CEE 618 Scientific Parallel Computing (Lecture 11)

OpenFOAM – Pipe Flow & small Pool Fire 2D/3D

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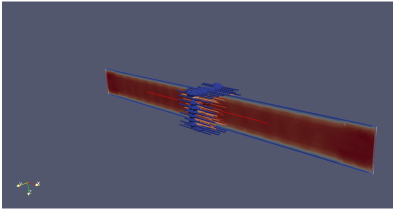
Square Pipe

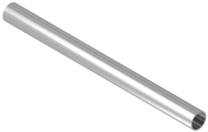


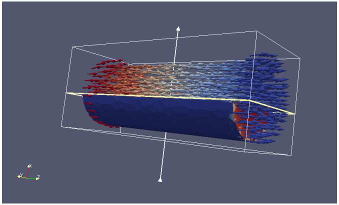
1. Analytic Solution
2. OpenFOAM CFD simulation

Square Pipe: geometry file

```
1 = 1;
Point(1) = {10, 1, 1, 1};
Point(2) = {10, -1, 1, 1};
Point(3) = {10, 1, -1, 1};
Point(4) = {10, -1, -1, 1};
Point(5) = {-10, 1, 1, 1};
Point(6) = {-10, 1, -1, 1};
Point(7) = {-10, -1, -1, 1};
Point(8) = {-10, -1, 1, 1};
Line(1) = {1, 5};
Line(2) = {5, 8};
Line(3) = {8, 2};
Line(4) = {2, 1};
Line(5) = {1, 3};
Line(6) = {5, 6};
Line(7) = {8, 7};
Line(8) = {2, 4};
Line(9) = {3, 6};
Line(10) = {6, 7};
Line(11) = {7, 4};
Line(12) = {4, 3};
```

Cylindrical Pipe



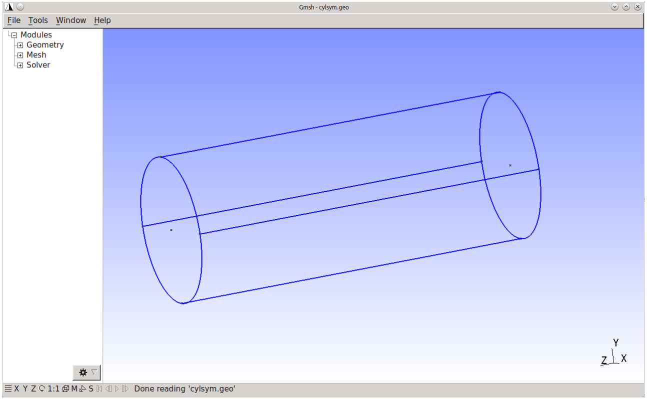


1. Analytic Solution
2. OpenFOAM CFD simulation

Cylindrical Pipe: geometry file

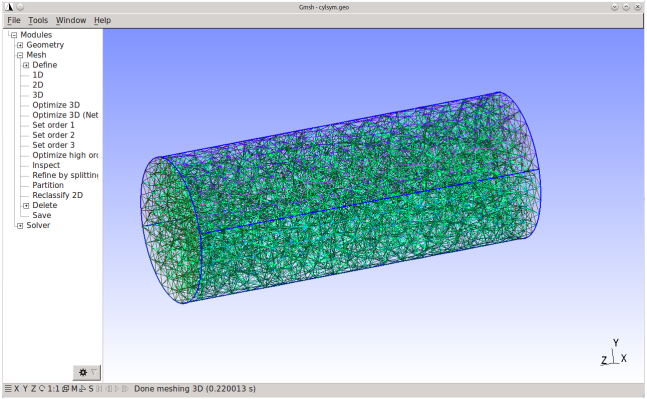
```
R = 2.0;
H = 10 ;

Point(1) = { 0, 0, 0 ,0.5};
Point(2) = { R, 0, 0 ,0.5};
Point(3) = { 0, R, 0 ,0.5};
Point(4) = {-R, 0, 0 ,0.5};
Point(5) = { 0,-R, 0 ,0.5};
Circle(1) = {2,1,3};
Circle(2) = {3,1,4};
Circle(3) = {4,1,5};
Circle(4) = {5,1,2};
Line Loop(5) = {1,2,3,4};
Plane Surface(6) = {5};
Extrude {0,0,H} {
  Surface{6};
}
Physical Surface("left") = {6};
Physical Surface("right") = {28};
Physical Surface("wall1") = {19};
Physical Surface("wall2") = {23};
```

