Objective:

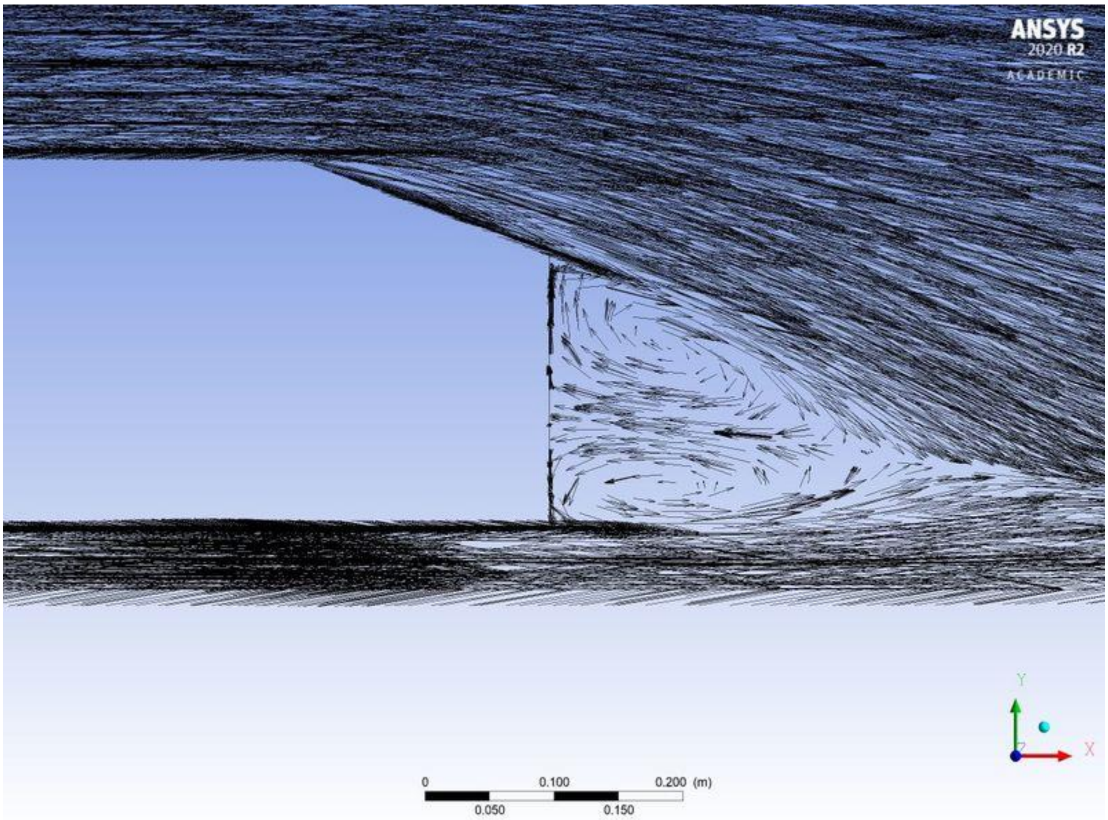
External flow simulation over an Ahmed body in Ansys fluent.

Theory:

Ahmed's body and its importance

- The Ahmed body is a simplified vehicle model or a bluff model body with basic aerodynamic properties of a vehicle and it was developed for investigating the influence of the slant angle at the back on the flow field and due to aerodynamic forces, with suppressed interaction between the front and the rear parts.
- This model is also used to describe the turbulent flow field around a car-like geometry.
- In terms of a car, the lower the drag coefficient, the more efficient the car is.
- As well as affecting the top speed of a vehicle, the drag coefficient also affects the handling.
- Cars with a low drag coefficient are sought after, but decreasing the drag drastically can reduce the downforce and lead to a loss in road traction and a higher chance of car accidents.

Reason for the negative pressure in the wake region

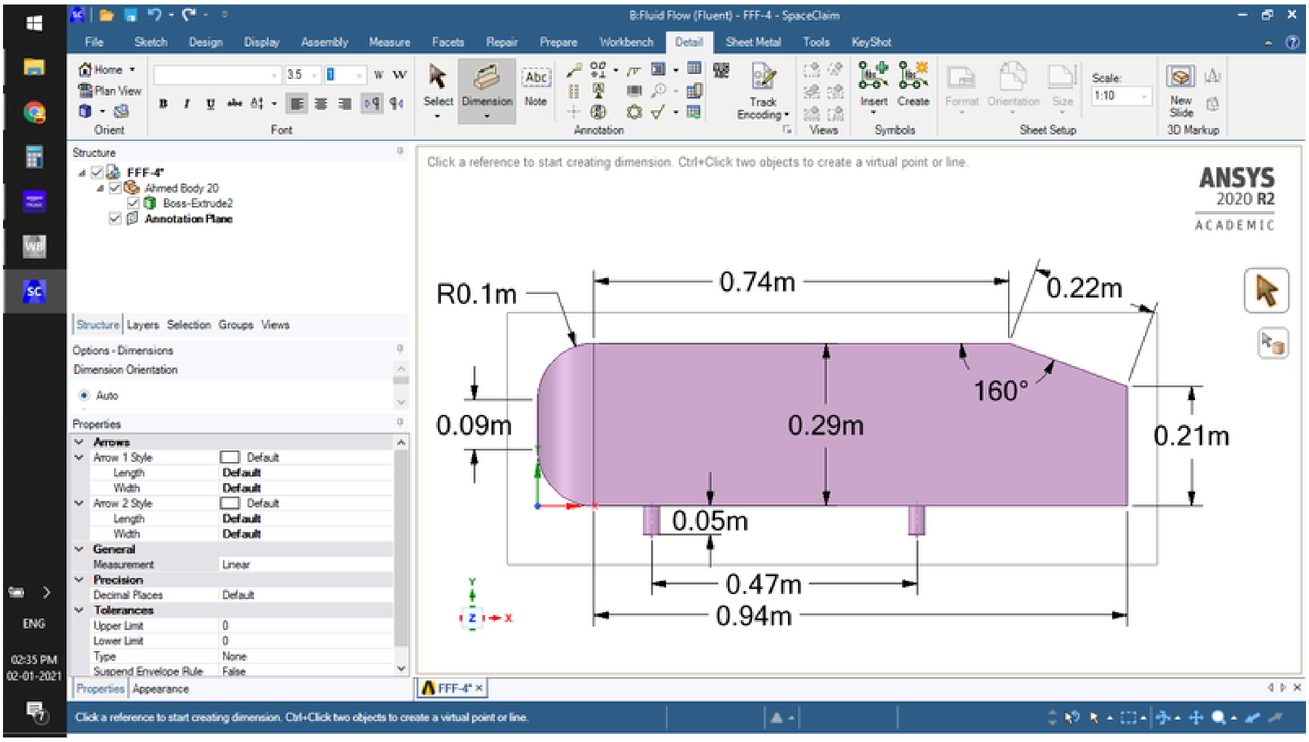


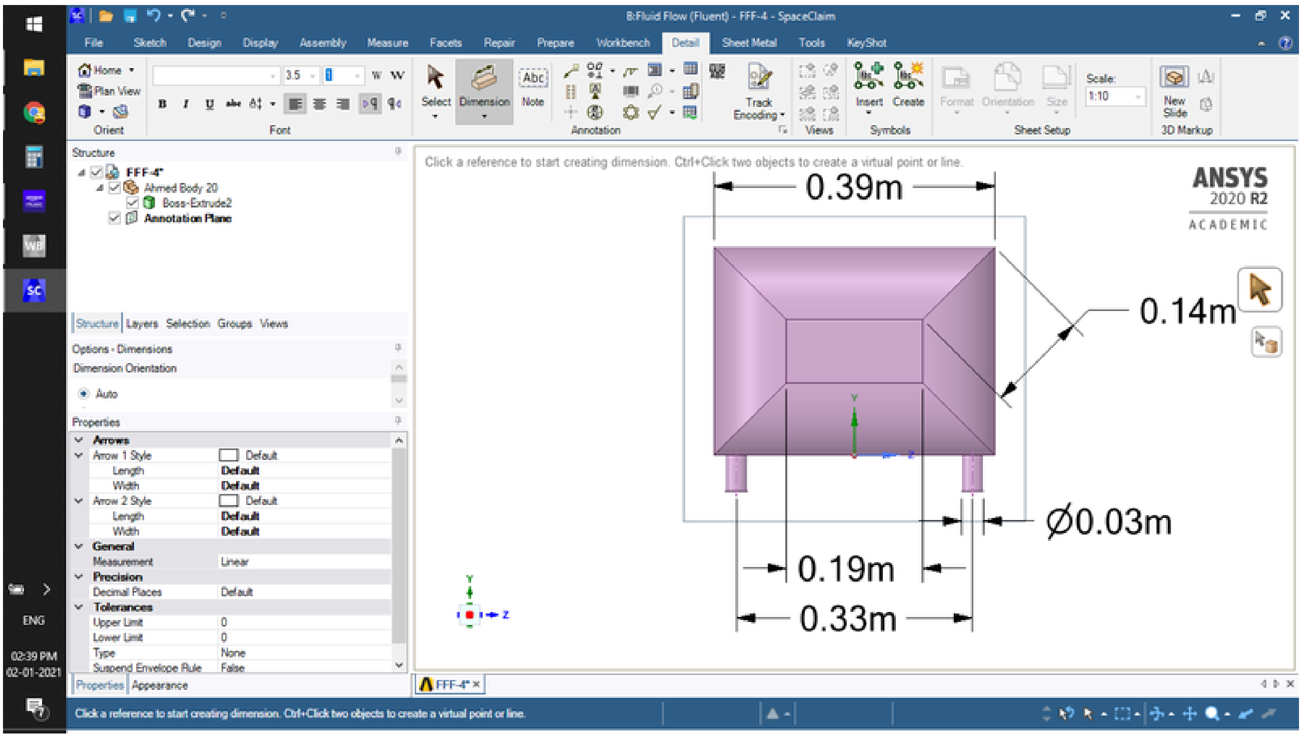
- Wake is defined as the region of recirculating flow immediately behind a moving or stationary blunt body, caused by viscosity, which may be accompanied by the flow of separation and turbulence.
- Adverse pressure gradients cause the boundary layers to separate, which creates a large wake filled with energetic eddies that dissipate a great deal of mechanical energy and thereby increase the drag.

