Task 1 **Name: ABIR KUMAR DEB**

Geometry details:

H = 1.0m, D = 0.5m, d = 0.04m and L = 0.1m

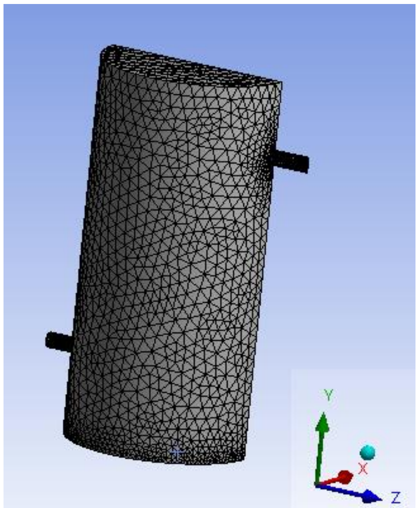
Where,

H = height of the tank

D = diameter of the tank

d = diameter of the inlet and outlet pipe

L = length of the inlet and outlet pipe from the tank



Add **Fluent (Flow)** to the workbench.

Import Geometry from your file location. (Geometry is made in **SOLIDWORKS**)

Open **Mesh:**

Mesh for the bottom surface: As the surface is interacting with the fluid. Fine mesh is used at the face.

Element size: 1e-02m

Behavior: Hard

The remaining body: Default mesh size is used with

Size function: Curvature

Relevance Center: Medium

Use automatic inflation: Program controlled

The mesh is generated by clicking '**Generate mesh**' option.

Name surfaces: Bottom, inlet, outlet and symmetry

Setup:

General:

Solver: Pressure-Based **Velocity Formulation**: Absolute **Time**: Steady

Gravity: Y-direction: -9.8m/s2

Model:

Energy-on

Viscous model: k-epsilon-Realizable

Materials:

Add a new material **Water**

Density (kg/m^3): 989.7576

$$\rho\ (\mathrm{kg\ m^{-3}}) = (999.83952 + 16.945176\,t - 7.9870401\times10^{-3}\,t^2 - 46.170461\times10^{-6}\,t^3 + 105.56302\times10^{-9}\,t^4 - 280.54253\times10^{-12}\,t^5) / (1 + 16.897850\times10^{-3}\,t, \quad (1)$$

Cp (j/kg-k): 4216 **Thermal Conductivity** (w/m-k): 0.677 **Viscosity** (kg/m-s): 0.0008

Thermal Expansion Coefficient (1/k) 0.00042826

Cell Zone Conditions:

Select **Water**

Define operating conditions:

Temperature (k): 318.15 and **density (kg/m^3):** 989.7576

Boundary Condition:

Bottom surface temperature: 338.15 K

Inlet temperature: 298.15 K and **velocity Z-direction (m/s):** -0.05

Hydraulic diameter (m): 0.04

Solution method: All Second order method is selected.
Monitors: create a surface monitor at the symmetry plane

Calculation of output temperature using custom function:
Using the User defined – **Custom Field Calculator**
Two separate equations are created.

$$T_{out} = \frac{\int\int v_n T \, dA}{\int\int v_n \, dA}$$

Solution Initialization:
Initialization method: Standard method
Compute from: inlet **Reference Frame**: Absolute
Initial values: Y-velocity (m/s): -0.01

Results:

