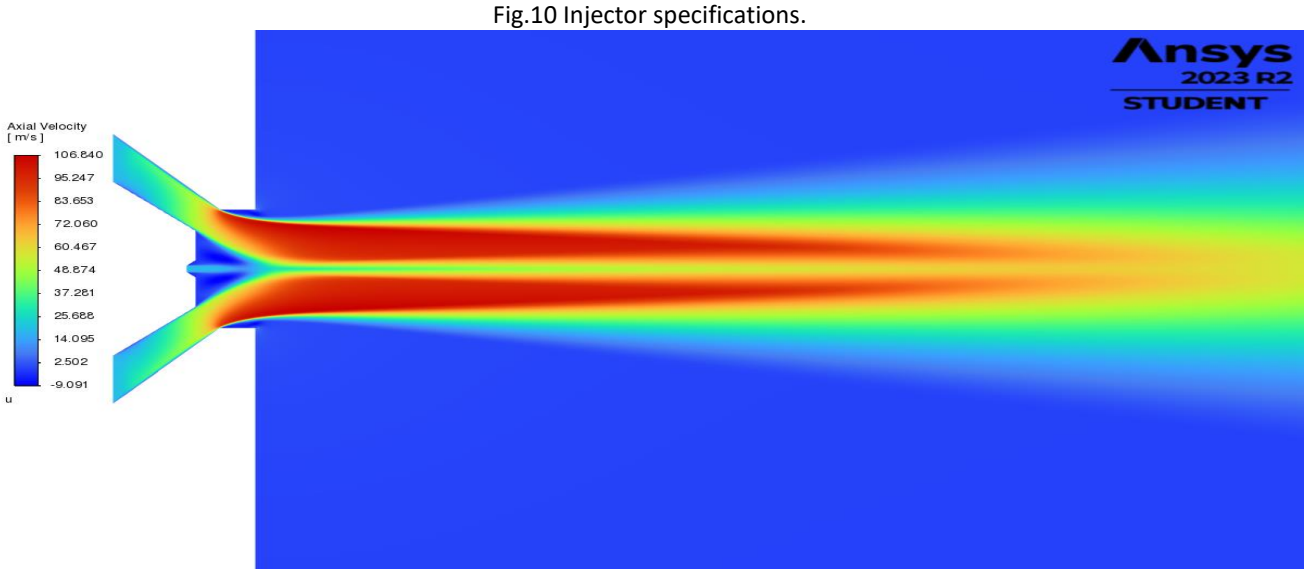


Fig.11 Axial velocity contour after injection.

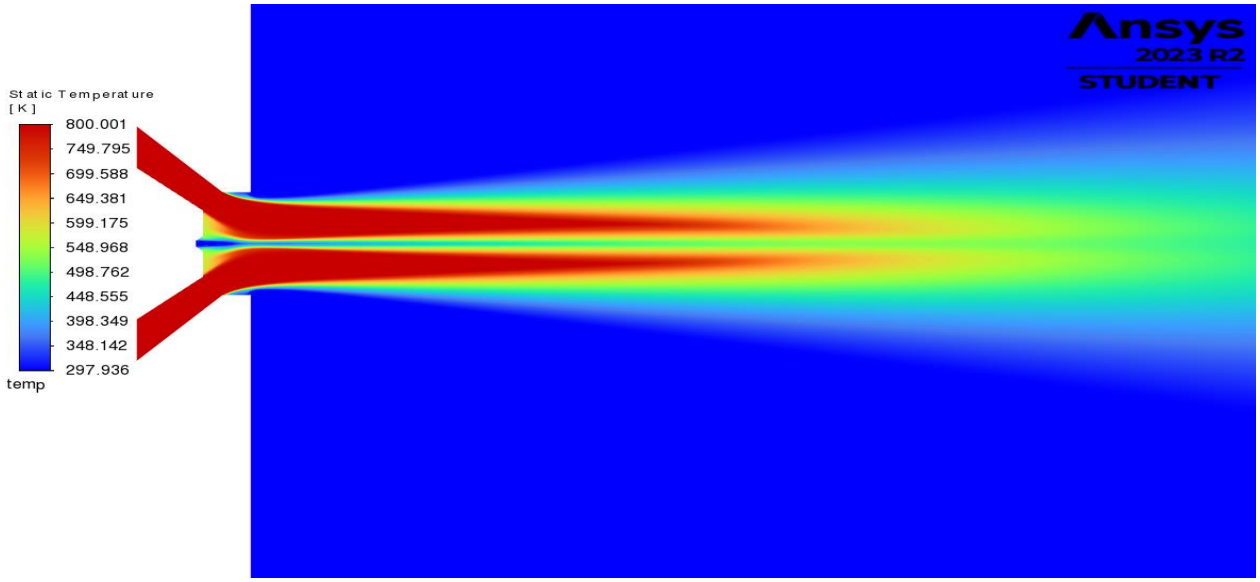


Fig.12 Static Temperature after injection.