Significance of the point of separation

- Flow separation is the detachment of a boundary layer from a surface into a wake.
- Optimizing the Point of separation helps to reduce the drag coefficient.

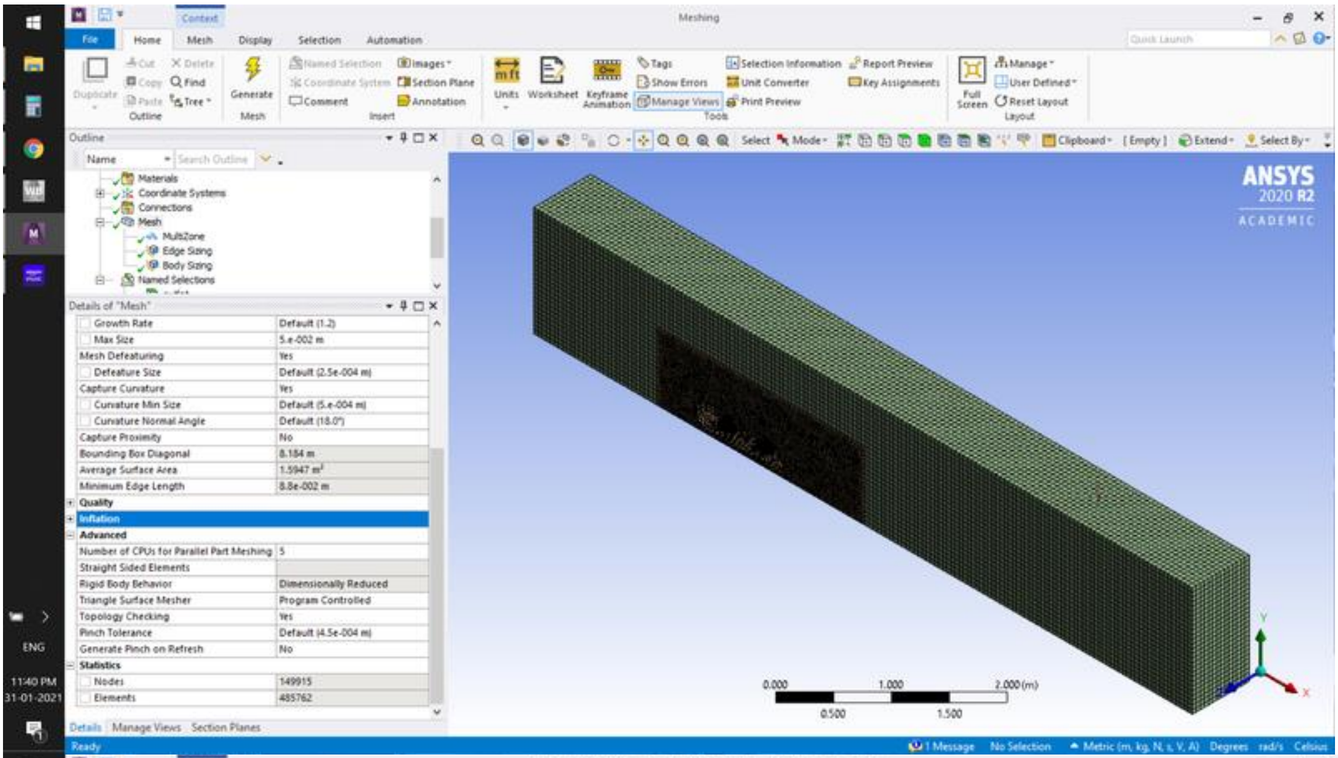
the geometry of Ahmed body:

