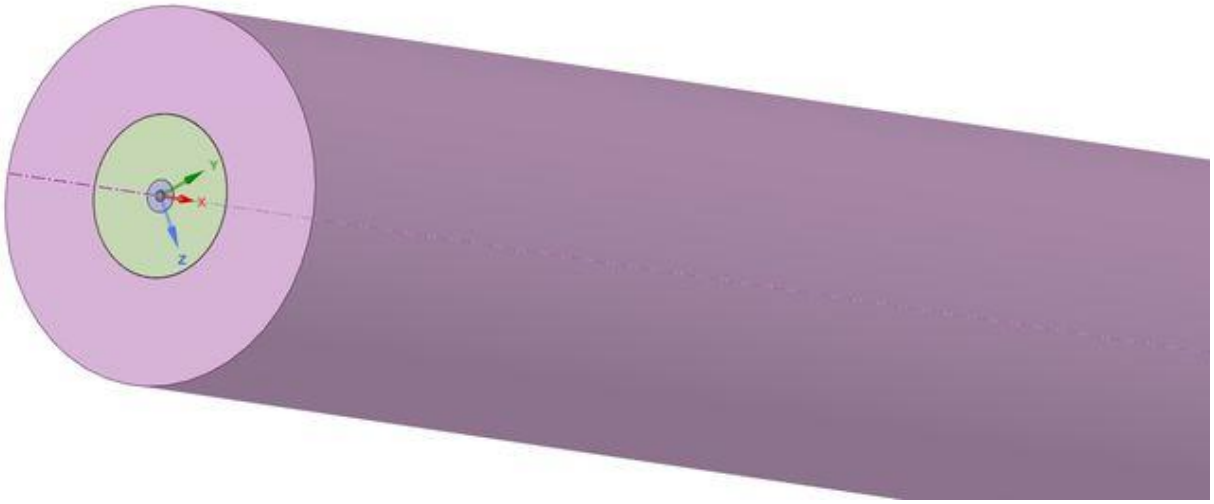
Aim: To perform a combustion simulation on a combustor model and to plot the variation of mass fraction of the different species.

Theory: Combustion is a process in which the fuel is oxidized and a large amount of chemically bound energy is released. This energy heats the products and combustion of fuel such as methane with air leads to a