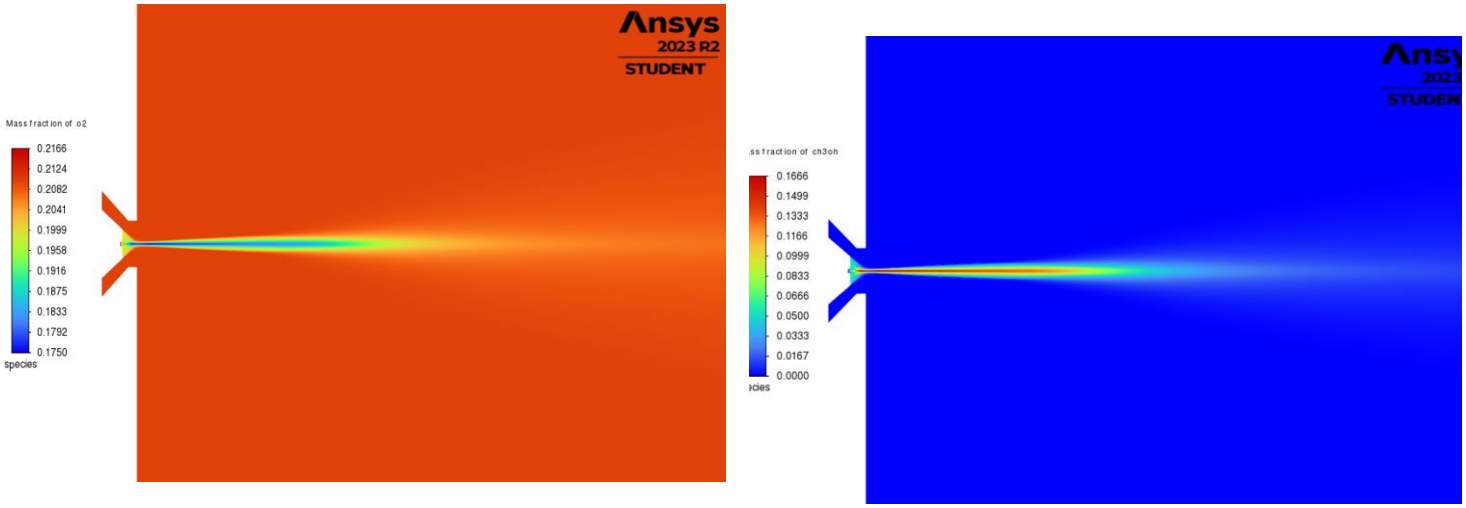


Fig 13 Mass fractions of o2 and ch3oh after injection of ch3oh.

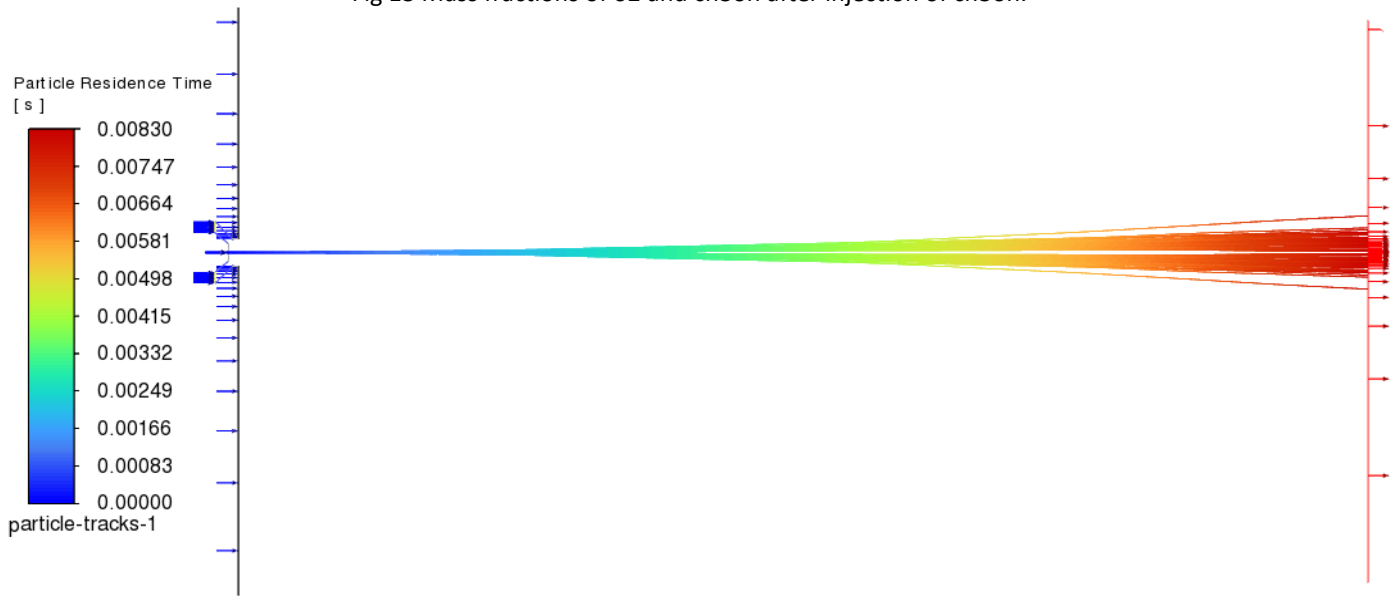


Fig. 14 Particle residence time.