1. The outlet temperatures

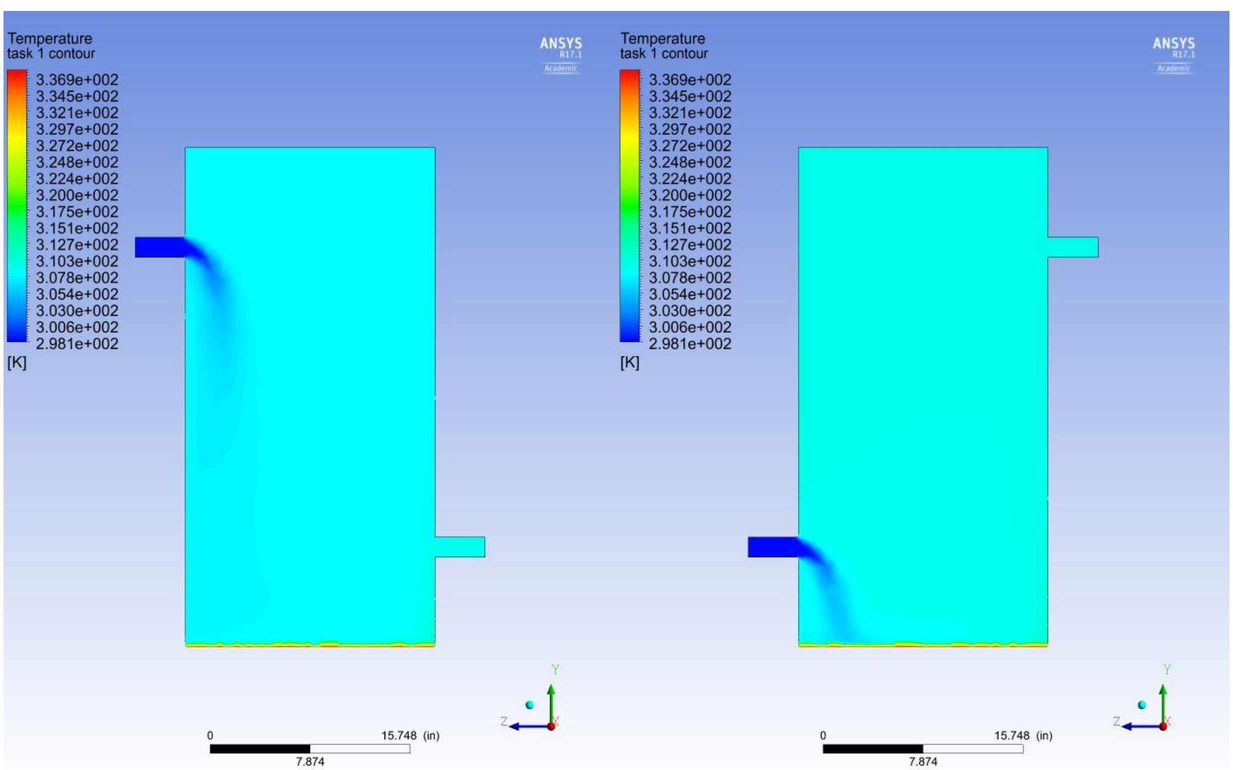
For Case A : Outlet temperature (k) = 309.1250823

```
                Area-Weighted Average
                    custom-function-0
-------------------------------- --------------------
                            outlet           -15.471166

                Area-Weighted Average
                    custom-function-1
-------------------------------- --------------------
                            outlet         -0.050048239
```

For Case B: Outlet temperature (k) = 309.5180029

```
                Area-Weighted Average
                    custom-function-0
-------------------------------- --------------------
                            outlet           -15.547054

                Area-Weighted Average
                    custom-function-1
-------------------------------- --------------------
                            outlet         -0.050229886
```

