UTSR Fellowship - 2012

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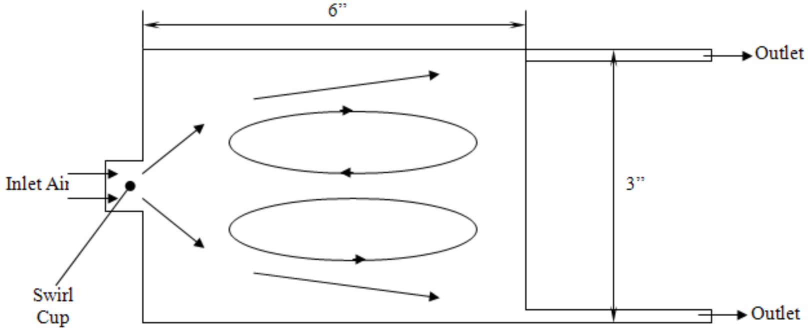
Outline

- Problem description and Objective
- Operating condition
- CFD model
- Spray model
- Results
- summary

Problem Description and objective



Problem description

- Spray cup with radial-inflow air swirler
- A pressure swirl atomizer injected fuel at the bottom of the spray cup exposing the spray directly to the incoming swirling air
- The air and fuel from the swirl cup discharged into a 10.0" inch long 3.00" by 3.00" square tube.

Objective

Investigate different approaches for predicting spray flame location and NOx emissions.

Operating condition

Fuel: $C_{12}H_{23}$ as a surrogate for jet-A fuel

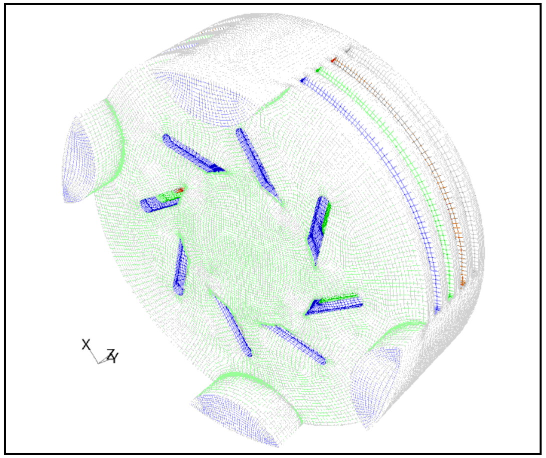
Non reacting case : Fixed pressure drop (4%)

Reacting case: Fixed mass flow rate

Type of gas : Incompressible ideal gas

CFD model

- Structured multi-block grid system that was generated using the GridPro
- The grid system contained a little over $2.0 \cdot 10^6$ hexahedral cells



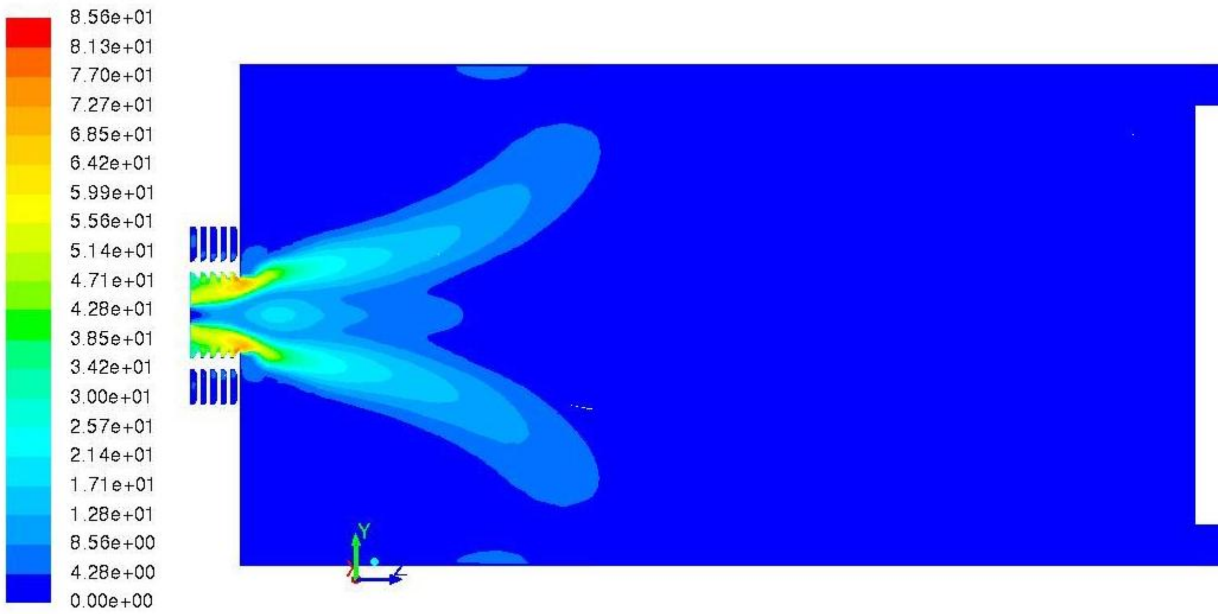
- Turbulence model : realizable k-epsilon model
- Combustion model: Flamelet model
- Reaction mechanism: 31 step reaction with 21 species

