Problem- Investigation of Thermal and Hydrodynamic Boundary Layers During Flow Across a Heated Plate Through ANSYS Simulation

T_∞ = 300 K ,

T_s = Surface temp.=400 K

ρ = 1.225 kg / m^3

Length of plate= 1m

μ = 1.7894 x 10^{-5} kg / $m.s$

k = 0.0242 W / $m.K$

Inlet

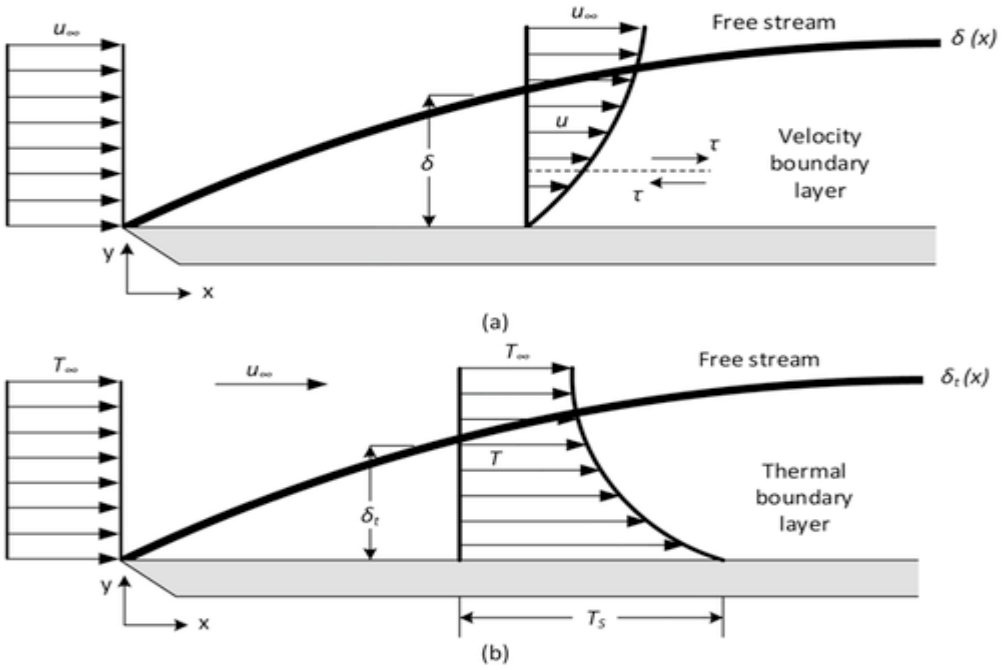
Outlet

$c\,p$ = 1006.43 J /$kg.K$

Pr = 0.744176

u_∞ = 1.4607 m / s

L=1m



Theoretical calculation

Reynolds number=Re_L = $\rho.u_\infty.L$ /μ = 1.225 × 1.4607 × 1 1.7894 × 10^{-5} = 99998 < 5 × 10^5

Mass flow rate inlet:

= $u_\infty * A$ = 1.4607*0.06 = 0.087642≈ 0.1 kg/s

Average Nusselt number = 0.664 Re_L $^{1/2}$ $Pr^{1/3}$ = 0.664 × $99998^{1/2}$ × $0.744176^{1/3}$ = 190.278

Average convection heat transfer coefficient = (Average Nusselt number)*k /L = 190.278×0.0242 1 = 4.605 W/m^2 k

Average skin or fanning friction coefficient= 1.328 *Re_L $^{-1/2}$

=0.004199547

$Locally, at\ x$ = 0.1 m:

Nu_x = 0.332 Re_x $^{1/2}$ Pr $^{1/3}$

h_x= 7.28070 W/m^2 .k

Cf_x = 0.664 Re_x $^{-1/2}$ = 0.006640079

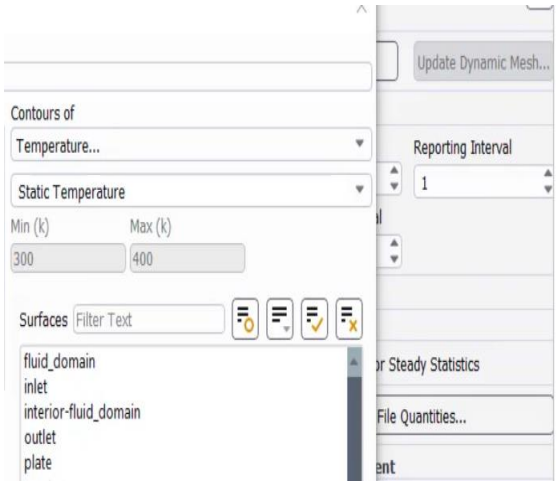
δ = velocity boundary layer thickness

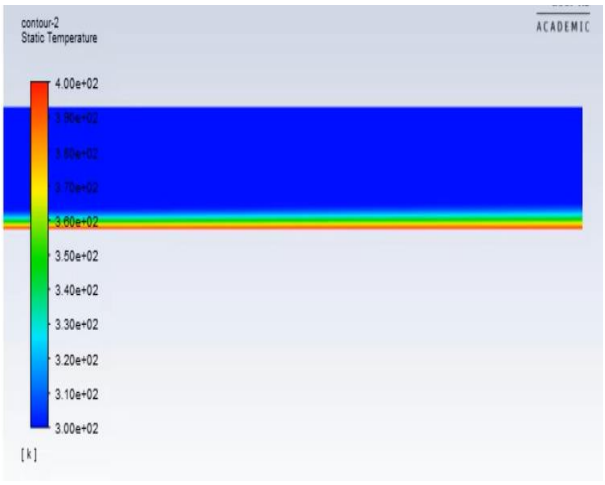
δ = 5L /Re_L $^{(1/2)}$ = 0.01581 m

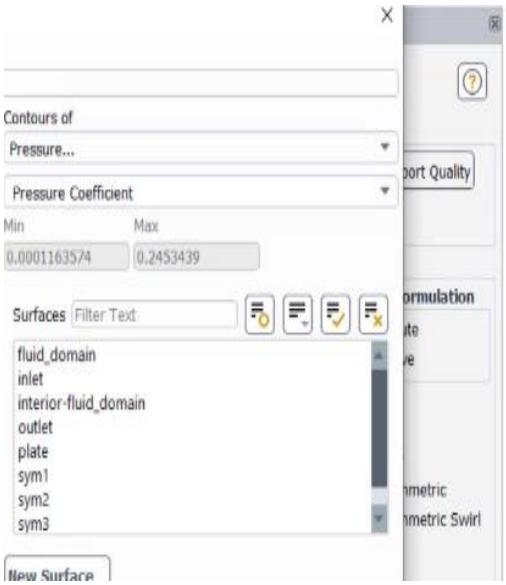
δ_t = Thermal boundary layer thickness

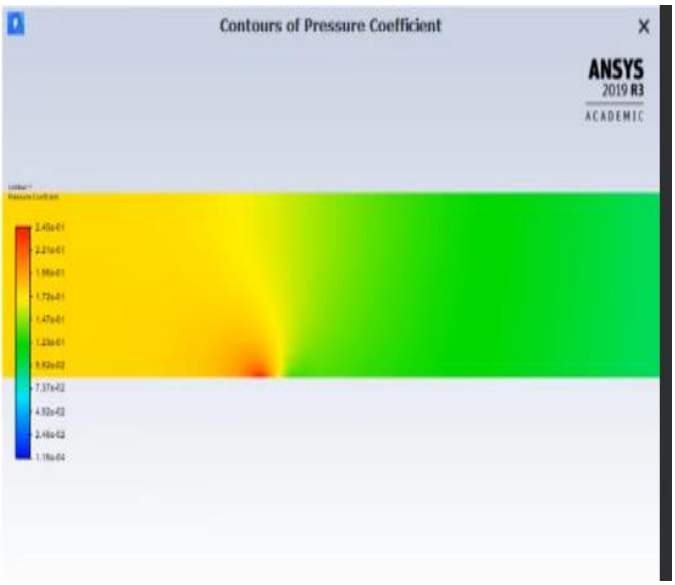
δ /δ_t = Pr $^{1\,3}$; δt = 0.017448172 m