2. Contour plot of temperatures for both the cases.



3. Plot of streamlines at both cases

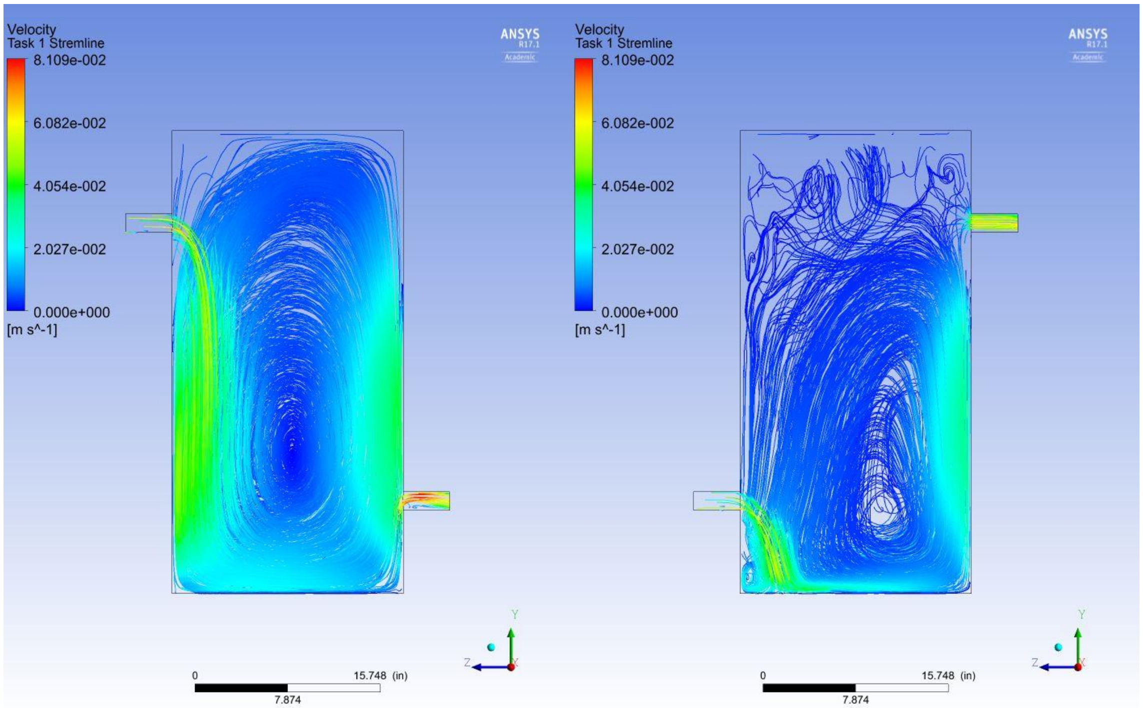


Fig. normal to the plane

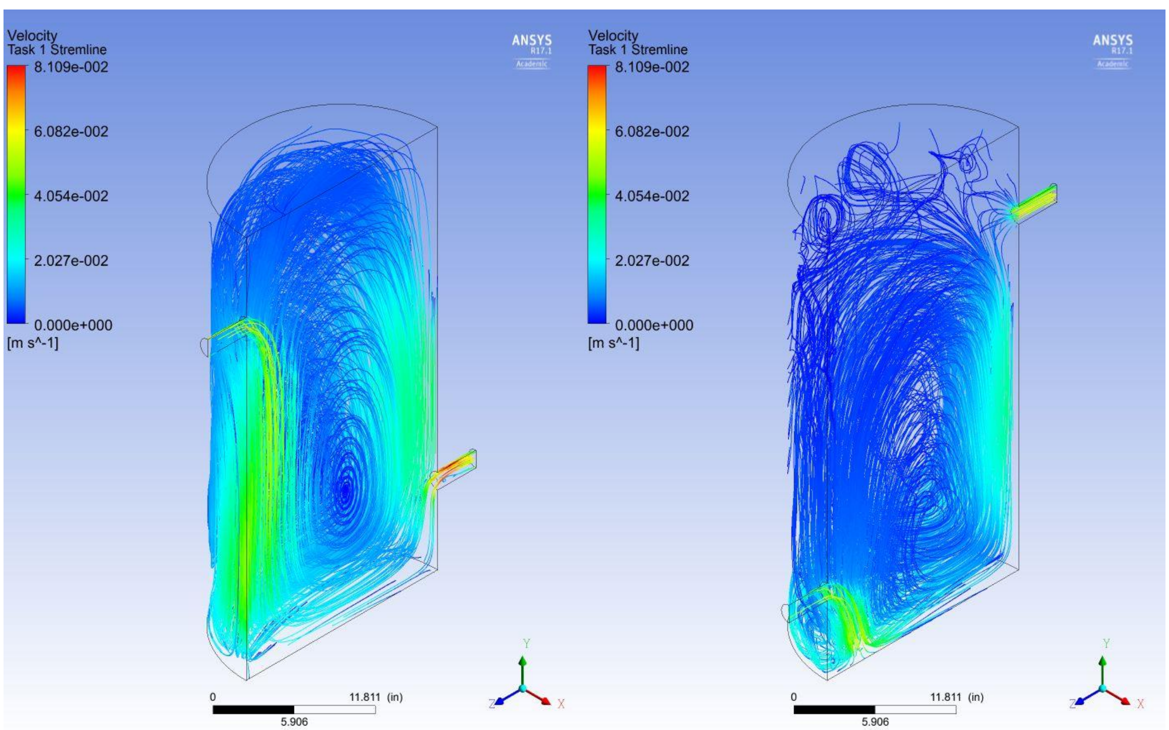


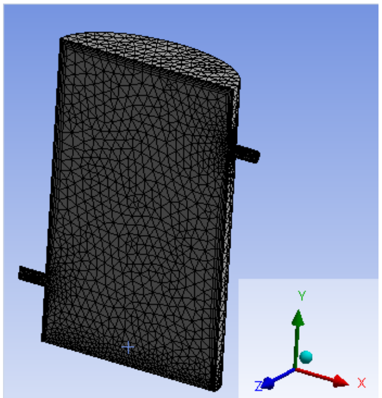
Fig. Isometric view

Discussion:

We can see a difference in output temperature between the two cases marginally. The case B has slightly higher temperature from the Case A which is expected as the inlet pipe of the case B is close to the bottom surface which is the heat source of the current setup.