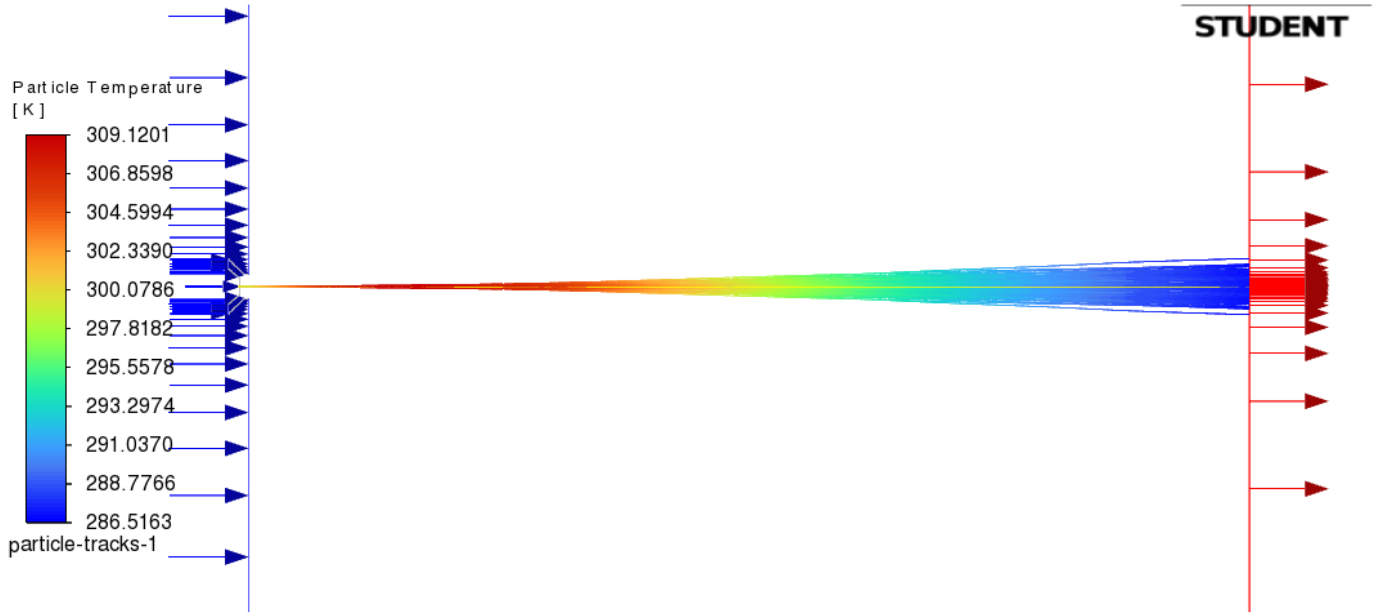


Fig.15 Particle Temperature.