Cylinder geometry



1. There are 6 surfaces.
2. Those are `wall1` – `wall4`, `left`, and `right`.

Cyinder mesh



Small Pool Fire 3D

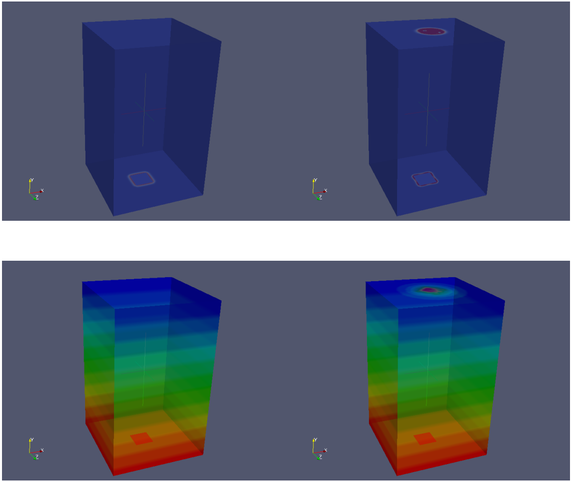


Figure: Temperature (first row) and Pressure (second row) Profiles: Initial (left) and Later (right)

Small Pool Fire 2D

Figure: Temperature (left) and pressure (right) profiles.

Note: Lab work

1. After you login fractal, make a directory 'smallPoolFire2D' under your OpenFOAM-Case directory.
2. Copy files from /opt/cee618s13/class11/fireFoam2D
   `cp␣/opt/cee618s13/class11/fireFoam2D/* ./`
3. To setup: `make`
4. Open system/controlDict, and change 'endTime' value from 3.0 to 1.0.
5. (For your homework, change to 5.0.)
6. To run: `make␣run`
7. This simulation will take approximately an hour.

Note: After you down load a zip file, change "0" directory to anything else such as "t0". This is because some configuration errors occur in Paraview: `mv␣0␣t0`

smallPoolFire2D: Makefile

```
OpenFOAMfireFOAM=~/OpenFOAM/OpenFOAM-2.1.1/tutorials/combustion/fir

all: copy
	touch smallPoolFire2D.foam

copy:
	cp -r $(OpenFOAMfireFOAM)/* ./

reset: clean
	rm -rf 0* 1* 2* 3* constant system processor* Allrun

clean:
	rm -f PBS-* *.foam *.msh *.geo

run:
	qsub fireFoam2Dsrl.pbs
```

fireFoam2Dsrl.pbs: PBS file for serial computation

```
#!/bin/bash
#PBS -l walltime=48:00:00
#PBS -q batch
#PBS -N PBS-fireFoam
#PBS -V
cd $PBS_O_WORKDIR
hostname
blockMesh
topoSet
createPatch -overwrite
date
time fireFoam
date
```

smallPoolFire2D: `Allrun` file

- blockMesh reads constant/polyMesh/blockMeshDict, generates the mesh and writes out the mesh data to points and faces, cells and boundary files in the same directory.
- topoSet and creatPatch are pre-processing actions.
- firFoam is a solver for this combustion problem using Large Eddy Simulation (LES) model developed for turbulence used in computational fluid dynamics.
- LES uses a filter (called LES filter). This filter is applied to a function $f(\boldsymbol{r}, t)$ and splits f into a filtered and sub-filtered parts. Governing equations are used separately for the two parts of the solution. Computation is faster than directly solving NS equation, i.e, direct numerical simulation (DNS).
- We will use this fireFoam2D case primarily for Paraview visualization. See HW11.