Task 2

Following the same steps as above but for different geometry



Boundary Condition:

Bottom surface temperature: 338.15 K

Inlet temperature: 298.15 K and

Velocity X-direction (m/s): 0.05

Hydraulic diameter (m): 0.04

Results:

1. The outlet temperatures

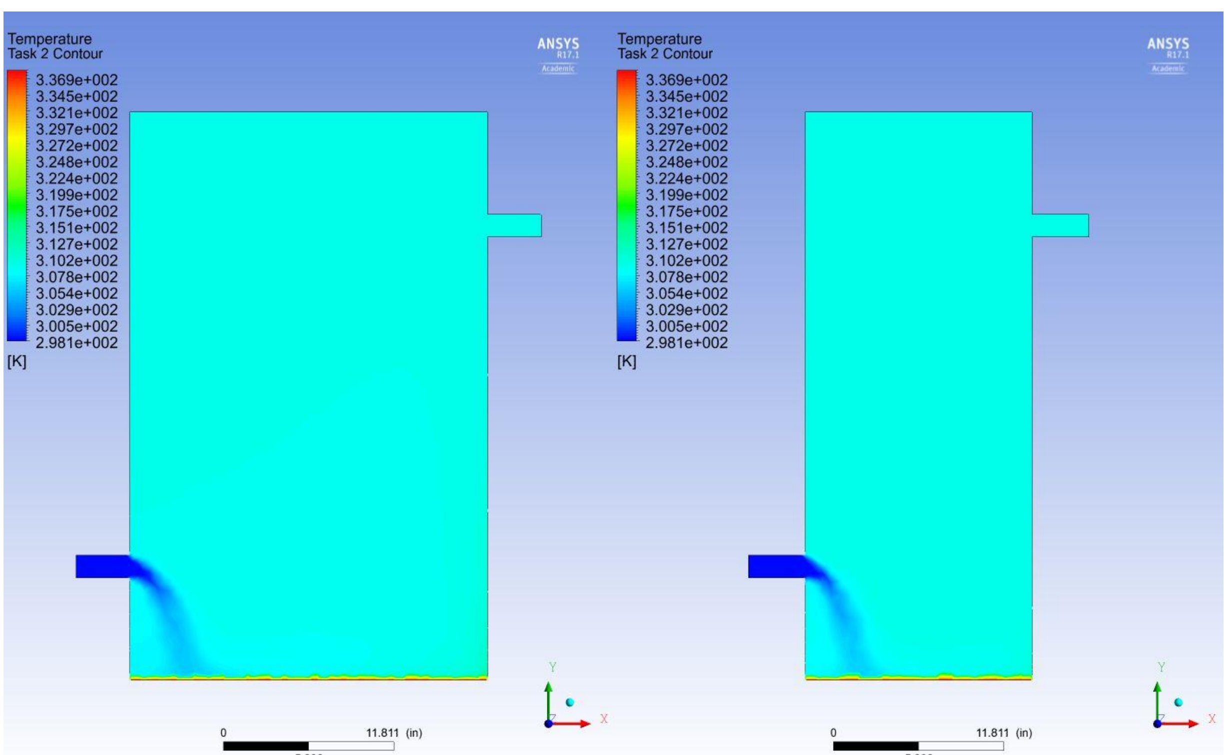
For Case C : Outlet temperature (k) = 310.0589332

```
         Area-Weighted Average
             custom-function-0
------------------------------ --------------------
                        outlet          0.011803324

         Area-Weighted Average
             custom-function-1
------------------------------ --------------------
                        outlet        3.8068003e-05
```

For Case D: Outlet temperature (k) = 309.7359323

```
         Area-Weighted Average
             custom-function-0
------------------------------ --------------------
                        outlet            15.486214

         Area-Weighted Average
             custom-function-1
------------------------------ --------------------
                        outlet          0.049998119
```