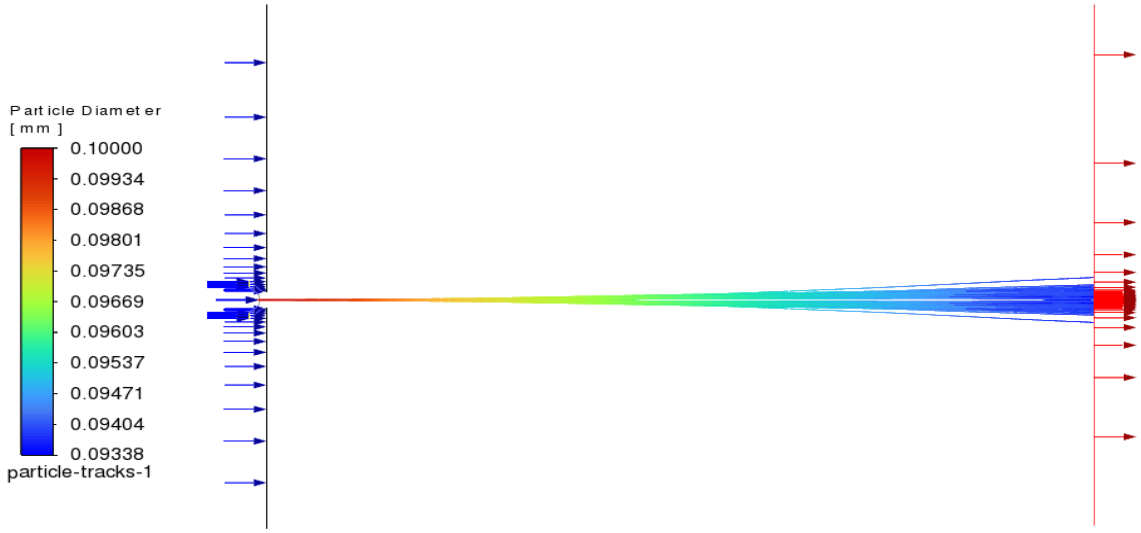
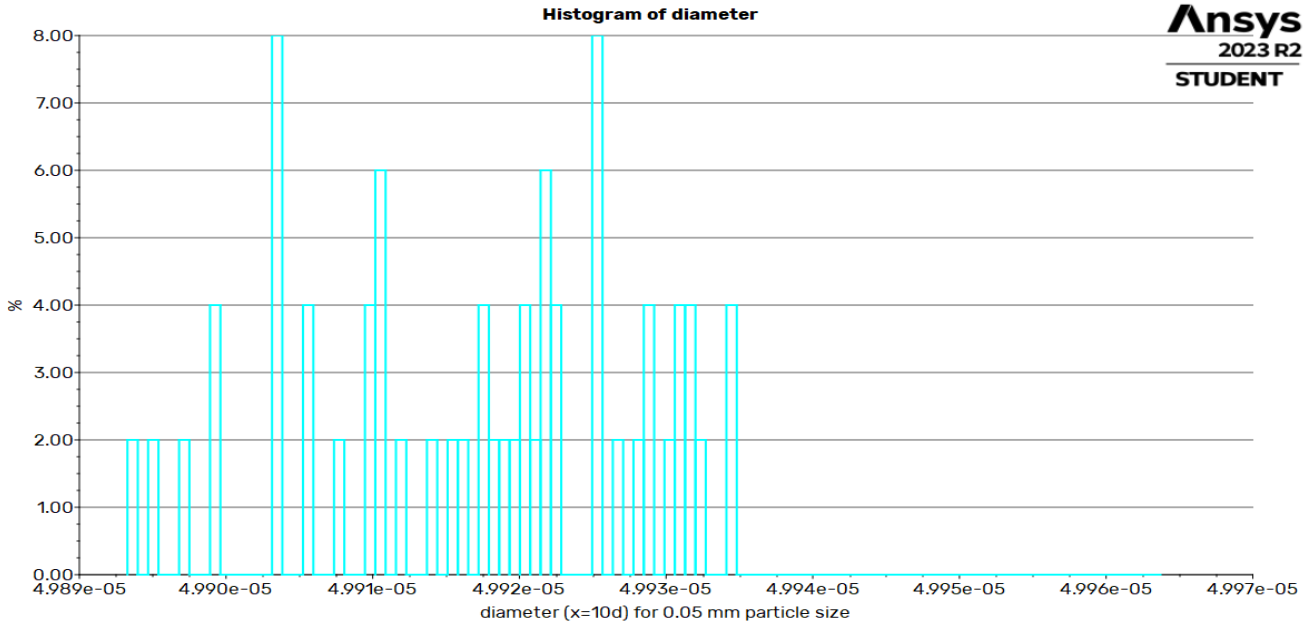
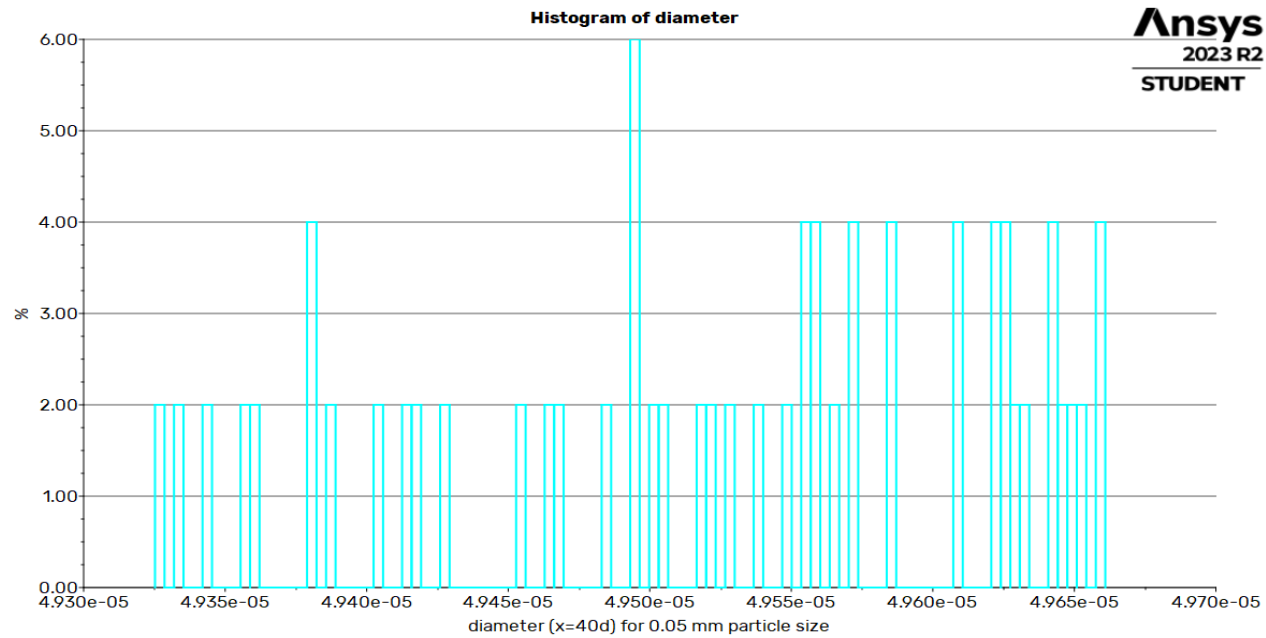


Fig 16 particle diameter.





