Submission Guidelines for ECN 4 Topic 8: Spray G Nozzle Geometry and Internal Nozzle Flow

# Goals:

1. Characterize the geometry of the Spray G Injectors. Evaluate the available measured geometries in terms of accuracy and precision. Decide on a “reference” geometry if necessary/possible.
2. Characterize the internal flow of the Spray G nozzles. This includes measurements of the flow rate and possibly x-ray diagnostics of internal flow.
3. Coordinate simulations of the internal flow of the Spray G nozzles. Compare the predictions with one another and with available experimental data. If possible, determine best practices for nozzle flow simulations.

# Measurements of Nozzle Geometry for Spray G

* 1. Development of STL Geometries
		1. GM has developed a model based on the nominal “idealized” geometry. This is available by contacting Lyle Pickett at Sandia. GridPro has used this model to develop a mesh of the idealized geometry, and will share this mesh.
		2. Sandia has procured x-ray tomography measurements from Northstar Imaging of #16 and #28. 5 m voxel resolution expected.
		3. Infineum has performed x-ray tomography on all 12 Spray G nozzles. Sandia and GM are analyzing the raw voxel data and comparing to Northstar Imaging results. Argonne is attempting to construct STLs from the raw data.
		4. CMT has made a silicone mold of broken spray G injector. They hope to extract diameters and radii. Argonne will also analyze the geometry of this injector.
		5. Sandia has extracted important parameters of interest (radii of curvature, diameters). GridPro will incorporate these into the nominal geometry and will share a mesh.
	2. Submission of STL Geometries
		1. Measurement technique should be described
		2. Reconstruction techniques should be described
		3. Coordinate system should be reported and follow the x-y-z guidelines of SAE J2715 consistent with the standard given at http://www.sandia.gov/ecn/G/targetCondition/SpGNozGeo.php
		4. Voxel resolution of geometry should be reported
		5. STL files will be maintained by Lyle Pickett
	3. “Standard Mesh” Development
		1. GridPro has used the GM “idealized” geometry to develop an “idealized” Spray G mesh. GridPro reported on this mesh during the web meeting on 5 Feb 2015. They will share this mesh with the community.
		2. GridPro will use Sandia’s measurements of the actual geometry to develop a mesh that more accurately captures the features of the real nozzles. They will share this mesh with the community.

# Measurements of Nozzle Flow

* 1. Expecting contributions from:

## GM has measured ROI of all injectors

## CMT/GM: mass flow rate and momentum flux data of AV67-026

## Submission of Results

1. Measurement technique should be described
2. Analysis techniques should be described
	1. Method of calibrating total mass injected
	2. Recommend Payri et al, SAE 2013-24-0001
3. For momentum measurements, report spray that was measured, steps taken to isolate influence of adjacent sprays?

# Simulations of Nozzle Flow

Expecting contributions from:

* David Schmidt, Miriam Moulai (UMass Amherst), Ron Grover (GM)
* Sibendu Som, Kaushik Saha (Argonne)
* Pedro Marti (CMT)
* Bizhan Befrui (Delphi)
* Mateus Ribeiro (University Duisburg-Essen)
* Chawki Habchi (IFPen)
* Ehsan Tahmasebi (Politecnico Di Milano)

## Mass and momentum flow rates and fluctuation distribution at the counterbore exit vs. time

Please calculate the mass flow rate and the flow rate of axial momentum vs. time and report these as a three column text file. Please give dimensions on these quantities. For the fluctuation, please report a mass weighted fluctuation of velocity magnitude (for ex. Farve averaged turbulent kinetic energy) averaged over the exit plane (N nodes). One can use the following equations written for compressible liquid:

$$m\_{f}=\sum\_{n=1}^{N}α\_{l,i}ρ\_{l,i}u\_{i}A\_{i} and M\_{f}=\frac{m\_{f}^{2}}{ρ\_{l}A\_{eff}} with A\_{eff}=\sum\_{n=1}^{N}α\_{l,i}A\_{i}$$

$$u^{'}=\frac{1}{M}\sum\_{n=1}^{N} m\_{i}\left(U-u\_{i}\right)^{2} with U=\frac{1}{M}\sum\_{n=1}^{N}m\_{i}u\_{i} and M=\sum\_{n=1}^{N}m\_{i} $$

$$T=\frac{1}{M}\sum\_{n=1}^{N}m\_{i}T\_{i} $$

Where l,i, mi and ui are the liquid volume fraction, mass, and the velocity at the node i.

## Cut Planes at the Nozzle Hole Exit, the Counterbore Exit, and 2 mm downstream of the nozzle tip showing:

## Velocity

## Density

## Temperature

## Turbulent kinetic energy

# Ideally, cut plane data should be reported at 1 ms after start-of-injection. If you only have data at an earlier instant in time, please submit a plot of flow versus time to demonstrate that flow has stabilized. Cut planes at the nozzle hole exit and counterbore exit should be made in eight distinct planes, one for each hole, and should be normal to the axis of the spray hole.

# Cut plane 2 mm downstream should be made perpendicular to the injector axis. This plane is chosen to best match available data.

# Need to define view, color map, range for plots

## Cd, Cv, and Ca for each of the eight holes

From Payri, ECN 1: (Mf is momentum flux and mf is the mass flux. The symbol uth represents the theoretical velocity predicted by the Bernoulli equation.)

Equations (1) can used to compute Cd, Cv, and Ca as follows:

|  |  |
| --- | --- |
|  |  |
| $$u\_{eff}= \frac{M\_{f}}{m\_{f}}$$ | $$C\_{v}= \frac{u\_{eff}}{u\_{th}}$$ |
| $$A\_{eff}=\frac{m\_{f}^{2}}{ρ\_{l}M\_{f}}$$ | $$C\_{a}= \frac{A\_{eff}}{A\_{geo}}$$ |
|  | $$C\_{d}=\frac{m\_{f}}{A\_{geo} ρ\_{l} u\_{th}}$$ |

Any time that liquid density is required, use the liquid density at the downstream pressure and temperature = 633.35 kg/m3. The geometric cross-sectional area for the nominal 0.170 mm nozzle is = 22.698e-9 m2.