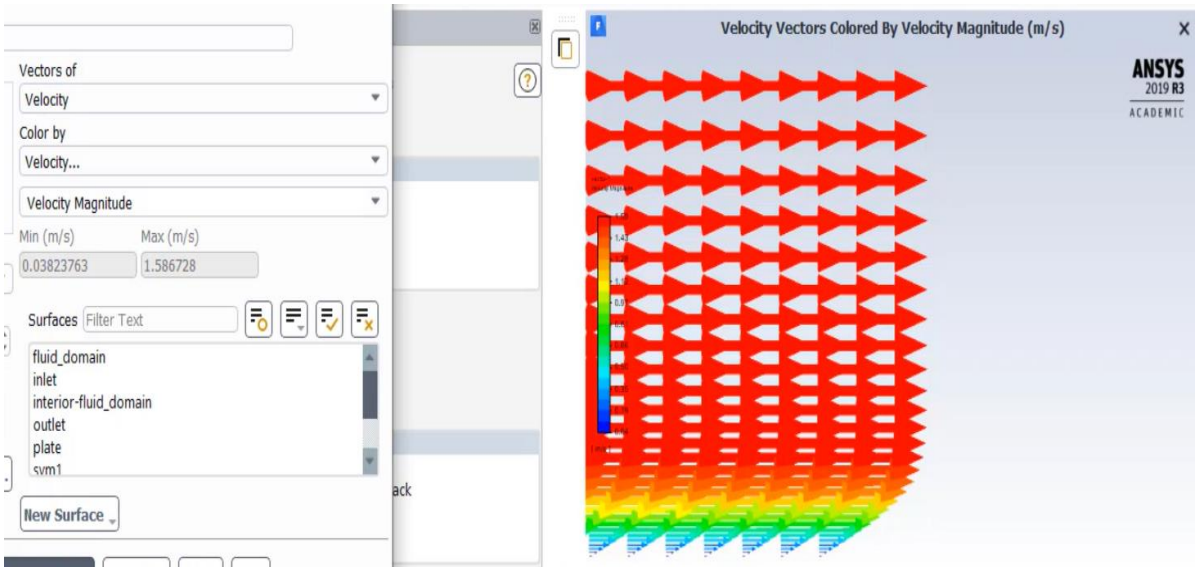
Results-

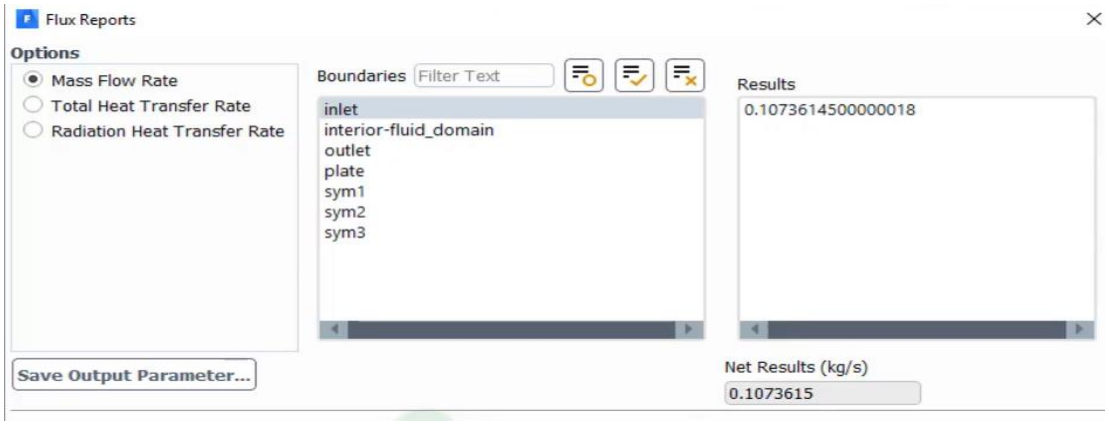


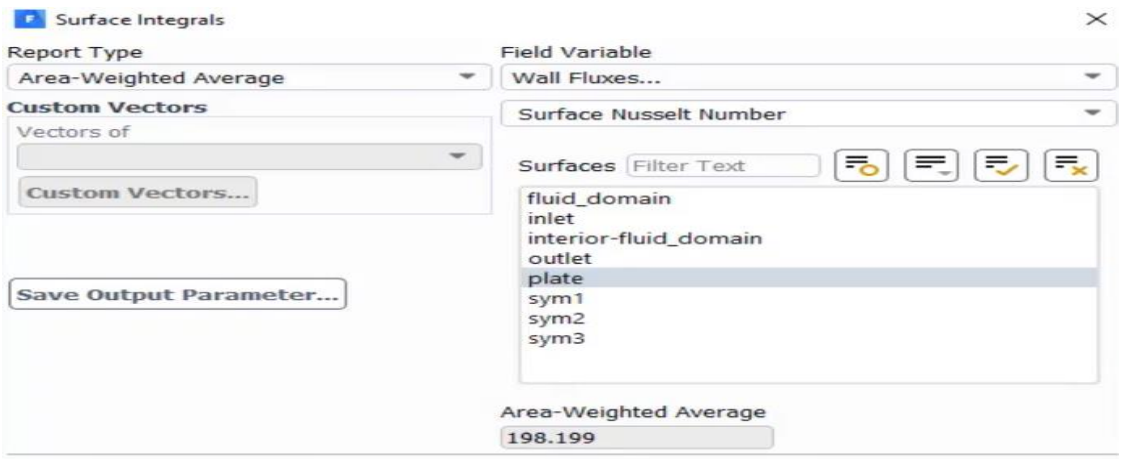


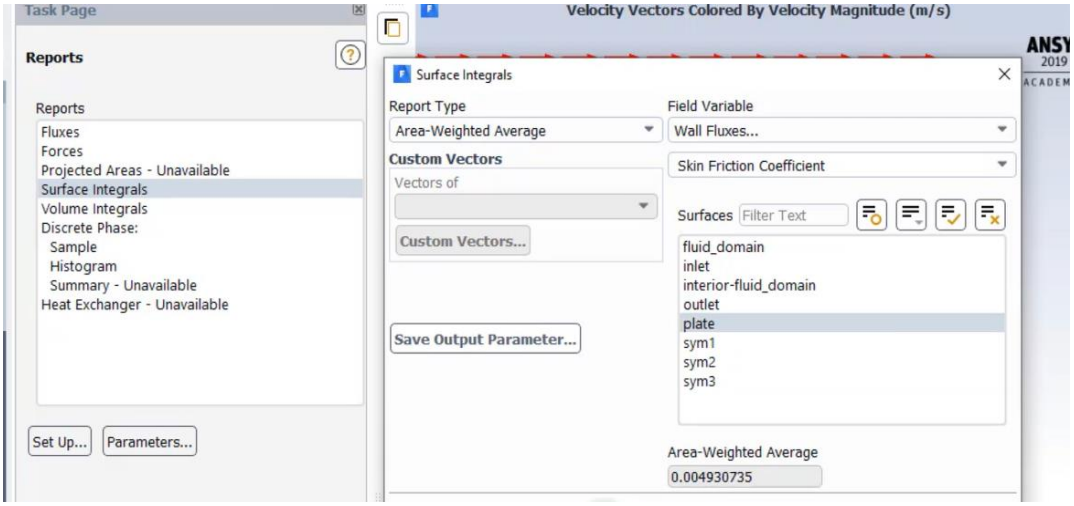


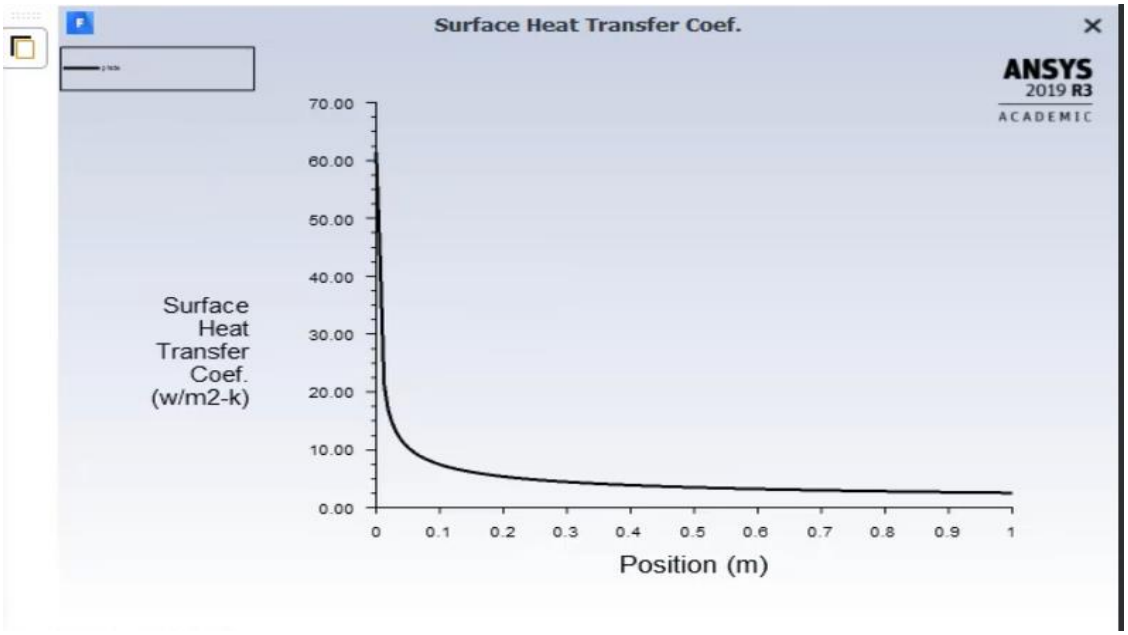