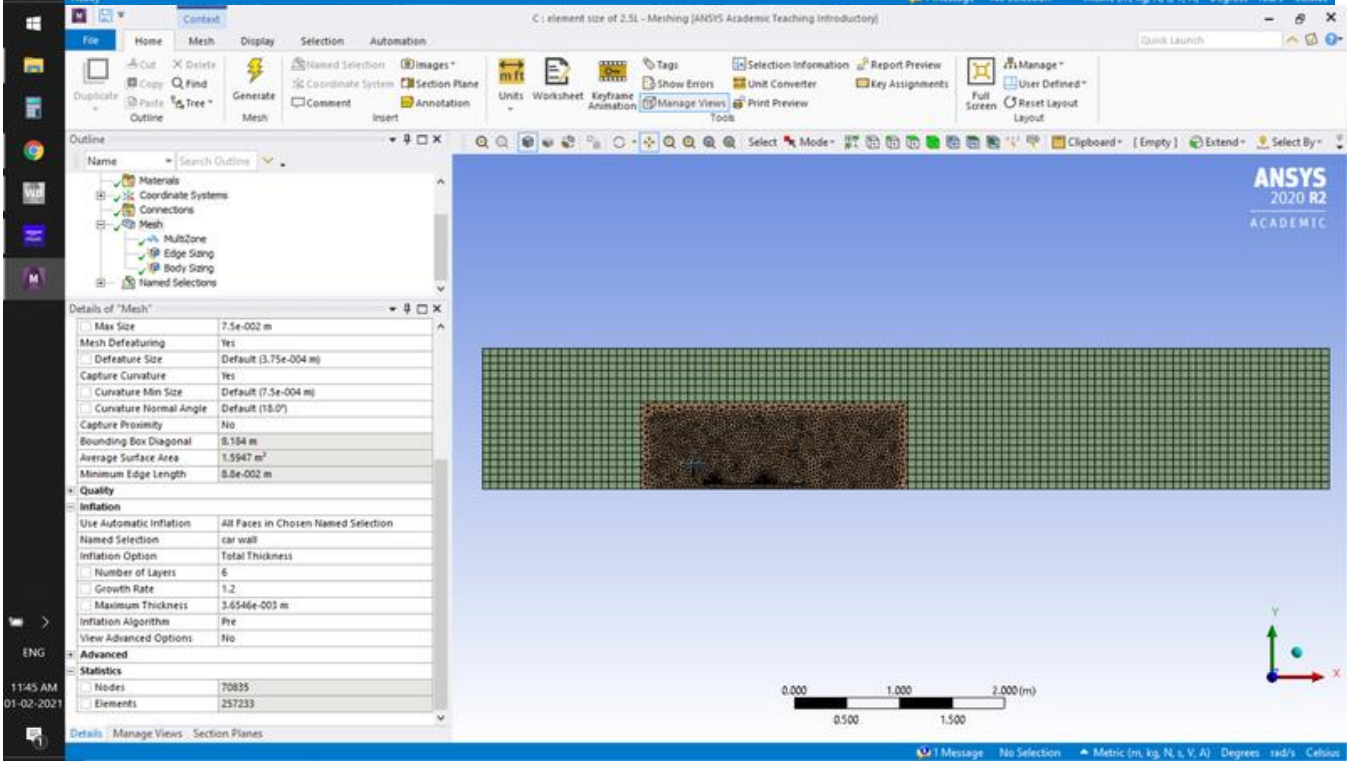


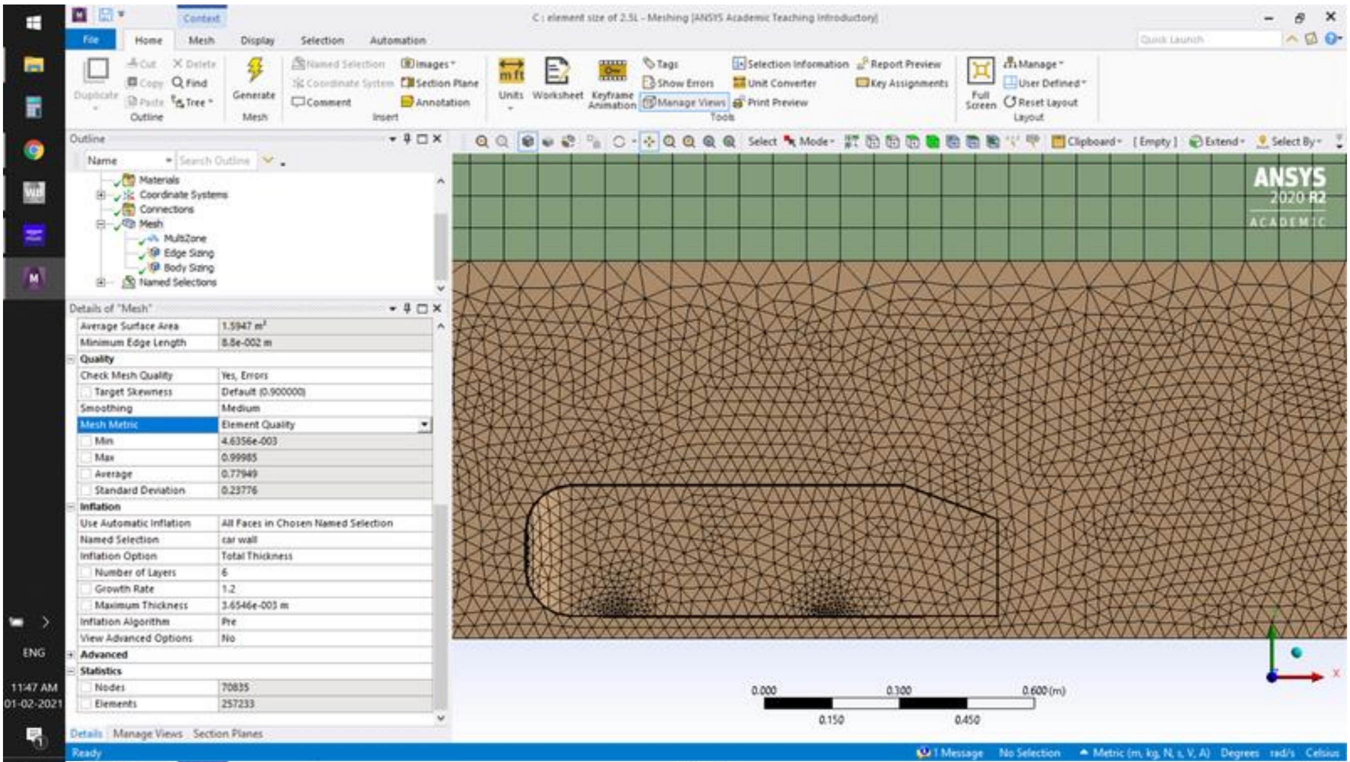


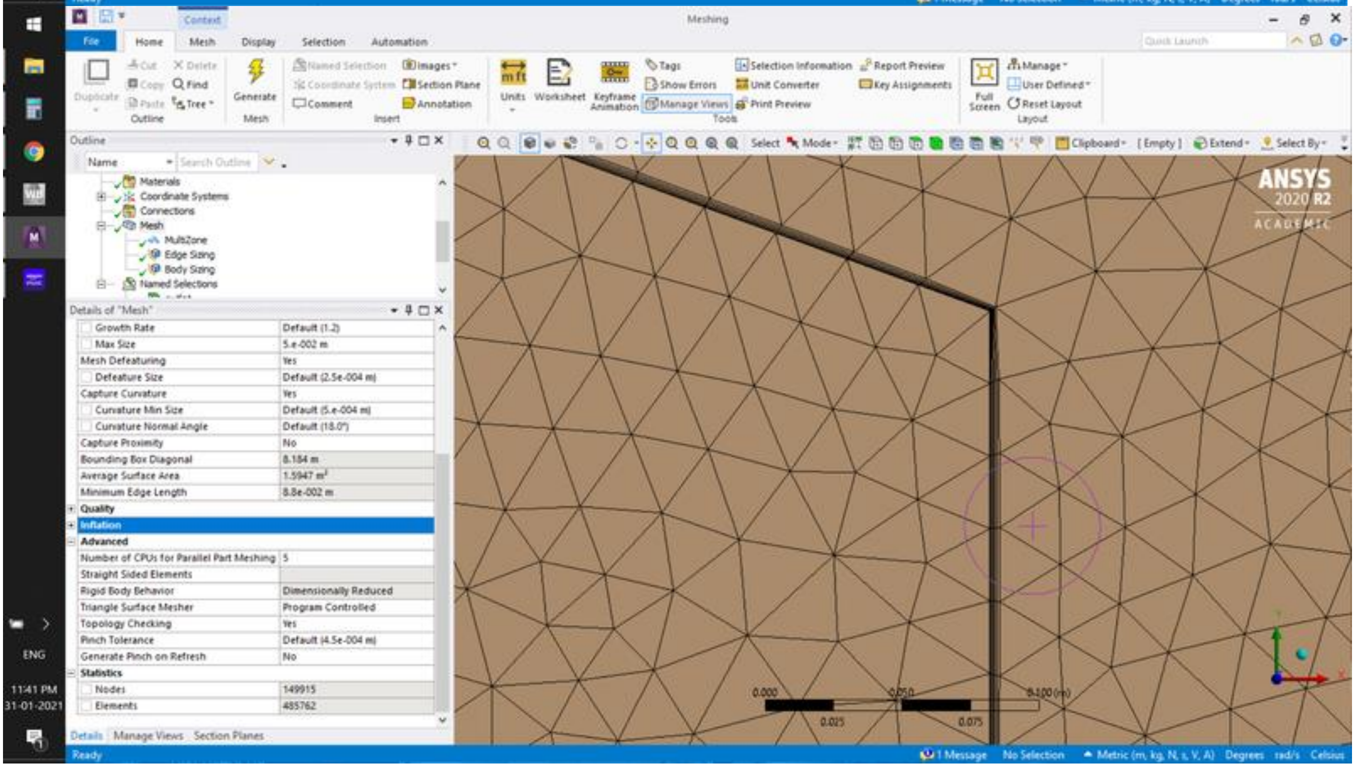
Mesh:

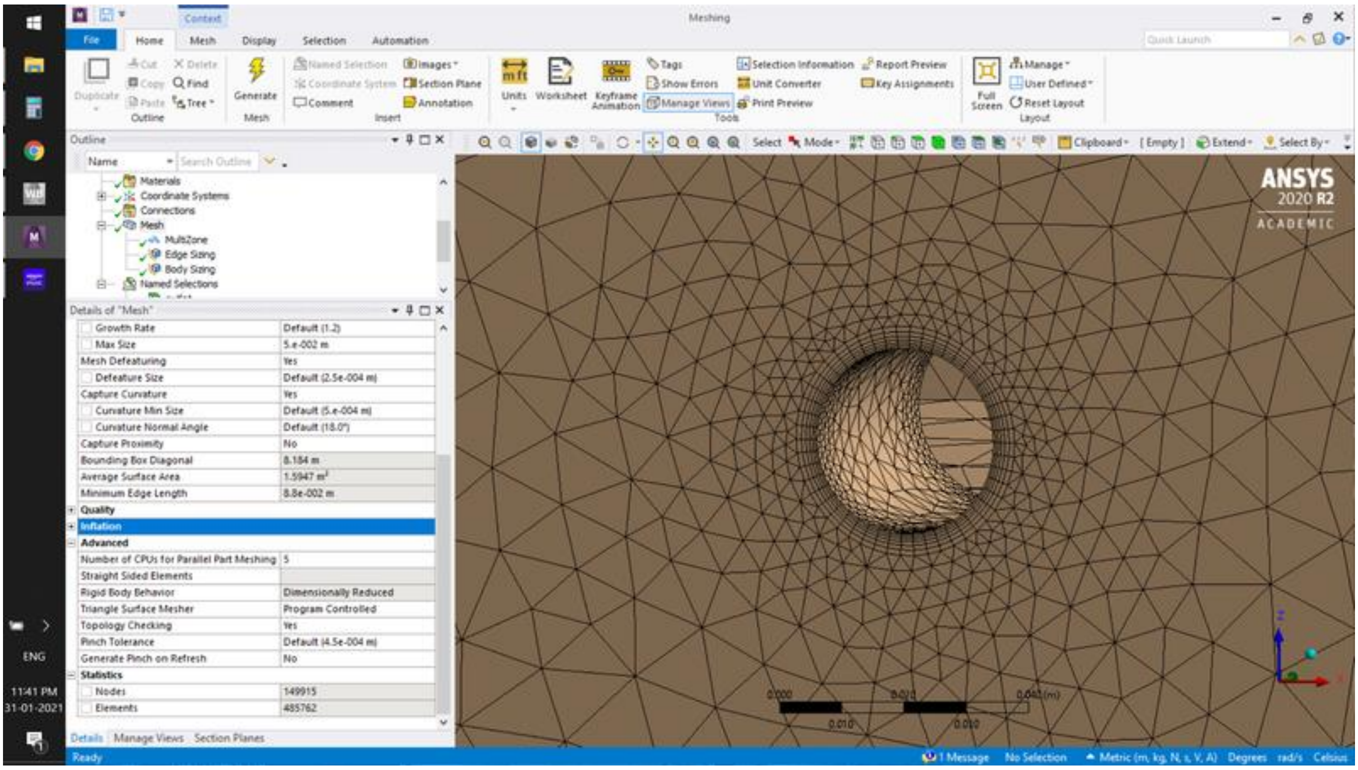
as the Ahmed body is a symmetrical body simulating either half of the body will give precise results as a whole body.





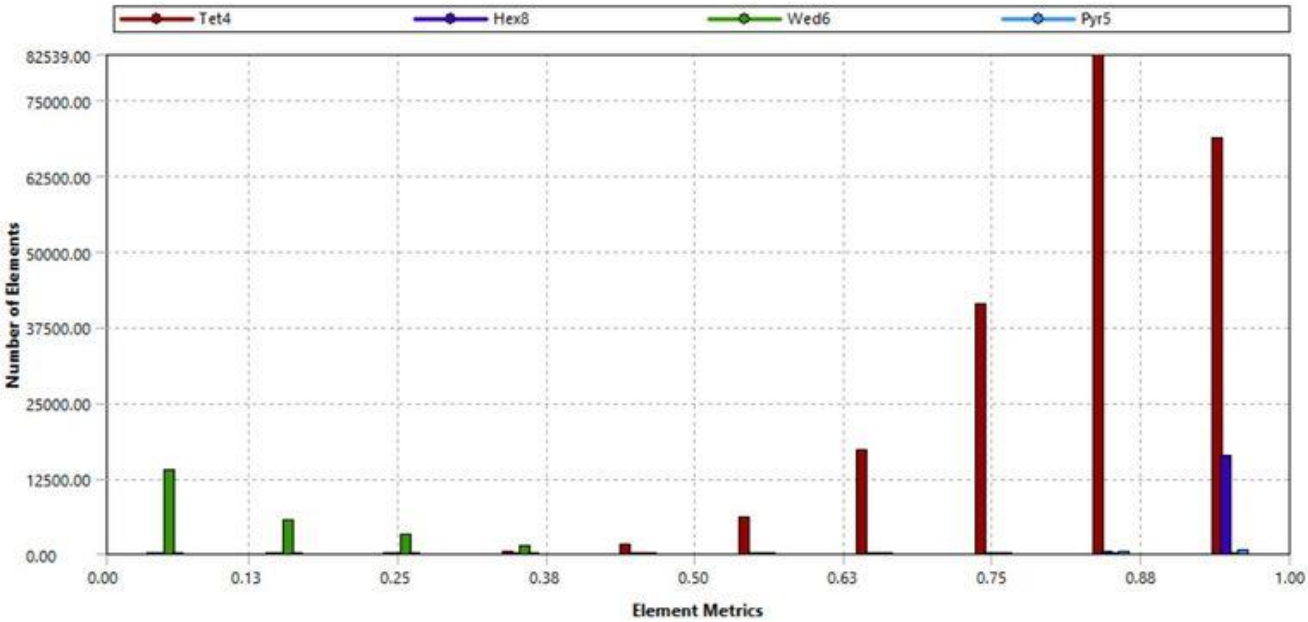

C : element size of 2.5L - Meshing [ANSYS Academic Teaching Introductory]
File
Home
Mesh
Display
Selection
Automation
Outline
Materials
Coordinate Systems
Connections
Mesh
MultiZone
Edge Sizing
Body Sizing
Named Selections
Details of "Mesh"
Average Surface Area 1.5947 m²
Minimum Edge Length 8.8e-002 m
Quality
Check Mesh Quality Yes, Errors
Target Skewness Default (0.900000)
Smoothing Medium
Mesh Metric Element Quality
Min 4.6356e-003
Max 0.99985
Average 0.77949
Standard Deviation 0.23776
Inflation
Use Automatic Inflation All Faces in Chosen Named Selection
Named Selection car wall
Inflation Option Total Thickness
Number of Layers 6
Growth Rate 1.2
Maximum Thickness 3.6546e-003 m
Inflation Algorithm Pre
View Advanced Options No
Advanced
Statistics
Nodes 70835
Elements 257233
ANSYS
2020 R2
ACADEMIC
0.000
0.300
0.600 (m)
0.150
0.450
Ready
1 Message
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
11:47 AM
01-02-2021