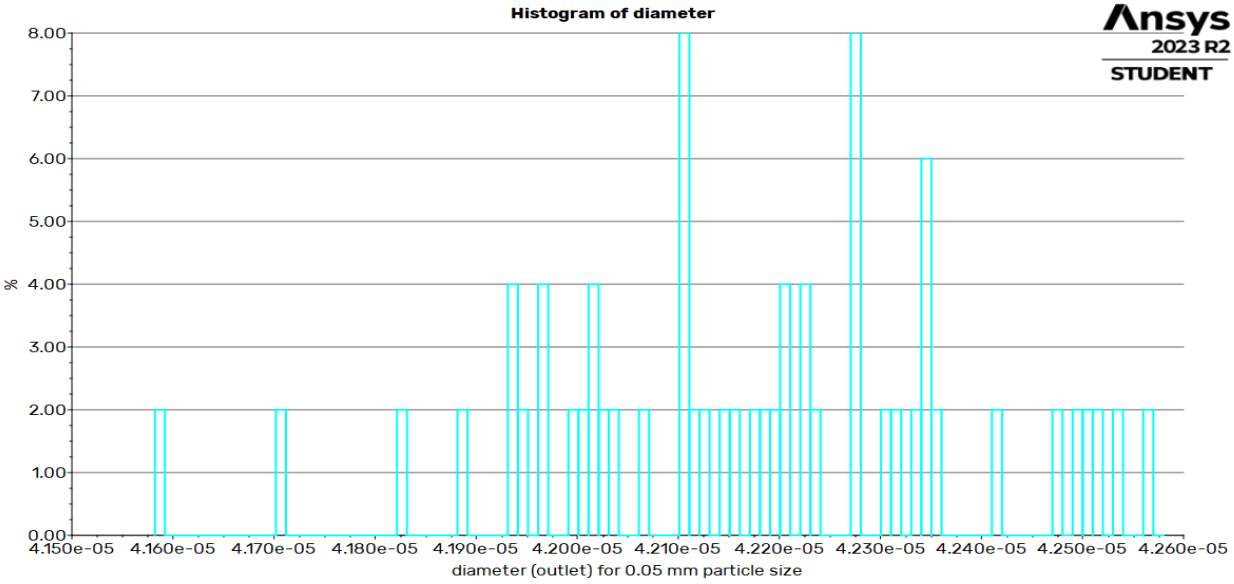


Fig. 17 Histograms of diameters at axial location 10d,40d and outlet.

Mass Flow Rate	[kg/s]
inlet_injectortip	1.2369892e-06
inlet_jet	0.00049648323
inlet_pressure_farstream	0.0094431639
inlet_pressure_sedcondary	0.0082229022
interior-sys_surface	-3.1318476
outlet	-0.018164564
sys_surface	0.00041245564
Net	-7.7763616e-07

Total Heat Transfer Rate	[W]
inlet_injectortip	0.0023168777
inlet_jet	262.25818
inlet_pressure_farstream	17.687021
inlet_pressure_sedcondary	15.401481
outlet	-290.76538
Net	4.5836167

Fig.18 Energy and mass balance report before injection.

Mass Flow Rate	[kg/s]
inlet_injectortip	1.2369892e-06
inlet_jet	0.00049648323
inlet_pressure_farstream	0.0093457317
inlet_pressure_sedcondary	0.0083159423
outlet	-0.018200602
DPM Mass Source	3.9960648e-05
Net	-1.247564e-06

Total Heat Transfer Rate	[W]
inlet_injectortip	0.0023168777
inlet_jet	262.25818
inlet_pressure_farstream	17.504524
inlet_pressure_sedcondary	15.575742
outlet	-248.76064
DPM Enthalpy Source	-43.047008
Net	3.533118

Fig. 18 Energy and mass balance report after injection.