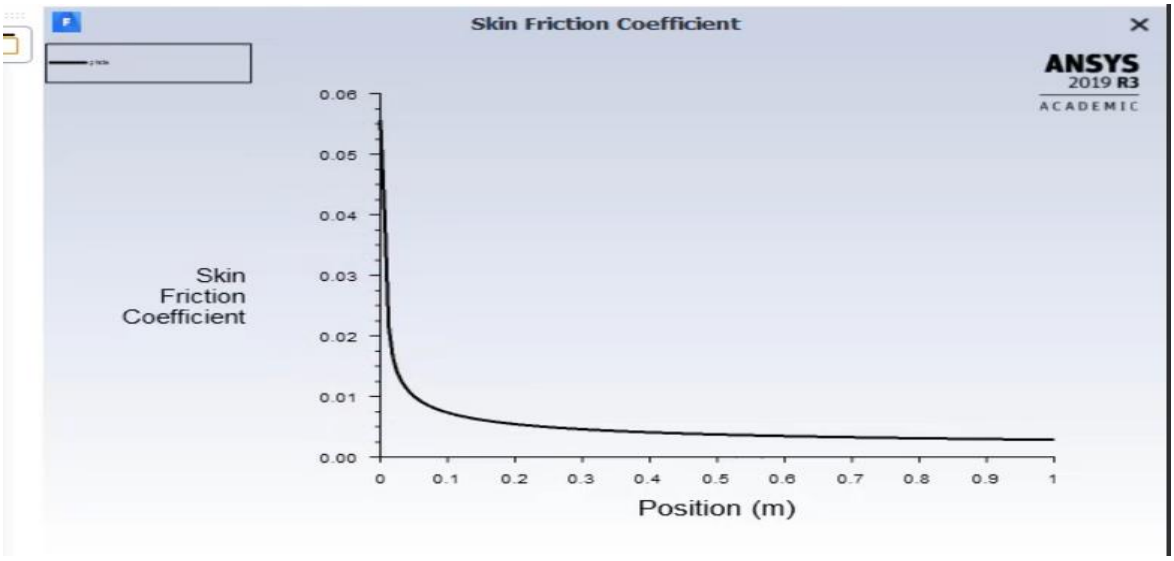

Vectors of
Velocity
Color by
Velocity...
Velocity Magnitude
Min (m/s)
Max (m/s)
0.03823763
1.586728
Surfaces
Filter Text
fluid_domain
inlet