Meshing
File
Home
Mesh
Display
Selection
Automation
Outline
Materials
Coordinate Systems
Connections
Mesh
MultiZone
Edge Sizing
Body Sizing
Named Selections
Details of "Mesh"
Growth Rate Default (1.2)
Max Size 5.e-002 m
Mesh Defeaturing Yes
Defeature Size Default (2.5e-004 m)
Capture Curvature Yes
Curvature Min Size Default (5.e-004 m)
Curvature Normal Angle Default (18.0°)
Capture Proximity No
Bounding Box Diagonal 8.184 m
Average Surface Area 1.5947 m²
Minimum Edge Length 8.8e-002 m
Quality
Inflation
Advanced
Number of CPUs for Parallel Part Meshing 5
Straight Sided Elements
Rigid Body Behavior Dimensionally Reduced
Triangle Surface Mesher Program Controlled
Topology Checking Yes
Pinch Tolerance Default (4.5e-004 m)
Generate Pinch on Refresh No
Statistics
Nodes 149915
Elements 485762
ANSYS
2020 R2
ACADEMIC
0.000
0.050
0.100 (m)
0.025
0.075
Ready
1 Message
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
11:41 PM
31-01-2021



Meshing
ANSYS
2020 R2
ACADEMIC
Outline
Materials
Coordinate Systems
Connections
Mesh
MultiZone
Edge Sizing
Body Sizing
Named Selections
Details of "Mesh"
Growth Rate	Default (1.2)
Max Size	5.e-002 m
Mesh Defeaturing	Yes
Defeature Size	Default (2.5e-004 m)
Capture Curvature	Yes
Curvature Min Size	Default (5.e-004 m)
Curvature Normal Angle	Default (18.0°)
Capture Proximity	No
Bounding Box Diagonal	8.184 m
Average Surface Area	1.5947 m²
Minimum Edge Length	8.8e-002 m
Quality
Inflation
Advanced
Number of CPUs for Parallel Part Meshing	5
Straight Sided Elements
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Default (4.5e-004 m)
Generate Pinch on Refresh	No
Statistics
Nodes	149915
Elements	485762

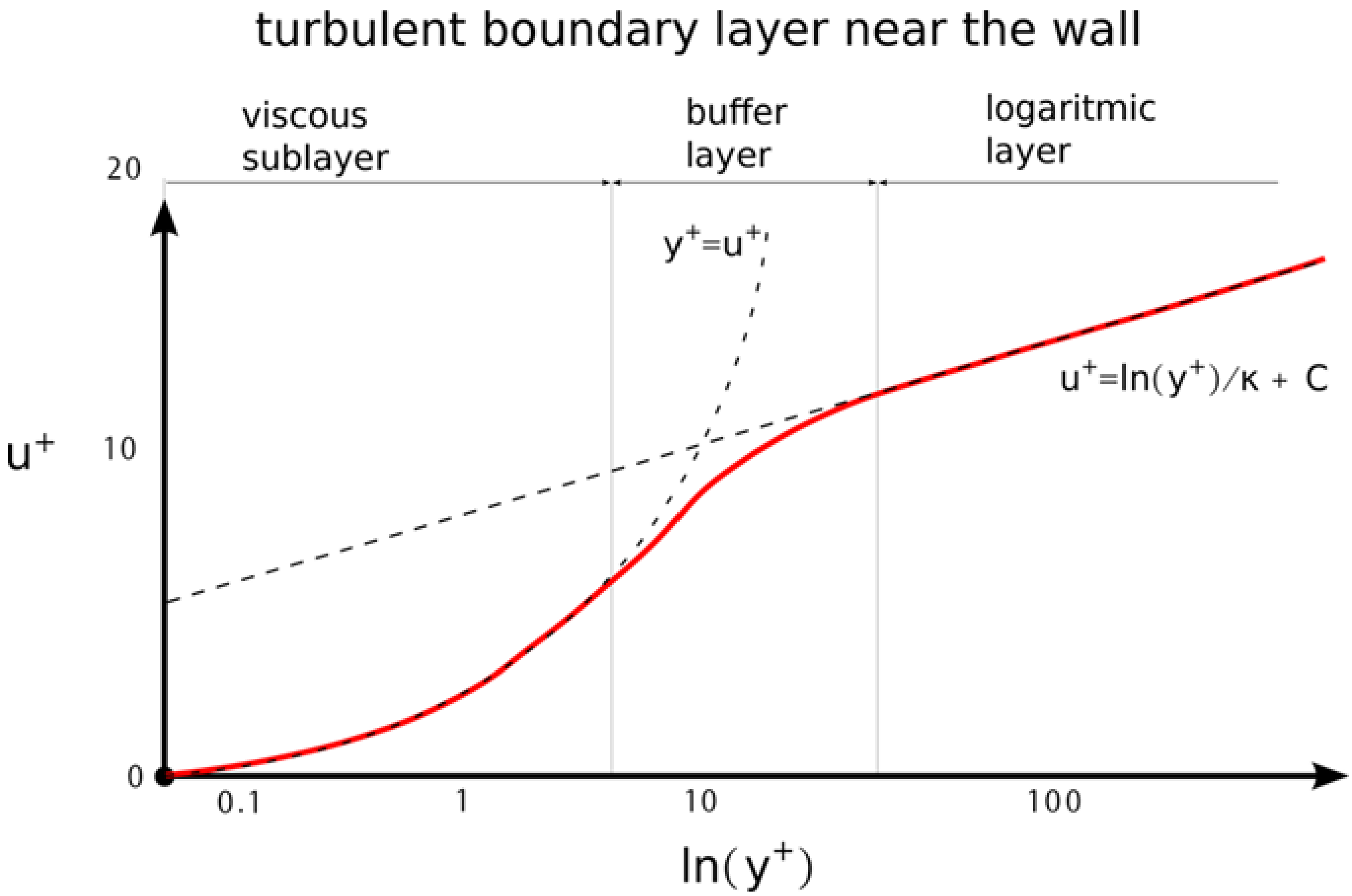
Controls



Tet4
Hex8
Wed6
Pyr5
82539.00
75000.00
62500.00
50000.00
37500.00
25000.00
12500.00
0.00
Number of Elements
0.00
0.13
0.25
0.38
0.50
0.63
0.75
0.88
1.00
Element Metrics

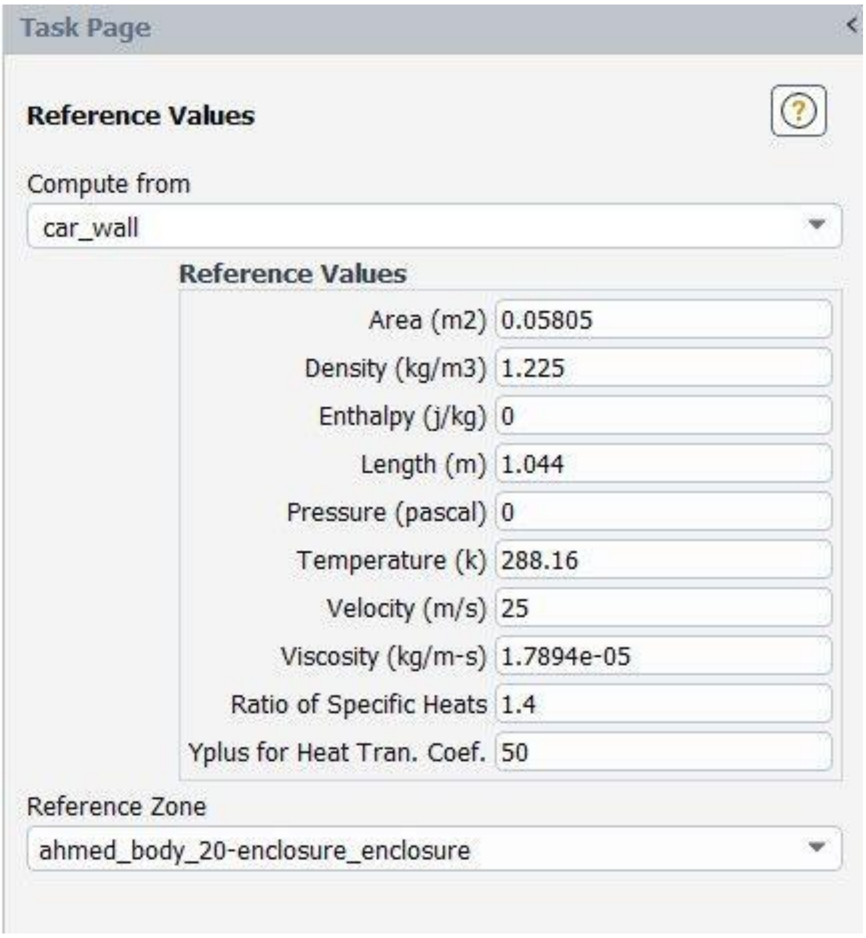
Matlab code to calculate wall thickness:

