<u>MAE 598 Applied CFD</u> <u>Project 1</u> <u>Part III: Challenge #2</u> Gargi Kailkhura (in collaboration with Suhail Jeet Singh)

Using Parametric Design to run 10 simulations





Figure 1: Case-A replica + parametric design

Deliverable-1:

Description for set-up of parametric design

• Step 1: Change in Boundary Conditions to set up parameters

Since there are 10 different velocity inputs, so set up the parameters by first **selecting 'new input parameter'** in the velocity type drop-down.





• Step 2: Enter the first Parameter

One the 'new input parameter' is selected, a dialogue box opens up asking about the properties of the parameter. Enter the first parameter and its value. Click on 'OK' to proceed further.

| nlet | | |
|---------------------------------|--------------------------|--------------------------|
| Momentum Thermal R | adiation Species DPM | Multiphase Potential UDS |
| Velocity Specification M | ethod Components | - |
| Reference | Frame Absolute | |
| Supersonic/Initial Gauge Pressu | re (pascal) 0 | constant |
| Coordinate S | stem Cartesian (X, Y, Z) | |
| X-Vel | ocity (m/s) 0.01 | New Input Parameter. |
| Y-Vel | ocity (m/s) 0 | constant |
| Specification Me | OK Cance | |

Figure 3: Entering first Parameter values

• Step 3: Create Output Parameters in Parameters and Customization

In this case, the output parameter is temperature, evaluated using integral formula. So, develop custom field function for the numerator. It is already discussed before in the previous HW1 and Tutorial-2.

$$T_{out} = \iint \frac{v_n * T * dA}{v_n * dA}$$

| File Sett | ting Up Domain | Setting Up | Physics U | lser-Defined | Solving | Postprocessing | Viewing P | Parallel | Design | 0 | |
|--|---|------------|---------------|--------------|--------------|----------------|-----------------|------------|-------------|---|---|
| √ α Custom | f(v) | f (x) Fu | nction Hooks. | 👗 Memor | ry 1D | Coupling | | | | | |
| In Units | 100 | 00101 | | X Scalars | Fa | n Model | | | | | |
| Parameter | ter 💶 Custom Field Function Calculator | | | | | | | | | | Ì |
| — Field Functio | Definition | | | | | | | | | | |
| Tree | Vx * temperate | ure | | | | | | | | | |
| 4 🍓 Setup | + | - | X | <i> </i> | у^х | ABS | Select Operand | d Field Fu | nctions fro | m | |
| 🗏 Geni | INV | sin | cos | tan | In | log10 | Field Functions | | | | |
| ▷ 📅 Mod | 0 | 1 | 2 | 3 | 4 | SQRT | Static Tomport | · | | | |
| Cell | 5 | 6 | 7 | 8 | 9 | CE/C | | acure | | | |
| ⊳ 🕽 🖡 Boui | |) | PI | e | | DEL | Select | | | | |
| ⊳ 🎜 Mes 🛃 Dyn: | Xi Mes Xi Mes | | | | | | | | | | |
| Refe Solution Solution | | | | Define | e Manag | e Close H | elp | | | | |
| Solut 🖉 Solut | itors | | | | | , v | 大 | | | | J |

Figure 4: Custom field function for computing temperature

After developing custom field functions, go to '**Parameters and Customization**' in the bottom of the tree. Select output parameters and wait for a new window to open. As seen, parameters are shown classified into input and output. Since, **input parameters** are defined in Step 1 and **Output parameter** (Temperature in this case) is defined just above. Click on '**Create**' to use surface integral option for integrating temperature. Use the surface Integral option as previously used to select field variable (normal velocity and custom field function in this case) and the surface (outlet and z=0.5m plane in this case). Then, click on '**Save Output Parameter**' tab to eventually create the output parameter. One can create as many input or output parameters as wanted.