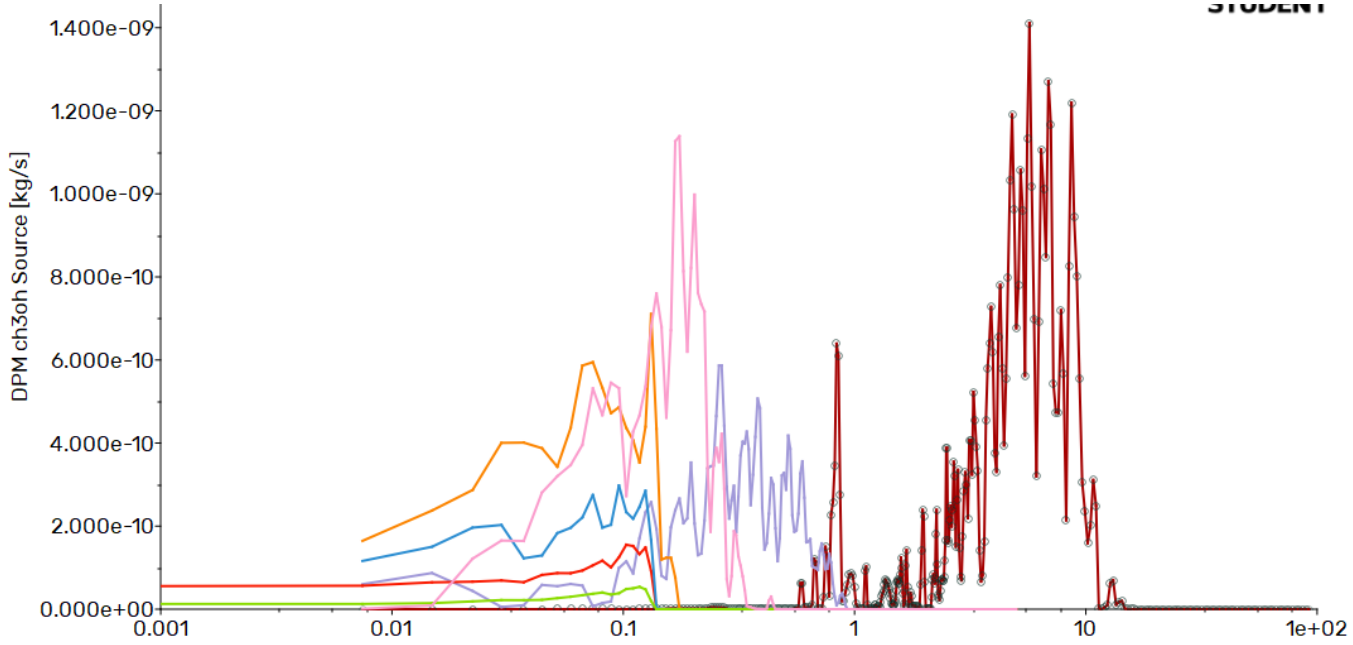


Fig 19 DPM ch3oh source.