Spray Model

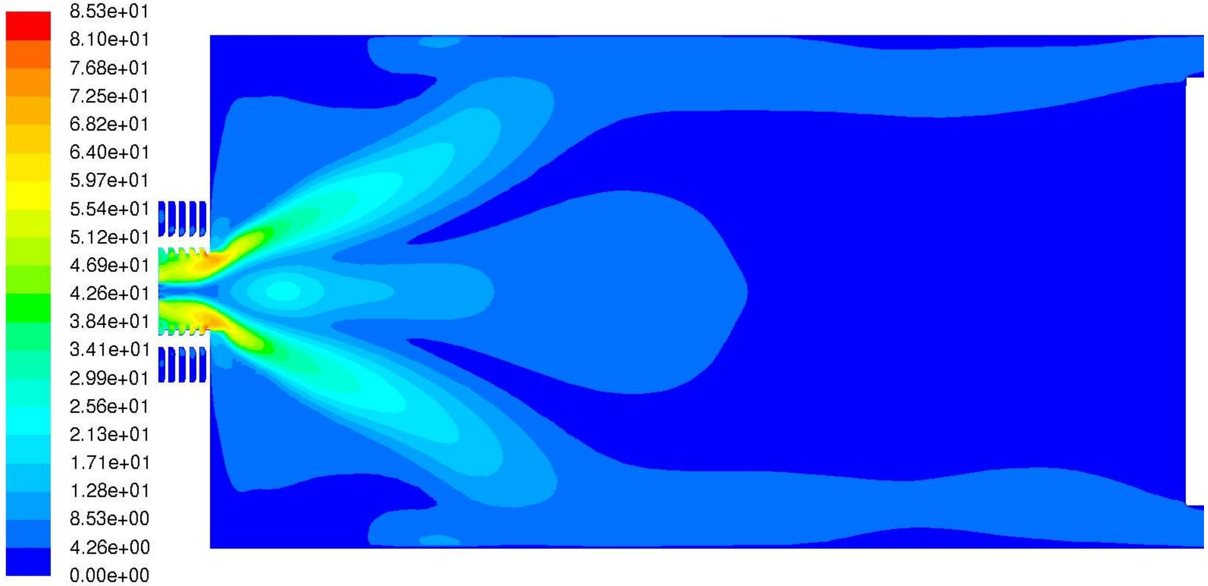
- Model: Discrete phase model
- Particle Type : Droplet
- Drople Size Distribution: Rosin-Ramler distribution
- Injector: Hollow conical spray
- Spray angle: 80