to calculate total thickness from the desired Y+

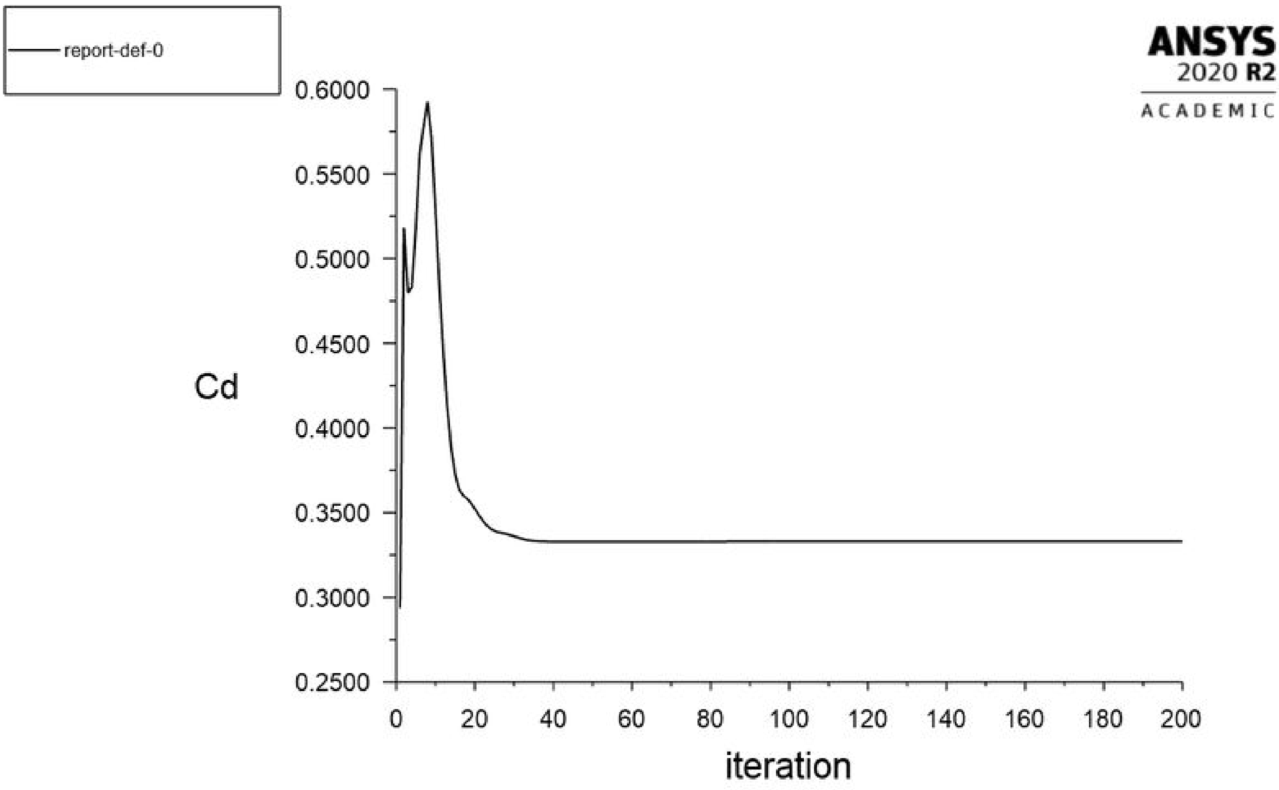


since we are using the k-epsilon model y+ will be above 30.

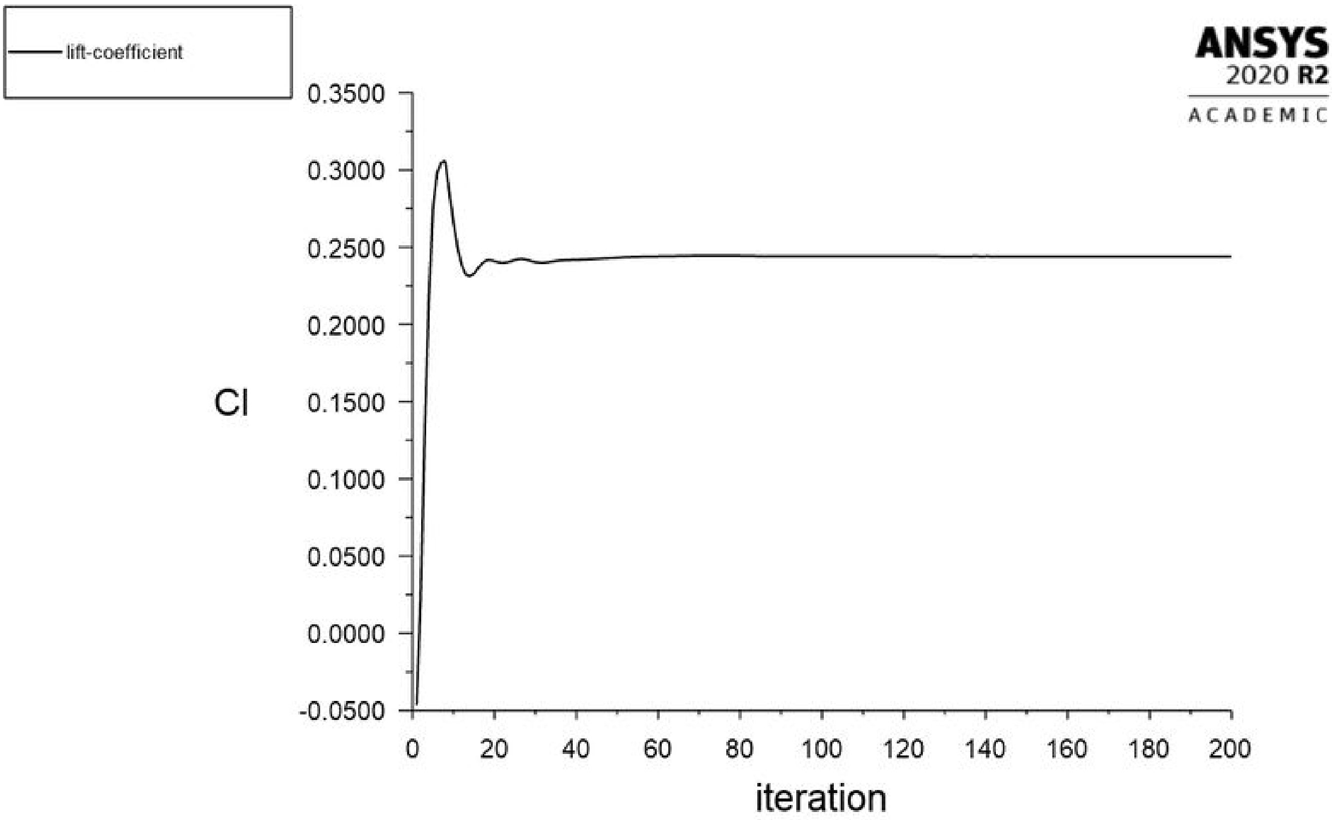
```
clear all
close all
clc

u = 25; %m/s
L = 1.044; %m
rho = 1.225; %kg/m3
mu = 0.000018375; %kg/m.s
Y_plus = input('enter desired value of Y+');

Re = u*L*rho/mu; %reynolds number

cf = 0.026/(Re^(1/7)); %skin friction coefficient

T_wall = 0.5*cf*rho*u^2; %wall shear stress

U_fri = sqrt(T_wall/rho); %friction velocity

del_s = Y_plus*mu/(U_fri*rho);

growthrate = 1.2; %growth rate of next cell from previous cell
no_cell = 6; % no of cells
tot_thick = del_s*2*1.2^(no_cell-1);

fprintf('n Reynolds number is %d n n',Re);
fprintf(' first wall thickness is %d in mn n',del_s);
fprintf(' Total thickness of the cell %d in mn', tot_thick);
```


Task Page
Reference Values
Compute from
car_wall
Reference Values
Area (m2) 0.05805
Density (kg/m3) 1.225
Enthalpy (j/kg) 0
Length (m) 1.044
Pressure (pascal) 0
Temperature (k) 288.16
Velocity (m/s) 25
Viscosity (kg/m-s) 1.7894e-05
Ratio of Specific Heats 1.4
Yplus for Heat Tran. Coef. 50
Reference Zone
ahmed_body_20-enclosure_enclosure

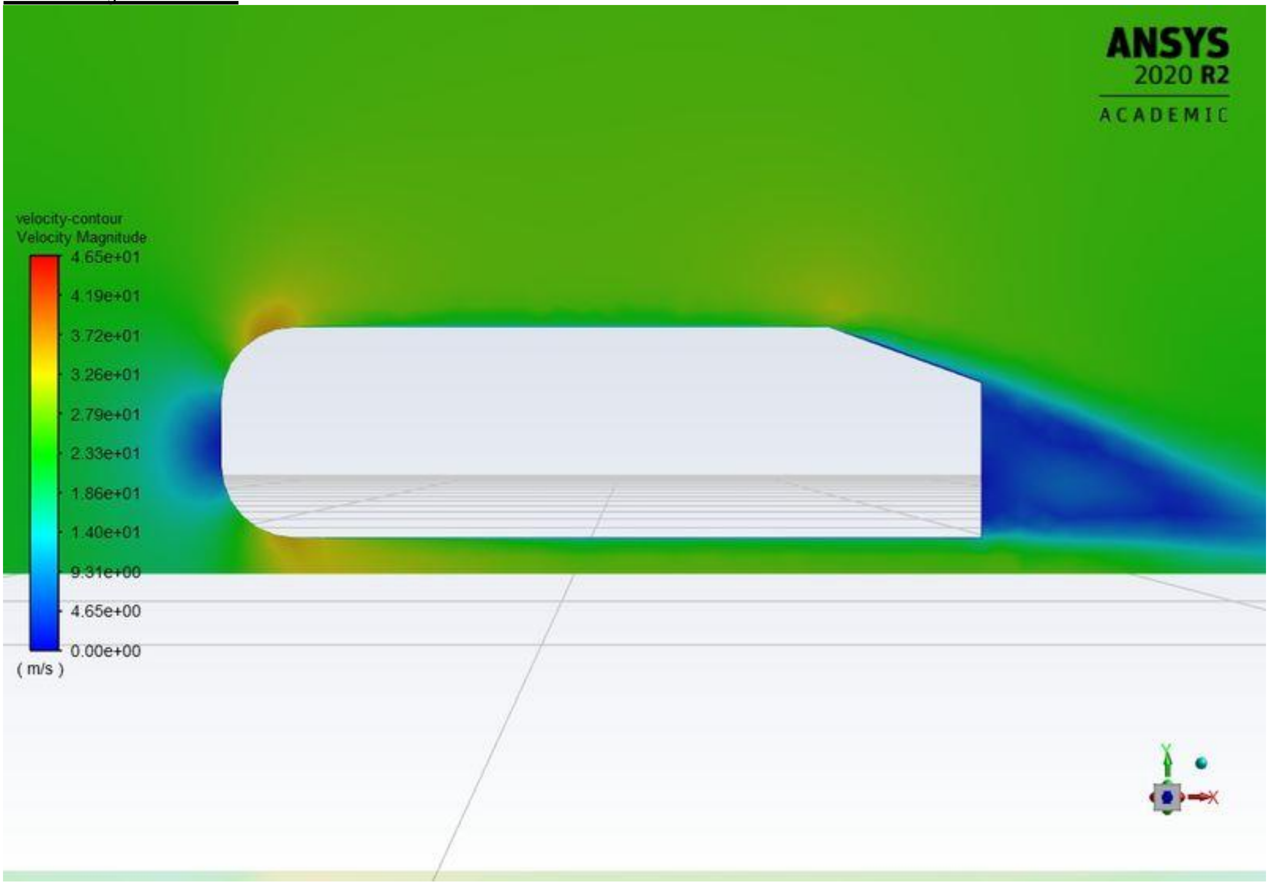
coefficient of drag:



coefficient of lift:

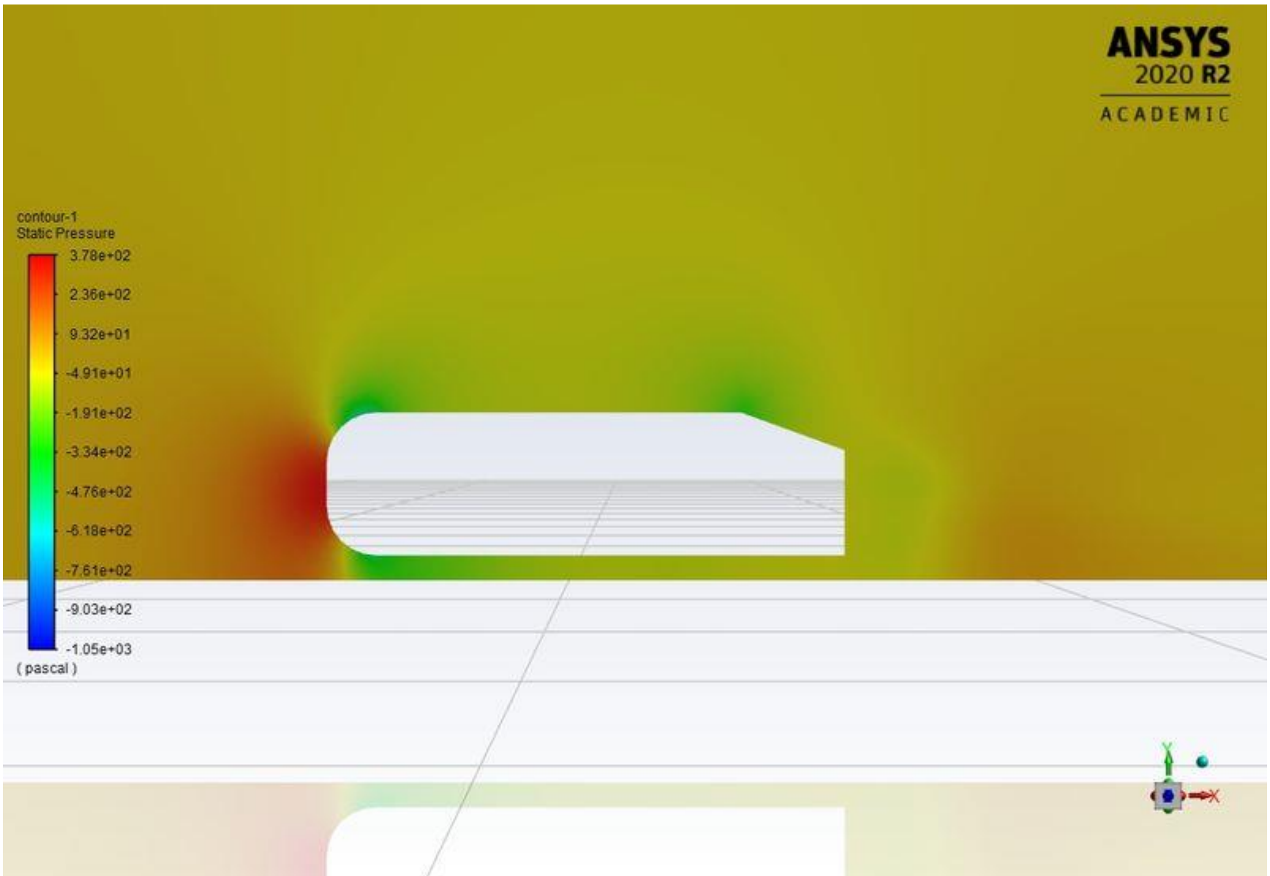


Velocity contour

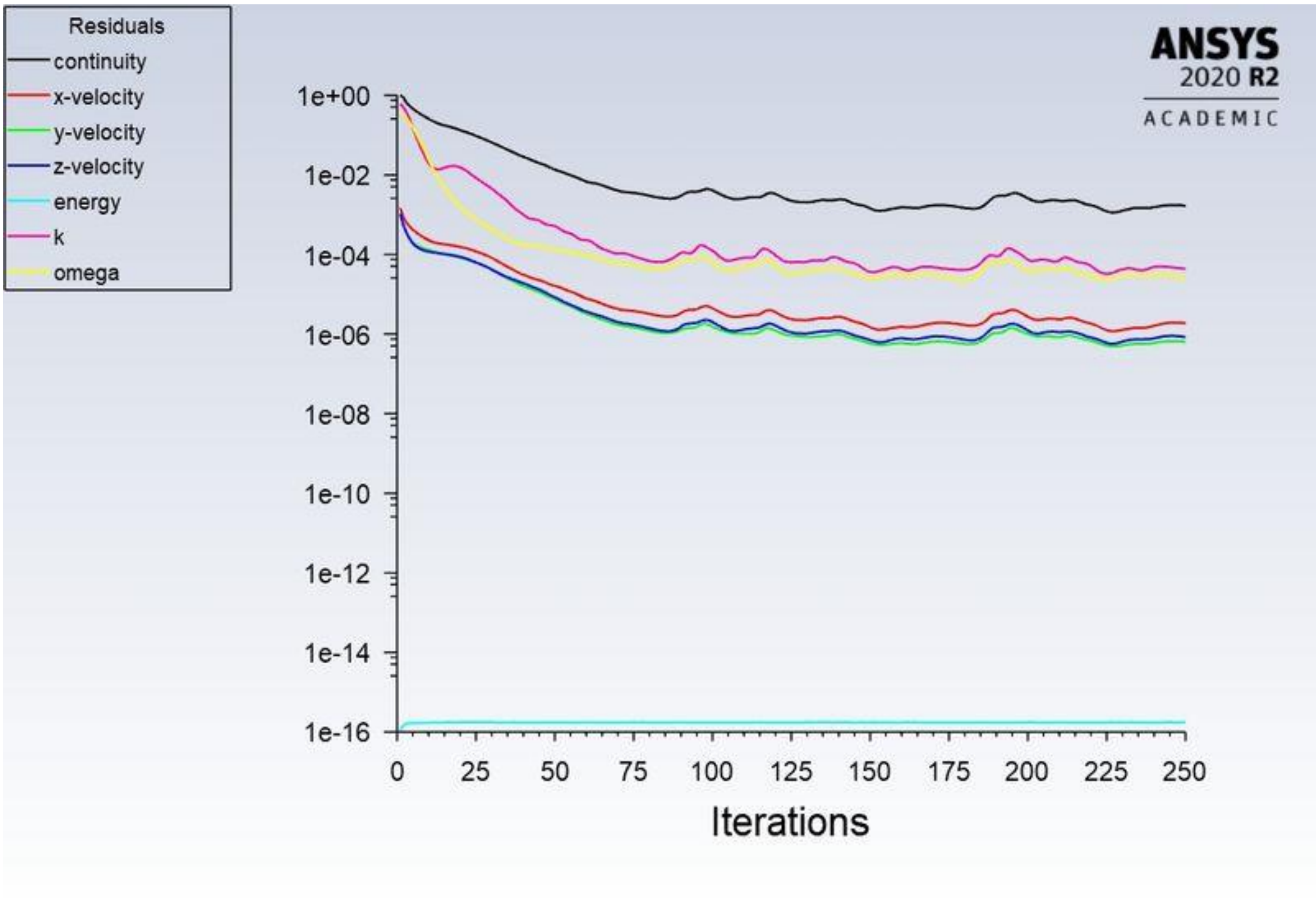


pressure contour:

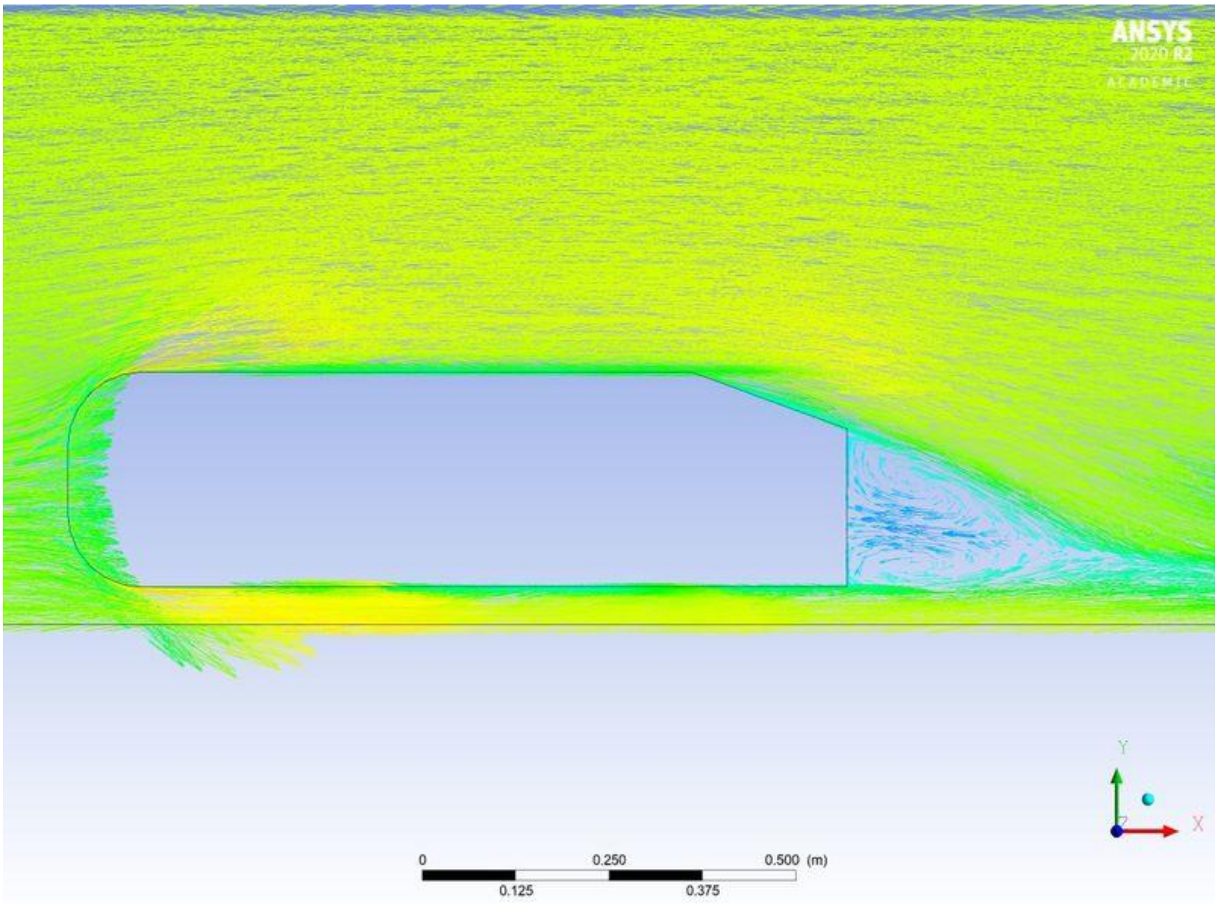
Pressure contour:

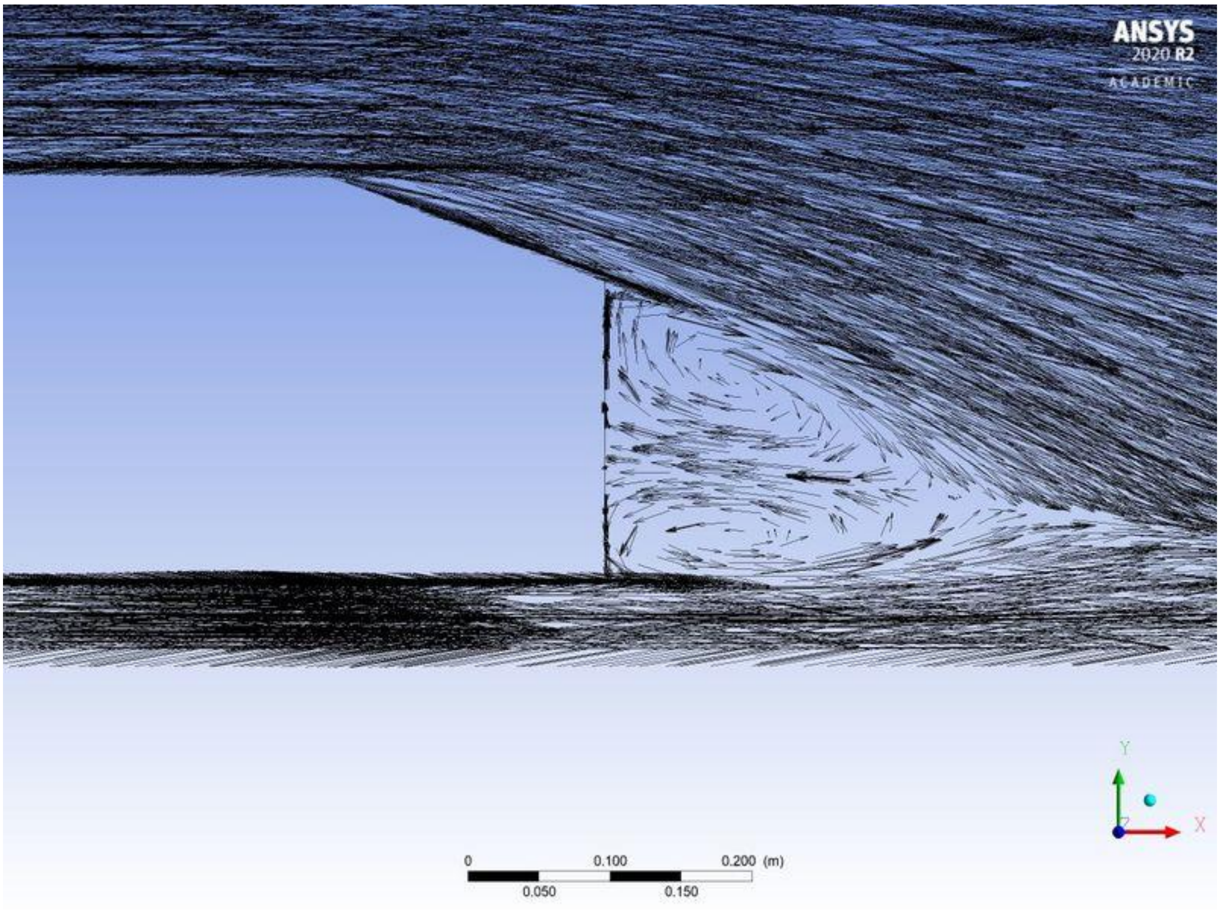


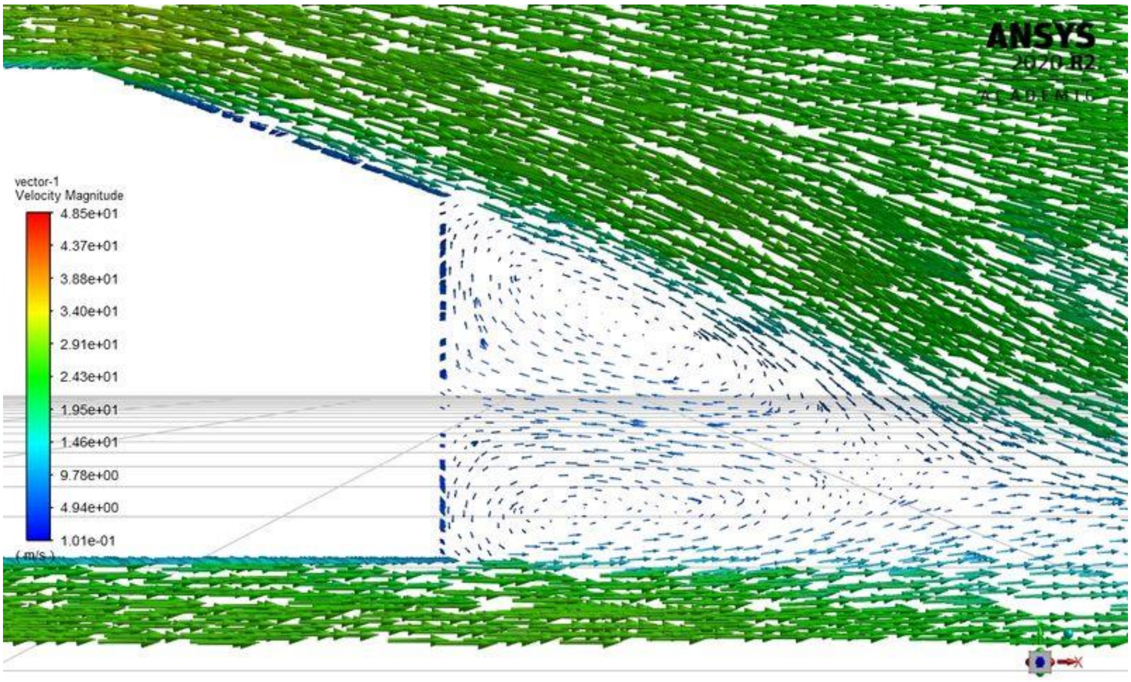
Residual :

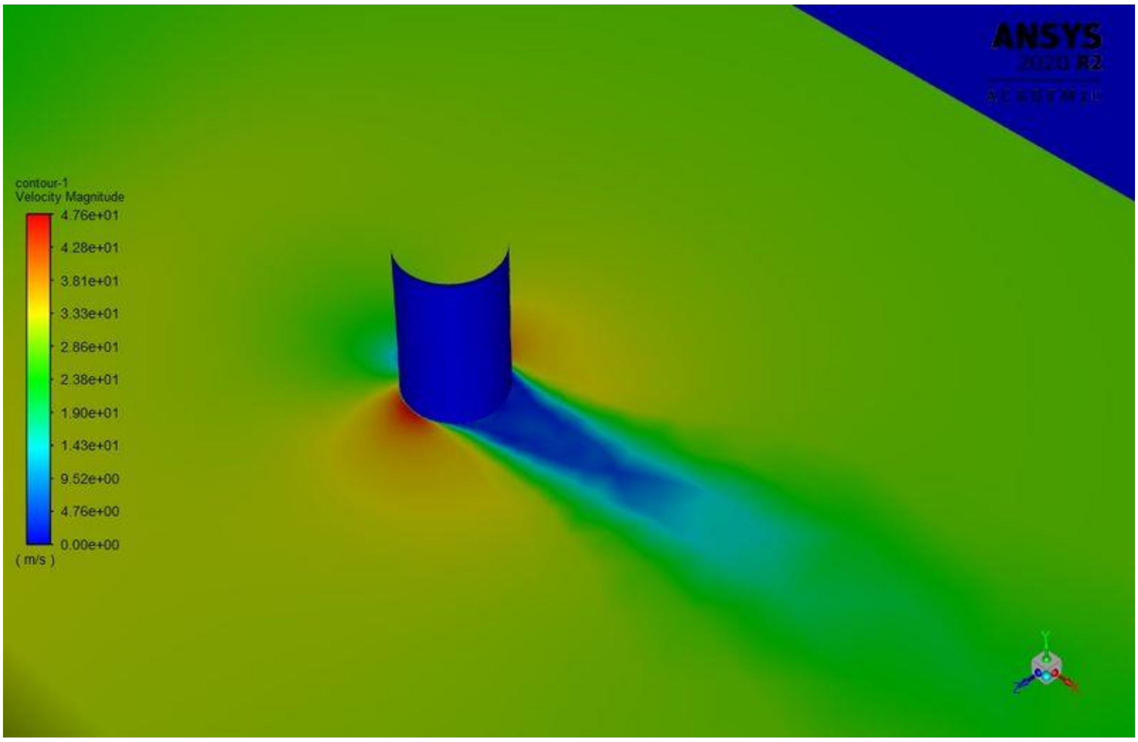


Vector plane:


ANSYS
2020 R2
ACADEMIC
Y
X
0
0.250
0.500 (m)
0.125
0.375


ANSYS
2020 R2
ACADEMIC
Y
X
0
0.100
0.200 (m)
0.050
0.150

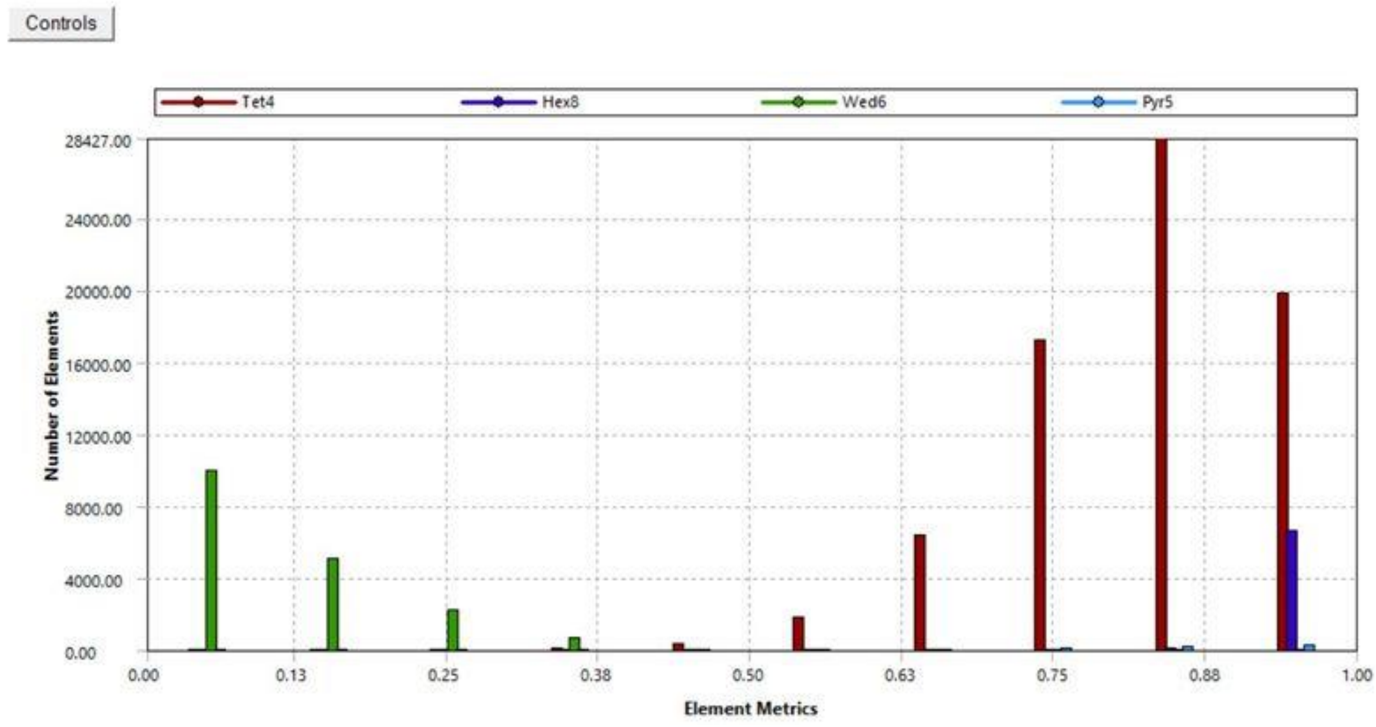

ANSYS
2020 R2
ACADEMIC
vector-1
Velocity Magnitude
4.85e+01
4.37e+01
3.88e+01
3.40e+01
2.91e+01
2.43e+01
1.95e+01
1.46e+01
9.78e+00
4.94e+00
1.01e-01
(m/s)


ANSYS
2020 R2
ACADEMIC
contour-1
Velocity Magnitude
4.76e+01
4.28e+01
3.81e+01
3.33e+01
2.86e+01
2.38e+01
1.90e+01
1.43e+01
9.52e+00
4.76e+00
0.00e+00
(m/s)

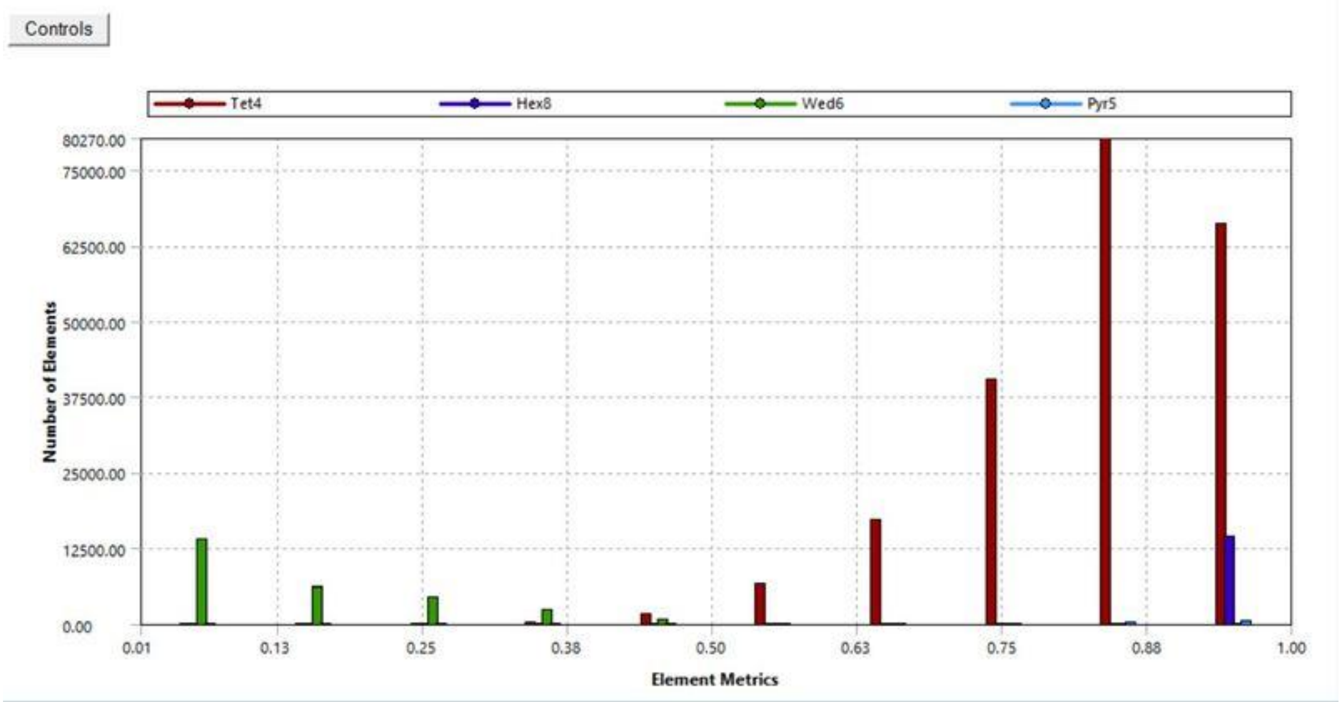
the grid independency test :

Element quality

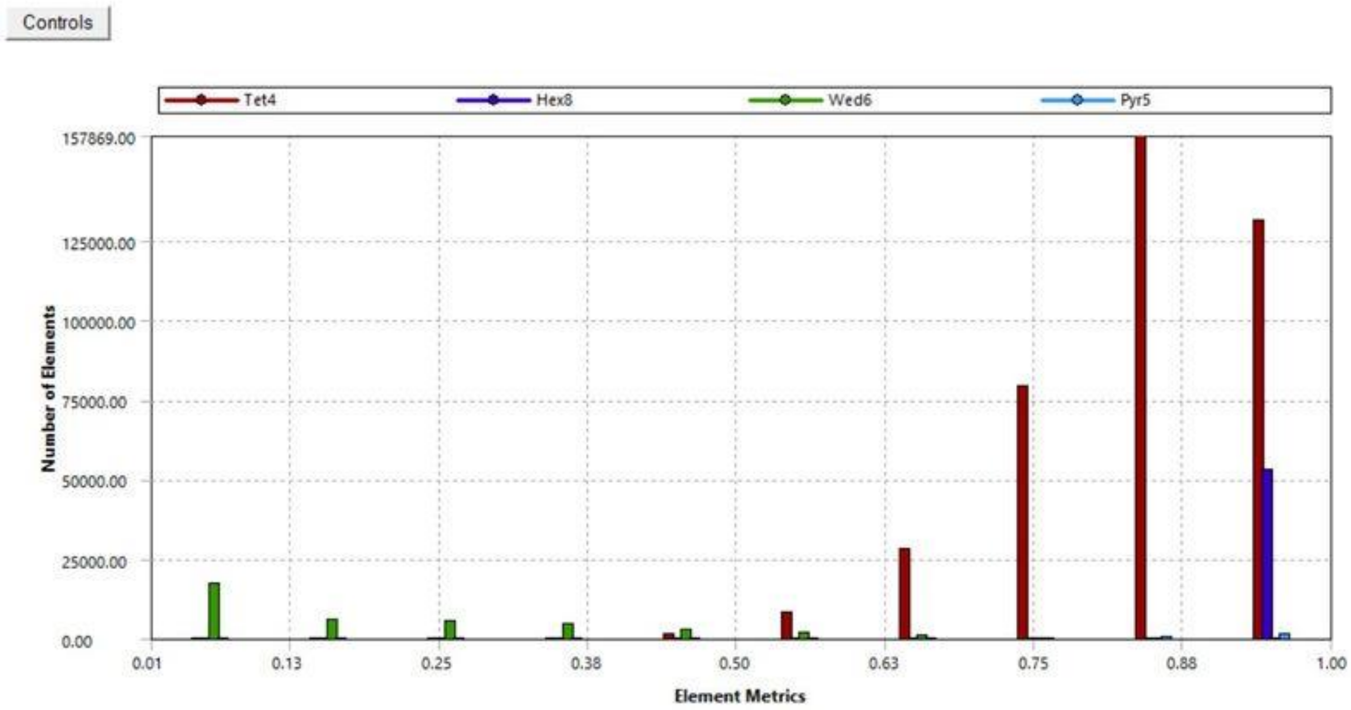
course mesh



medium mesh



fine mesh



	No. of element	Drag coefficient	Lift coefficient
Course	**98989**	**0.4023**	**0.2015**
Medium	**253876**	**0.356**	**0.23728**
Fine	**498965**	**0.333**	**0.244**

Conclusion:

- From grid independent study, finer the mesh will give the result more accuracy.
- Boundary layer thickness depends on the y+ value.

Reference:

targeting-a-specific-y-value-for-your-turbulent-flow-cfd-simulation

https://www.researchgate.net/publication/266883948_Flow_and_Turbulence_Structures_in_the_Wake_of_a_Simplified_Car_Model_Ahmed_Model

https://www.researchgate.net/publication/330383775_Experiments_and_numerical_simulations_on_the_aerodynamics_of_the_Ahmed_body