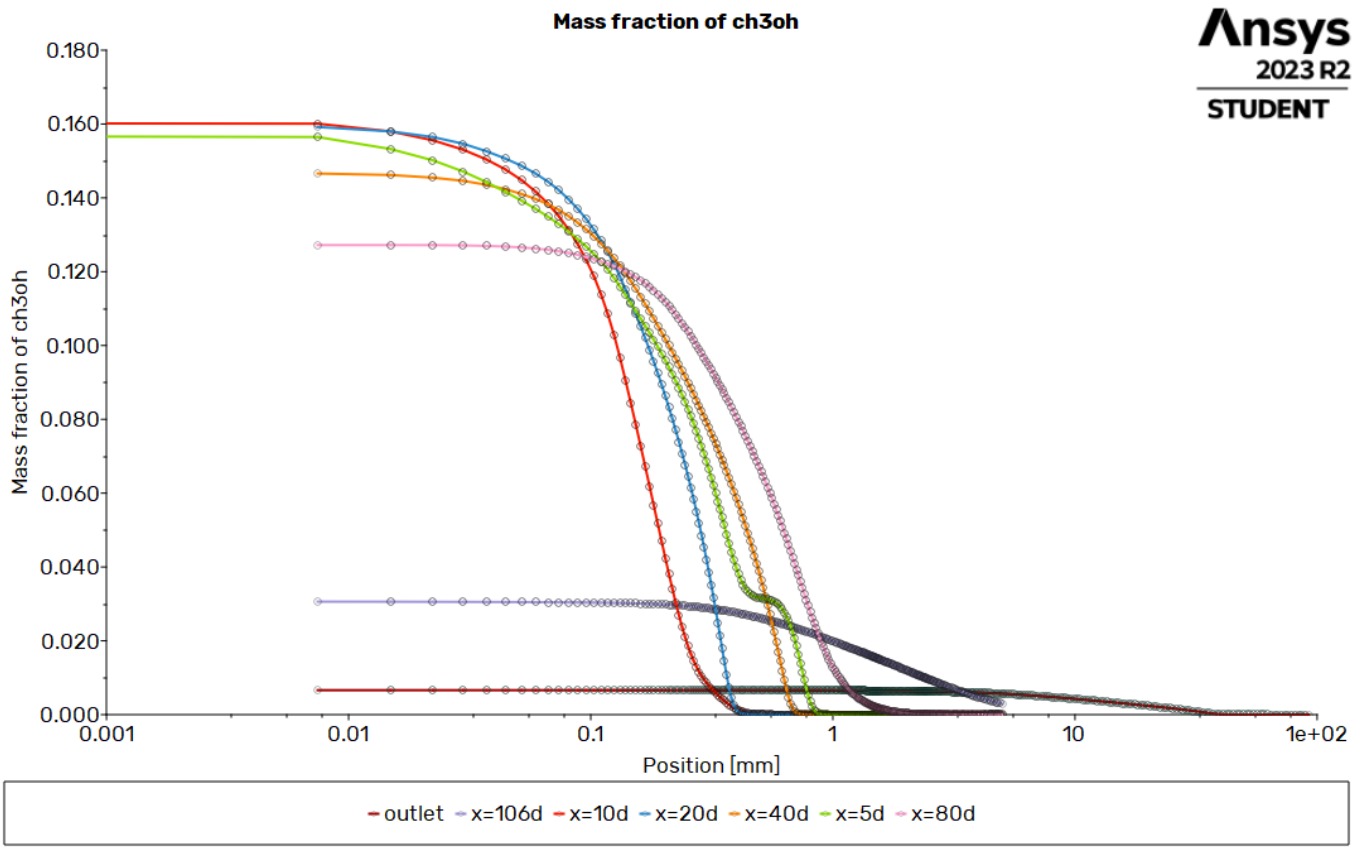


Fig. 20 Mass fractions of ch3oh at different location axially along radial direction.

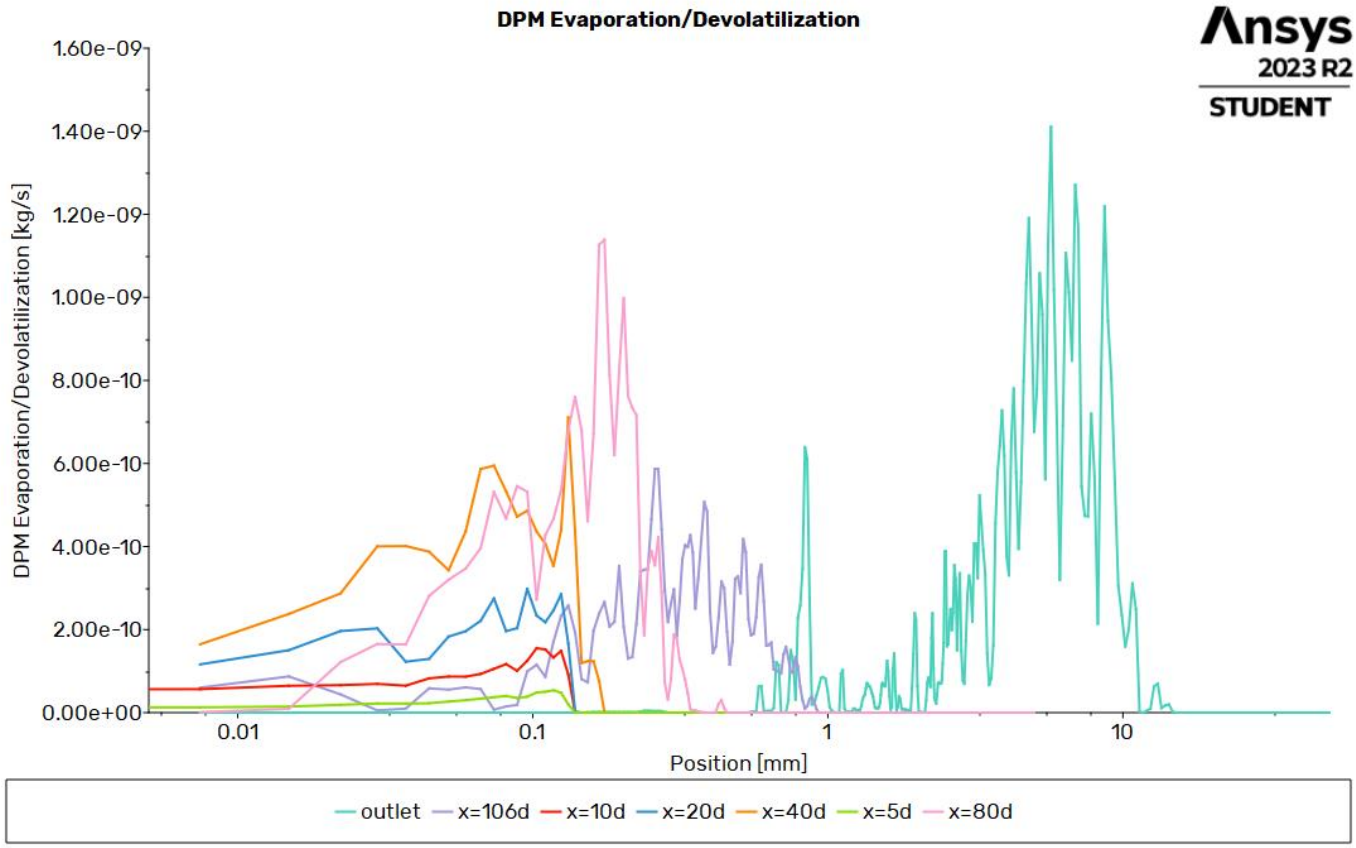


Fig. 21 Evaporation rates at different axial locations of ch3oh at 0 Pa reference gauge pressure.