2. Contour plot of temperatures for both the cases.



3. Plot of streamlines at both cases

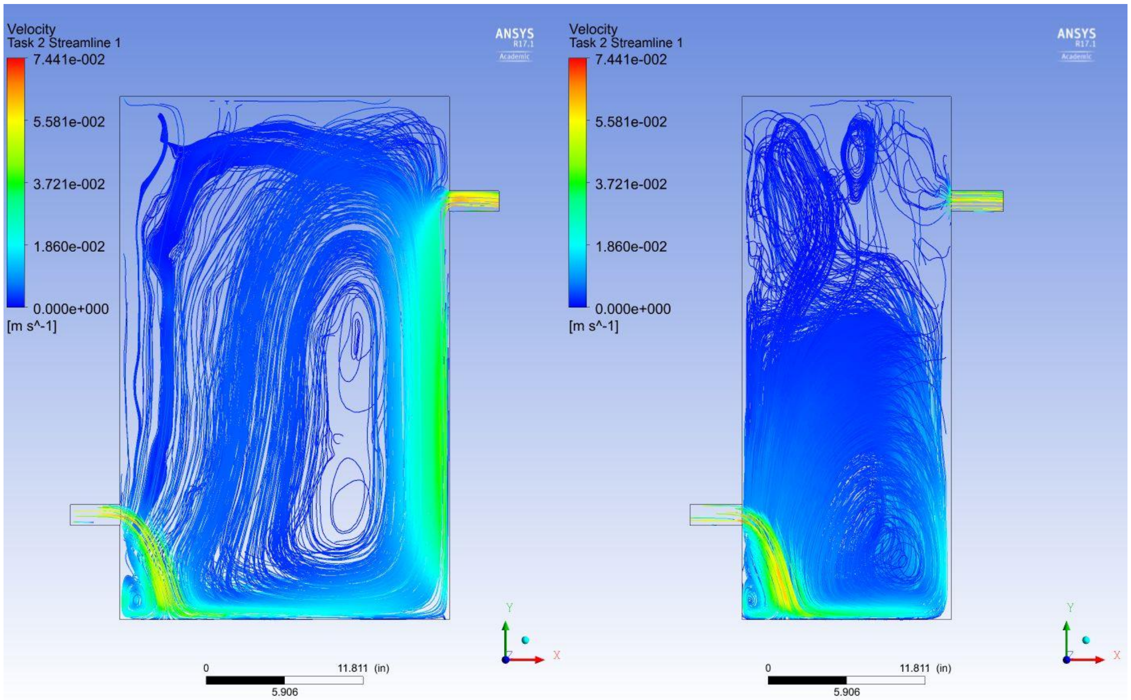


Fig. normal to the plane

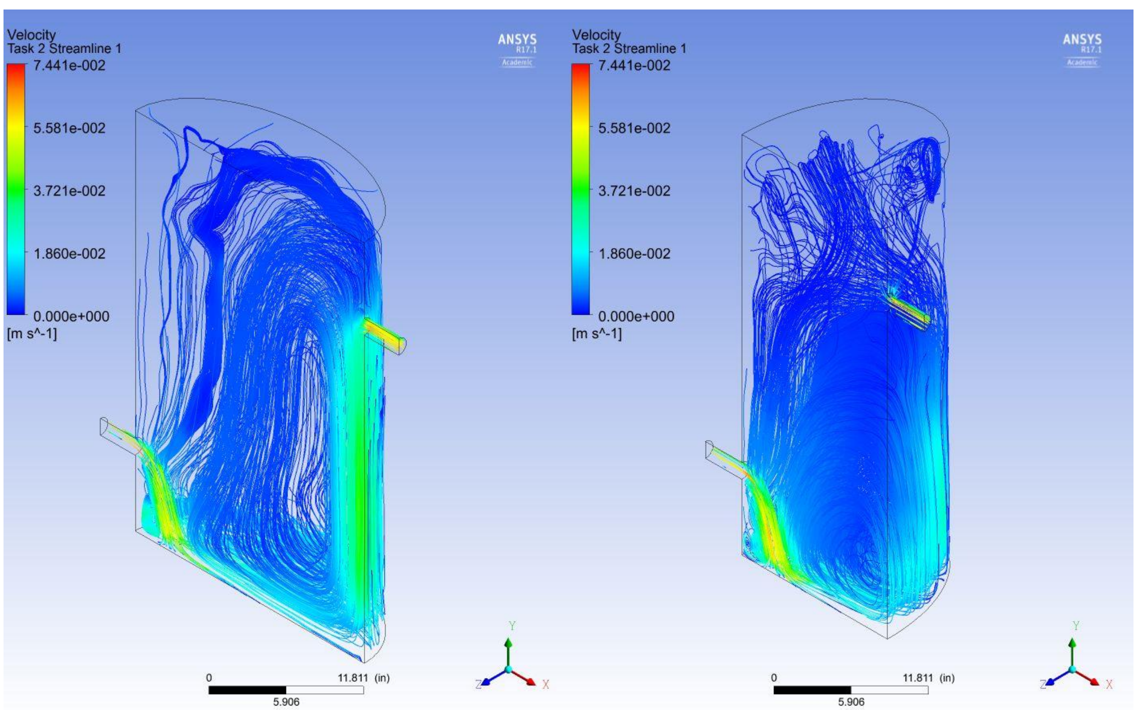


Fig. isometric view

<u>Discussions:</u>

The output temperature of Case C is slightly higher than Case D as the water coming from the inlet moves across the bottom surface before it rises up to the outlet. In case C the water stays in contact with the bottom surface slightly more than the Case D hence letting it carry slightly more heat than Case D.

Task 3

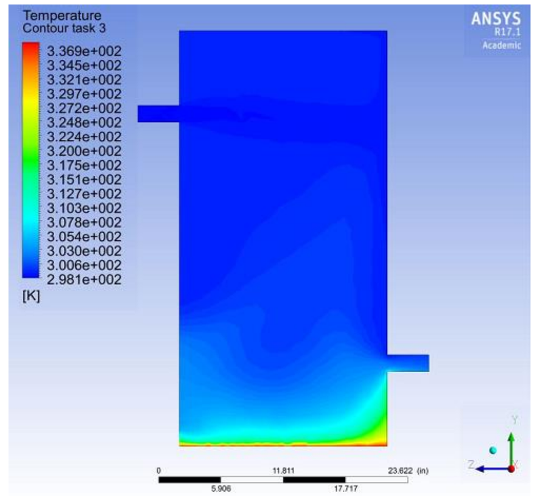
The density is set constant and gravity is turned off.

1. The outlet temperatures

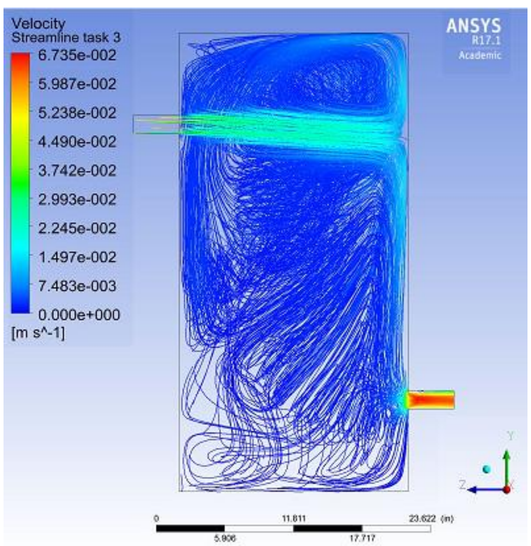
For Case A : Outlet temperature (k) = 300.6296042

```
           Area-Weighted Average
              custom-function-0