interior-fluid_domain
outlet
plate
sym1
New Surface
Velocity Vectors Colored By Velocity Magnitude (m/s)
ANSYS
2019 R3
ACADEMIC

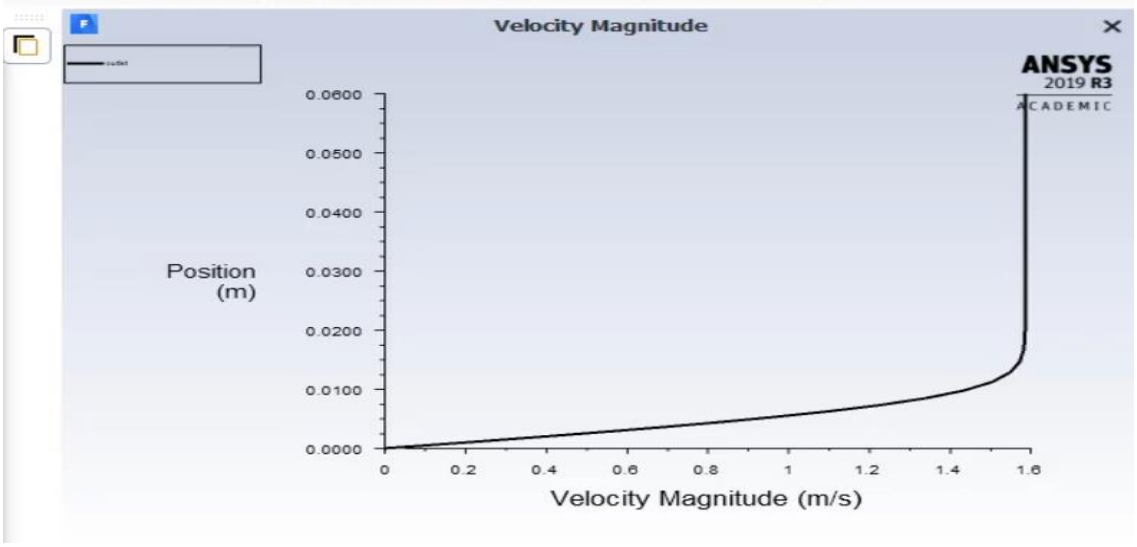

Flux Reports
Options
Mass Flow Rate
Total Heat Transfer Rate
Radiation Heat Transfer Rate
Boundaries
Filter Text
inlet
interior-fluid_domain
outlet
plate
sym1
sym2
sym3
Results
0.1073614500000018
Save Output Parameter...
Net Results (kg/s)
0.1073615