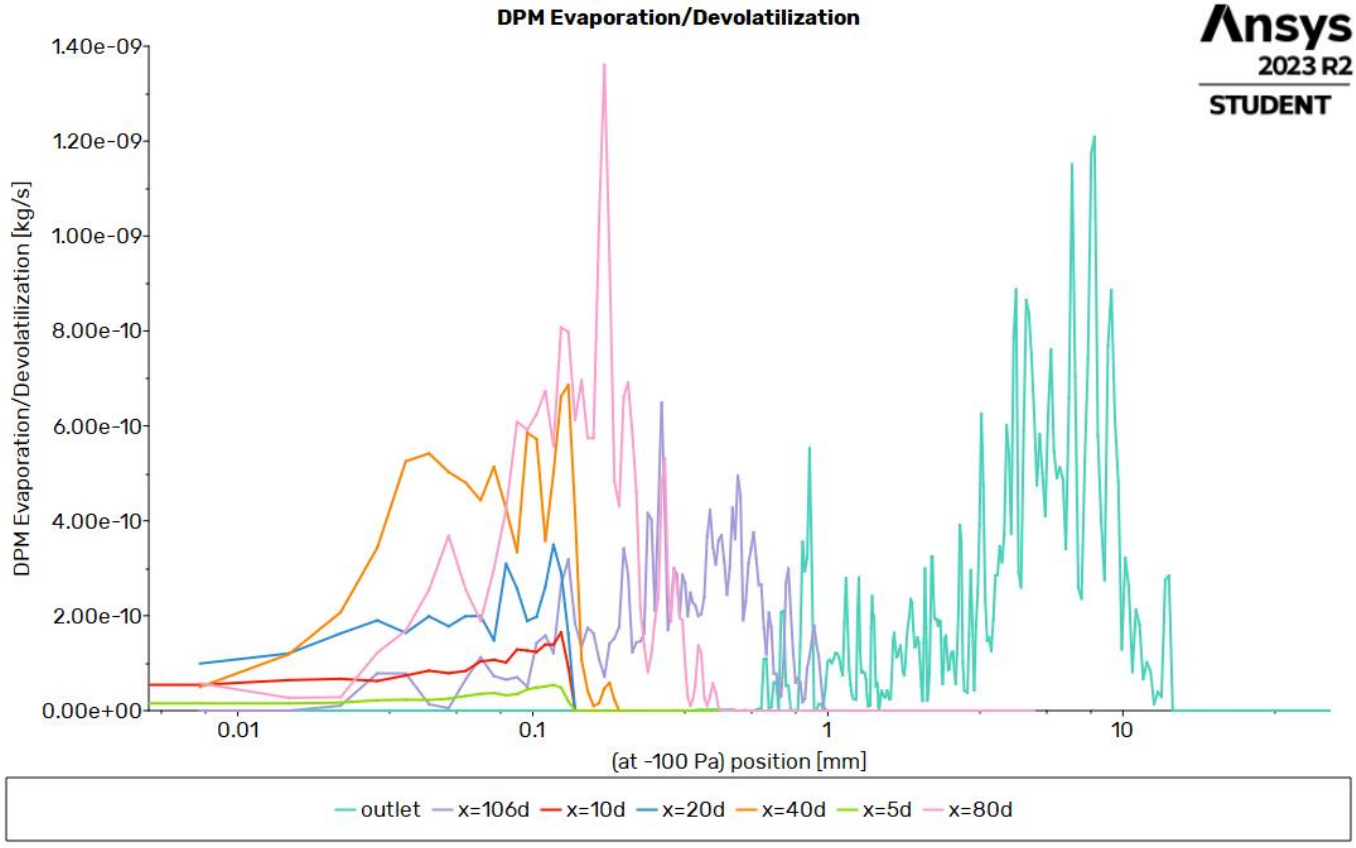


Fig.22 Evaporation rates at different axial locations of ch3oh at -100 Pa reference gauge pressure.

Discussions:

- From the temperature and velocity contours,and from the formula of speed of sound varying with temperature, we can say that our maximum velocity is less than 0.3M, hence in-compressible flow formulation is justified.
- From the initial plots of species contours of ch3oh and o2, we can check the correctness of model, we can see no mass fractions of ch3oh and specified mass fractions of o2.
- From the comparison plot of axial velocity at different locations, we can see as we go along axially we first see increase in axial velocity but after a certain location it decreases. This effect could give us an idea into the interaction of incoming jet and surrounding medium.The particle residence time track also validate this.
- After injection of ch3oh we can see change in mass fractions of Ch3oh and o2 at center-line which vanishes after a certain axial distance giving idea on evaporation of ch3oh species injected. This can also be seen from DPM Evaporation graph, at higher axial distance the evaporation rate is higher and highest at outlet. Near the injection area it is quite low.The DPM ch3oh plot which signifies transfer of fluid species to particles also validate this.
- On comparing the velocity contours before and after injection we see decrease in velocity as we go farther axially.
- From mass flow report, we can see increase in mass flow rate after injection as Net flow rate before injection it was 7.77e-07 kg/s but after injection it increased to 1.247e-06 kg/s.
- From heat transfer rate report, we can see decrease in net heat transfer rate from 4.583 W to 3.533 W. Thus 1.05 W energy was absorbed in evaporation of ch3oh species.
- From changing the refrence pressure to -100Pa, only slight change in evaporation rate at x=80d was seen, other locations' evaporation rated didn't varied much as evident from above plot.