| Scalars Fan | Model |
|-----------------------|-----------------------------------|
| Surface Integrals | |
| Report Type | Field Variable |
| Integral 👻 | Custom Field Functions 👻 |
| Custom Vectors | num 👻 |
| Vectors of | Surfaces [1/13] |
| Custom Vectors | bottom_wall contact_region_2-trg |
| Surface Types [0/31] | inlet interior-4 |
| axis clip-surf | interior-solid outlet |
| exhaust-fan | plane-zmid |
| fan | symmetry |
| Surface Name Pattern | top_wall |
| Match | wall |
| | Highlight Surfaces |
| Save Output Parameter | Integral |
| | 0 |
| Compute | e Close Help |
| | |
| Parameters | 23 |
| Input Parameters | Output Parameters |
| parameter-1 | parameter-vel_mid |
| | parameter-num-mid |
| | parameter-outlet_den |
| | output-num |
| · • | |
| | |
| 1 | |
| | |
| | |
| View Delete More - | Create - View More - |
| | Done. |

Figure 5: Create Output Parameters

• Step 4: Initialize the solution and run the simulation normally.

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- Step 5: After running the simulation, go back to the workbench and do not close ANSYS- Fluent.
- Step 6: In the workbench, **the parameter Set is displayed** across the current Fluid Flow.

| | | - | | E | | | - | | F | |
|--|--------------------------|----------------------------|-----|---|---|---|-----|----------|---------------------|---|
| | | 1 | | Fluid Flow (Fluent) | | | 1 | | Fluid Flow (Fluent) | |
| | | 2 | 00 | Geometry | × . | | 2 | 00) | Geometry | ~ |
| | | 3 | 6 | Mesh | × . | | з | ۲ | Mesh | ~ |
| | | 4 | | Setup | × . | | 4 | | Setup | ~ |
| | | 5 | | Solution | × . | | 5 | | Solution | ~ |
| | | 6 | 9 | Results | ~ | 4 | 6 | @ | Results | 2 |
| | | | | Challenge-1 | | | > 7 | ¢γ | Parameters | |
| | | | | | | | | | Challenge-2 | |
| | | | | | | | | | | |
| Fluid Flow (Fluent) | ~ <u>-</u> | 1 | 000 | Fluid Flow (Fluent) Geometry | × . | | | | | |
| Fluid Flow (Fluent) Geometry Mesh | ~ . ~ . | 1 | | Fluid Flow (Fluent) Geometry Mesh | . . . | 4 | | | | |
| Fluid Flow (Fluent) Geometry Mesh Setup | ~ . ~ . ~ . | 1 2 3 4 | | Fluid Flow (Fluent) Geometry Mesh Setup | | 4 | | | | |
| Fluid Flow (Fluent) Geometry Mesh Setup Solution | ~ . ~ . ~ . | 1 2 3 4 5 | | Fluid Flow (Fluent) Geometry Mesh Setup Solution | Y Y Y Y | | | | | |
| Image: Fluid Flow (Fluent) Image: Geometry Image: Geometry | × . × . × . × . | 1 2 3 4 5 6 | | Fluid Flow (Fluent) Geometry Mesh Setup Solution Results | > > > > > > > > > > > > > > > > > > > | | | | | |

- Step 7: Double Click on Parameters to find out that **another tab of Parameters is opened** on the workbench.
- Step 8: Enter the values of input parameters (in this case velocity) and right click on the selected input parameter and select the option of 'Update Selected Design Points'.

| 1 | A | | Fable of Design Points | | | | | | | | | | | | |
|-----|----------------|----------------------|------------------------|-----------------------------|------------------------------|--------------------------|----------|---------------|--------|--|--|--|--|--|--|
| 1 | | В | С | D | E | F | G | н | I | | | | | | |
| 2 | Name 💌 | P1 - parameter - 1 🔽 | P2 - output-num 💌 | P3 - parameter-outlet_den 💌 | P7 - parameter - num - mid 💌 | P8 - parameter-vel_mid 💌 | 📃 Retain | Retained Data | Note 💌 | | | | | | |
| 4 | Units | m s^-1 💌 | | m^3s^-1 | | m^3s^-1 | | | | | | | | | |
| 3 1 | DP 0 (Current) | 0.01 | 0.00192 | 5.9027E-06 | -0.058303 | -0.00018053 | V | \checkmark | | | | | | | |
| 4 1 | DP 1 | 0.02 0.0037569 | | 1.1838E-05 | -0.00022342 | | | | | | | | | | |
| 5 I | DP 2 | 0.03 | 0.0057727 | 1.845E-05 | -0.070006 | -0.00022417 | | | | | | | | | |
| 6 I | DP 3 | 0.04 | 0.0075114 | 2.4201E-05 | -0.066997 | -0.00021635 | | | | | | | | | |
| 7 | DP 4 | 0.05 | 0.0095659 | 3.1017E-05 | -0.06449 | -0.00020948 | | | | | | | | | |
| 8 1 | DP 5 | 0.06 | 0.011295 | 3.6772E-05 | -0.058563 | -0.0001911 | | | | | | | | | |
| 9 1 | DP 6 | 0.07 | 0.013069 | 4.2684E-05 | -0.051963 | -0.00017016 | | | | | | | | | |
| 10 | DP 7 | 0.08 | 0.015092 | 4.9436E-05 | -0.04138 | -0.00013589 | | | | | | | | | |
| 11 | DP 8 | 0.09 0.016943 | | 5.5615E-05 | -0.025869 | -8.5132E-05 | | | | | | | | | |
| 12 | DP 9 | 0.1 | 0.018792 | 6.1796E-05 | -0.005801 | -1.9087E-05 | | | | | | | | | |
| * | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