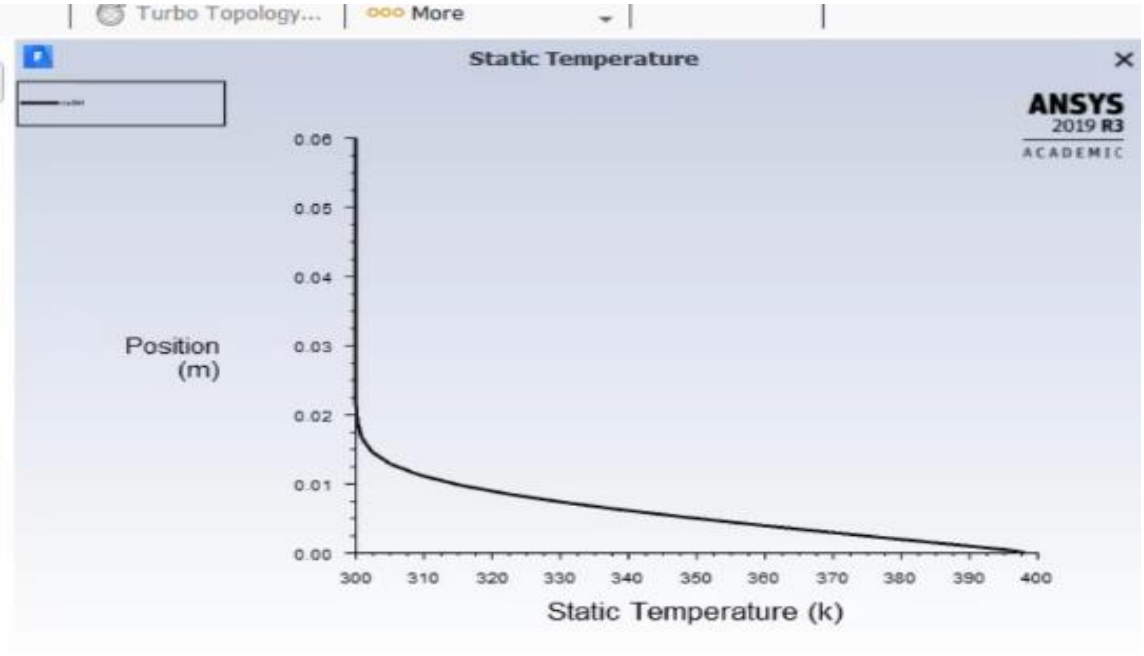

Surface Integrals
Report Type
Area-Weighted Average
Field Variable
Wall Fluxes...
Surface Nusselt Number
Custom Vectors
Vectors of
Custom Vectors...
Surfaces
Filter Text
fluid_domain
inlet
interior-fluid_domain
outlet
plate
sym1
sym2
sym3
Save Output Parameter...
Area-Weighted Average
198.199


Task Page
Reports
Reports
Fluxes
Forces
Projected Areas - Unavailable
Surface Integrals
Volume Integrals
Discrete Phase:
Sample
Histogram
Summary - Unavailable
Heat Exchanger - Unavailable
Set Up...
Parameters...
Velocity Vectors Colored By Velocity Magnitude (m/s)
Surface Integrals
Report Type
Area-Weighted Average
Field Variable
Wall Fluxes...
Custom Vectors
Skin Friction Coefficient
Vectors of
Surfaces
Filter Text
Custom Vectors...
fluid_domain
inlet
interior-fluid_domain
outlet
plate
sym1
sym2
sym3
Save Output Parameter...
Area-Weighted Average
0.004930735


Surface Heat Transfer Coef.
ANSYS
2019 R3
ACADEMIC
Surface Heat Transfer Coef. (w/m2-k)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Position (m)


Skin Friction Coefficient
ANSYS
2019 R3
ACADEMIC
Skin Friction Coefficient
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Position (m)


Velocity Magnitude
ANSYS
2019 R3
ACADEMIC
Position (m)
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Velocity Magnitude (m/s)


Turbo Topology...
More
Static Temperature
ANSYS
2019 R3
ACADEMIC
Position (m)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
300
310
320
330
340
350
360
370
380
390
400
Static Temperature (k)