Results

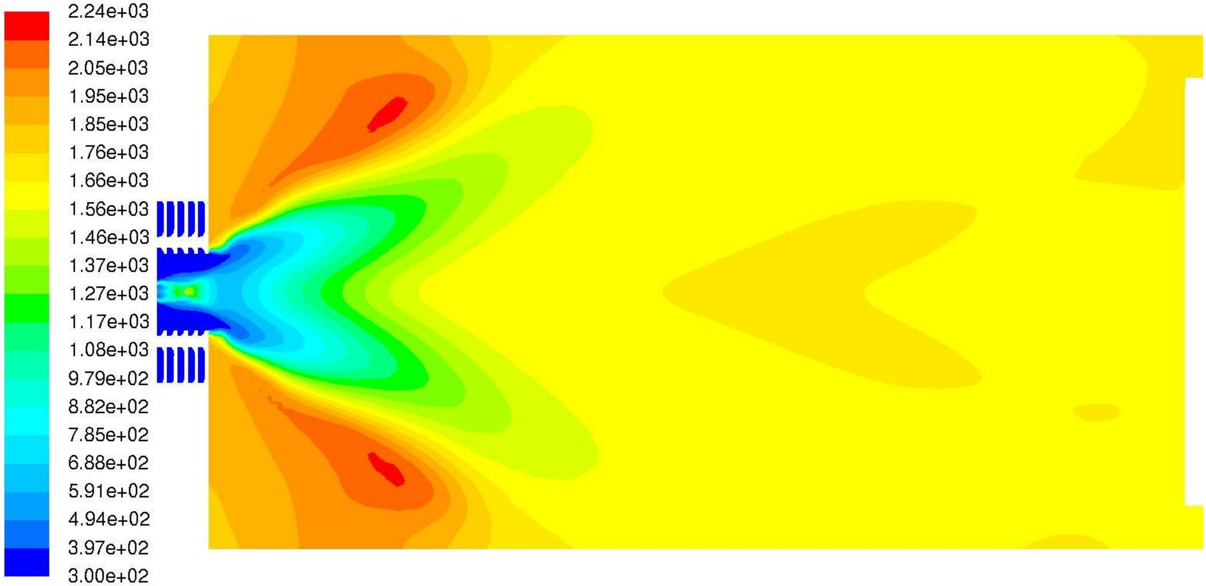
Non-reacting velocity field



Reacting velocity field

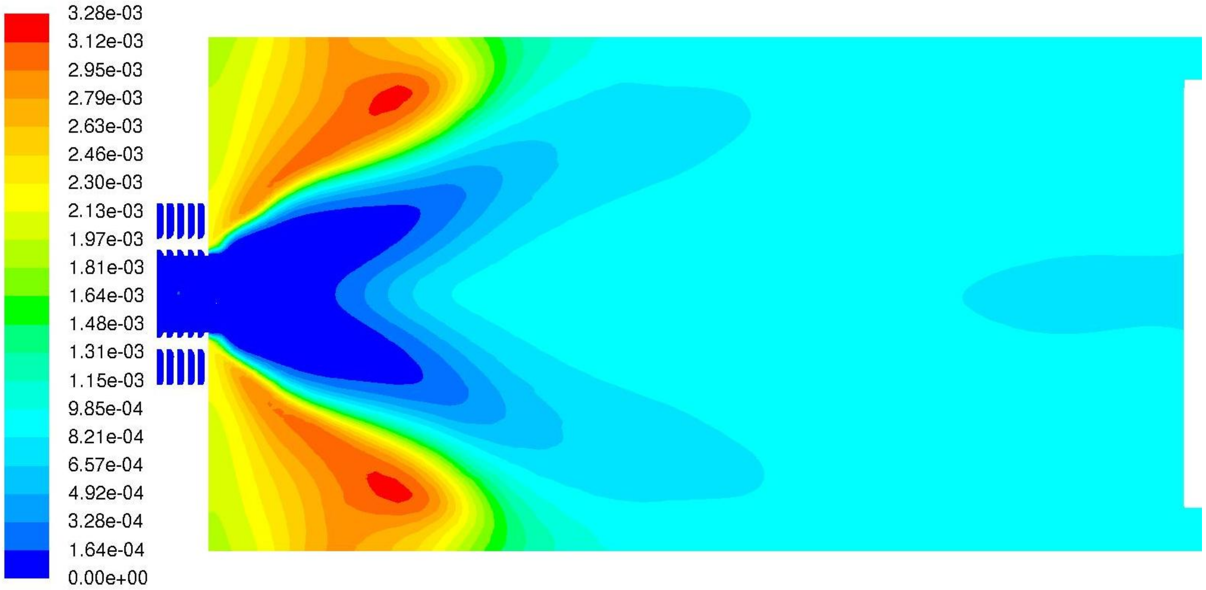


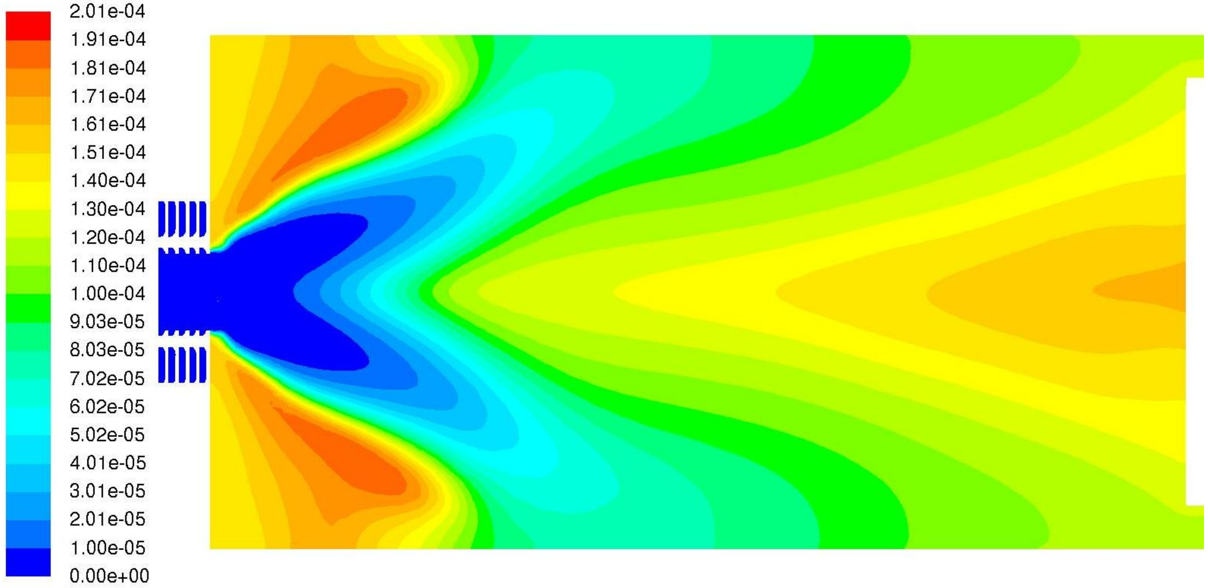
Temperature



Maximum temperature:2240 K
Exit temperature: 1638 K

Mass fraction of OH – Unsteady Flamelet Results




2.01e-04
1.91e-04
1.81e-04
1.71e-04
1.61e-04
1.51e-04
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1.20e-04
1.10e-04
1.00e-04
9.03e-05
8.03e-05
7.02e-05
6.02e-05
5.02e-05
4.01e-05
3.01e-05
2.01e-05
1.00e-05
0.00e+00

Summary

- Strongly swirling flow downstream of the cup and swirl induced vortex breakdown that stabilizes the flame.
- Temperature profile for the reacting flow shows the maximum temperature is 2240 K and exit temperature is 1638 K with the burning zone positioned downstream of the cup
- An unsteady flamelet model was used as a post processing step to estimate NO emissions

References

1. Cai, J., Jeng, S.-M., Steinthorsson,E., “Experimental and Numerical Investigation of a Macro-Laminated Radial Swirler”, AIAA 2003-0826.
2. Tacina,R.,Wey,C.,Laing,P.,Mansour,A., “Sector test of a low NOx, lean-direct-injection, multipoint integrated module combustor concept,”ASME Turbo Expo2002.