| × | Table of | Design Points | | | | | | | | | | |
|---------------|------------------------|--|---------------------------------------|----------------------|--|----------------|---------------|-------------------|-----------|--------------------------|------------|--|
| ^ | | А | в | | с | | | D | | E | | |
| | 1 | Name 💌 | P1 - paramete | er-1 💌 | P2 - output-num | - | P3 - parar | meter-outlet_den | - | P7 - parameter-num-mid 💌 | P8 - param | |
| | 2 | Units | m s^-1 | - | | | | m^3s^-1 | | | m | |
| E | 3 | DP 0 (Current) | 0.01 | | 0.00192 0.0037569 0.0057727 | | 5.9027E-06 | | | -0.058303 | -0.000180 | |
| | 4 | DP 1 | 0.02 | | | | 1.1838E-(| 05 | | -0.070671 | -0.000223 | |
| | 5 | DP 2 | 0.03 | | | | 1.845E-05 | | -0.070006 | -0.000224 | | |
| | 6 | DP 3 | 0.04 | | 0.0075114 | | 2.4201E- | 05 | | -0.066997 | -0.000216 | |
| | 7 | DP 4 | 0.05 | 2 | 0.0005650 | | 2 1017 | 95 | | -0.06449 | -0.000209 | |
| | 8 | DP 5 | 0.06 | | ру ste | | |)5)5 | | -0.058563 -0.051963 | -0.000191 | |
| - | 9 | DP 6 | 0.07 | Pa | | | | | | | -0.000170 | |
| × | 10 | DP 7 | 0.08 | Se | t Update Order by Row)5 | | | | -0.04138 | -0.000135 | | |
| | 11 | DP 8 | 0.09 | Sh | how Update Order 15 ptimize Update Order 15 | | |)5)5 | | -0.025869 | -8.5132E-0 | |
| | 12 | DP 9 | 0.1 | Or | | | | | | -0.005801 | -1.9087E- | |
| | * | | | | | | | | | | | |
| | | | L | | Iplicate Design Point | e Design Point | | | | | | |
| | | | | 🕑 Se |) Set as Current | | | | | | | |
| | • | | | × De | Delete Design Point III | | | | | | | |
| | Chart: N | lo data | | Ex Ex | port Selected Design | n Poi | nts | | | | | |
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| are i | not availa | ble: Please try upd | ate on 'compon | ent Mes | h in system Task1-Ca | aseA | | | | | | |

 Step 9: After some time, output parameters are computed and are used for post-processing other data. In this case, these parameters are exported into MATLAB for computing temperature by dividing numerator by normal component of velocity at both outlet and midplane. Line plots are then attained for this processed data.

Deliverable 2:-

Line Plots for Temperature corresponding to different velocity inputs at both outlet and mid-plane are obtained with the help of MATLAB (Step 9).



Figure 6: Line Plot of Outlet and Mid-plane Temperature vs Velocity

The outlet temperature is a bit higher than temperature across middle of the tank. Also, temperature values decrease with increase in velocity as smaller the velocity, longer the interaction time of water packets with heat and higher the water temperature.