-------------------------------- --------------------
                          outlet           -15.029135

           Area-Weighted Average
              custom-function-1
-------------------------------- --------------------
                          outlet         -0.049992199
```

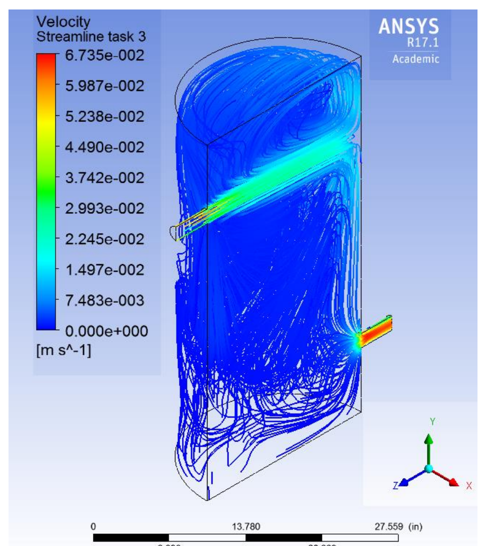
2. Contour plot of temperatures for both the cases



3 a. Plot of streamlines (normal to the plane)



3 b. Plot of streamlines (isometric view)



Discussions:

1. When there is no gravity the water doesn't come in contact with the bottom surface as the water flows inside. When it starts filling up the water level goes down and starts exiting from the outlet so not letting the water to exchange heat with the bottom surface efficiently. Hence, the output temperature is significantly less when compared with one with gravity.

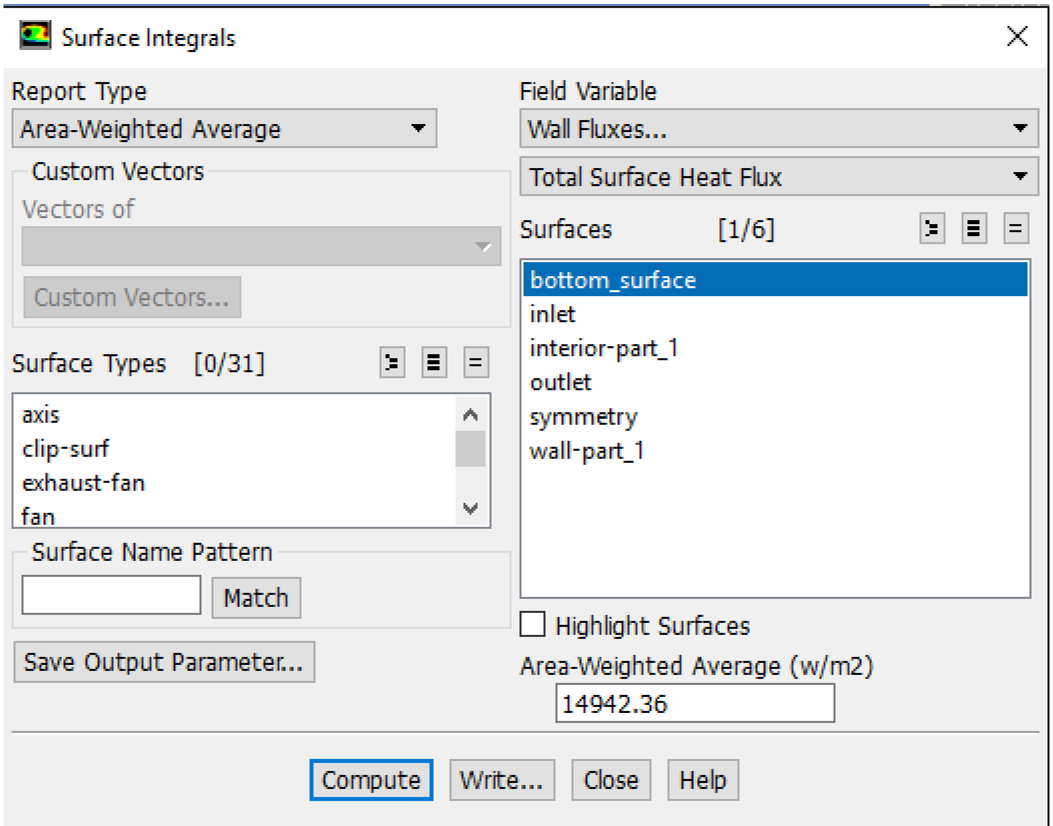
2. Critical process which are missing when density is set constant are
a. Operating temperature setting is not required
b. Operating density setting is not required
c. Boussinesq approximation for density is not used.

Task 4

Part a

Finding out the flux for Case B in Task 1

The total surface heat flux is calculated from Flux report in results. **Net Results (w/m2): 14942.36**



Part b

Area of the bottom plate: 0.098146946 m^2

Total surface heat flux from part a: **1466.548 W/m2**

The output temperature is (k) 309.52

```
                 Area-Weighted Average
                       custom-function-0
-------------------------------- --------------------
                                outlet        -15.506406

                 Area-Weighted Average
                       custom-function-1
-------------------------------- --------------------
                                outlet      -0.050097549
```

Discussions:

We can see that the Output temperature is identical from Case B in Task 1 and in Task 4 this is found as expected. Since at the both the case the values are constant and one value is derived from another so it is basically means same amount of work done but the interpretation is different in both the cases.