flame temperature of around 1900 °C (2173 K). In the combustion of methane and air, the main products are carbon dioxide and water. However, the formation of these products is very complex and hundreds of different species such as H, O, OH, CH, CH3, etc are intermediated in the combustion process. Besides carbon dioxide and water, a large number of pollutants are formed as, for instance, nitrogen oxides, carbon
monoxide and soot particles. The efficiency of the combustion process depends on several parameters, such as oxygen supply, temperature history, and mixing properties.

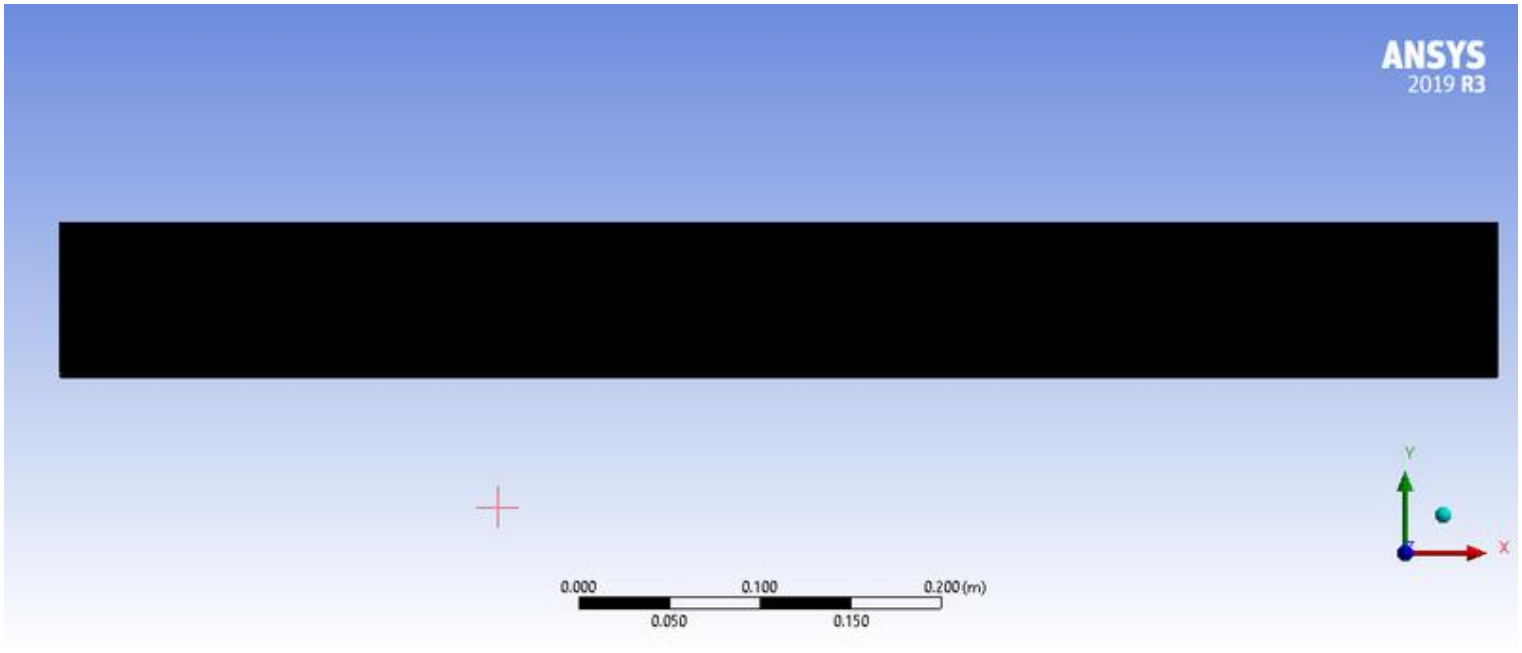
Solving & Modelling approach :

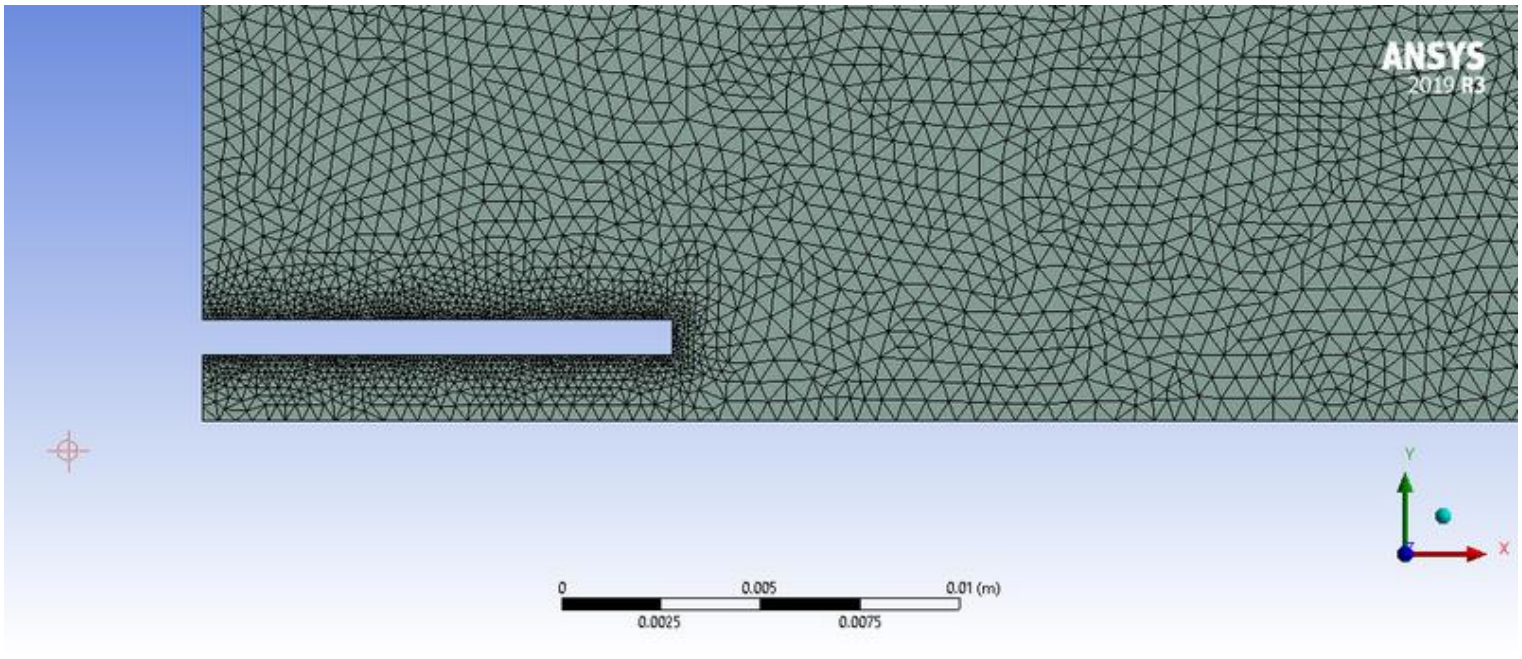
Geometry



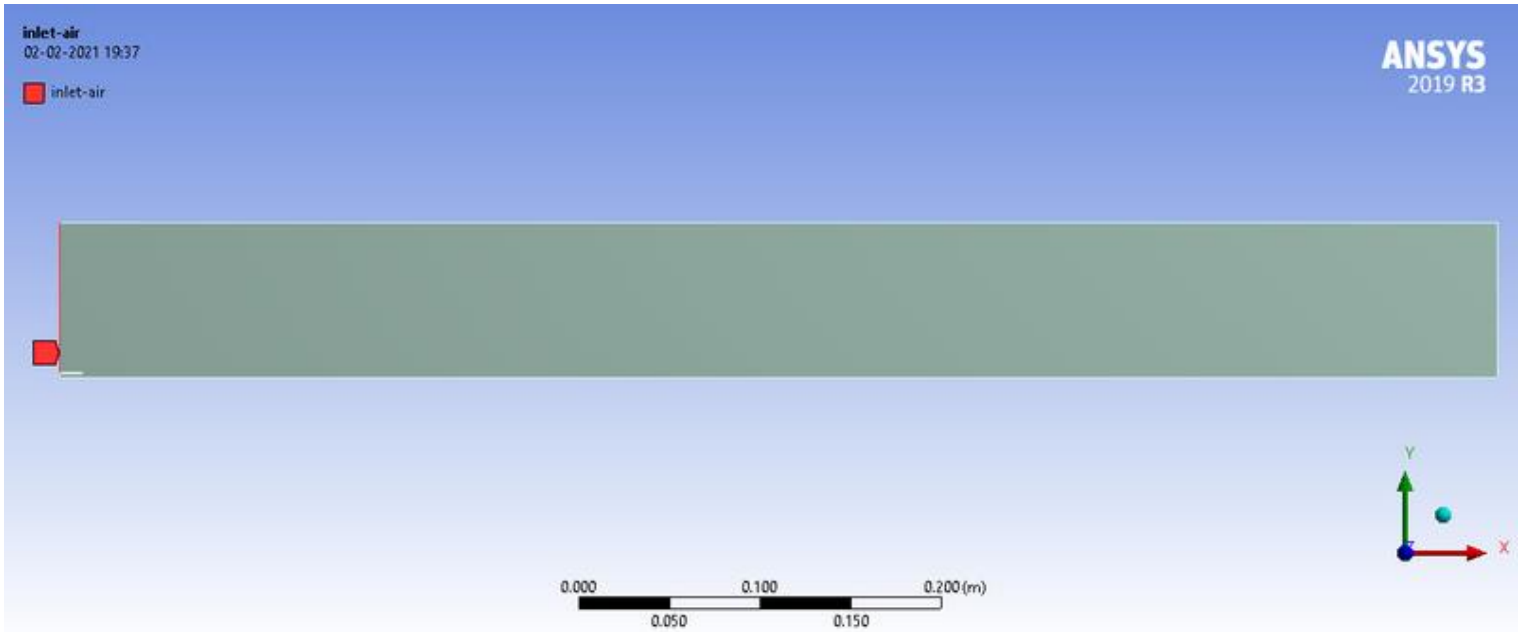
After Modification

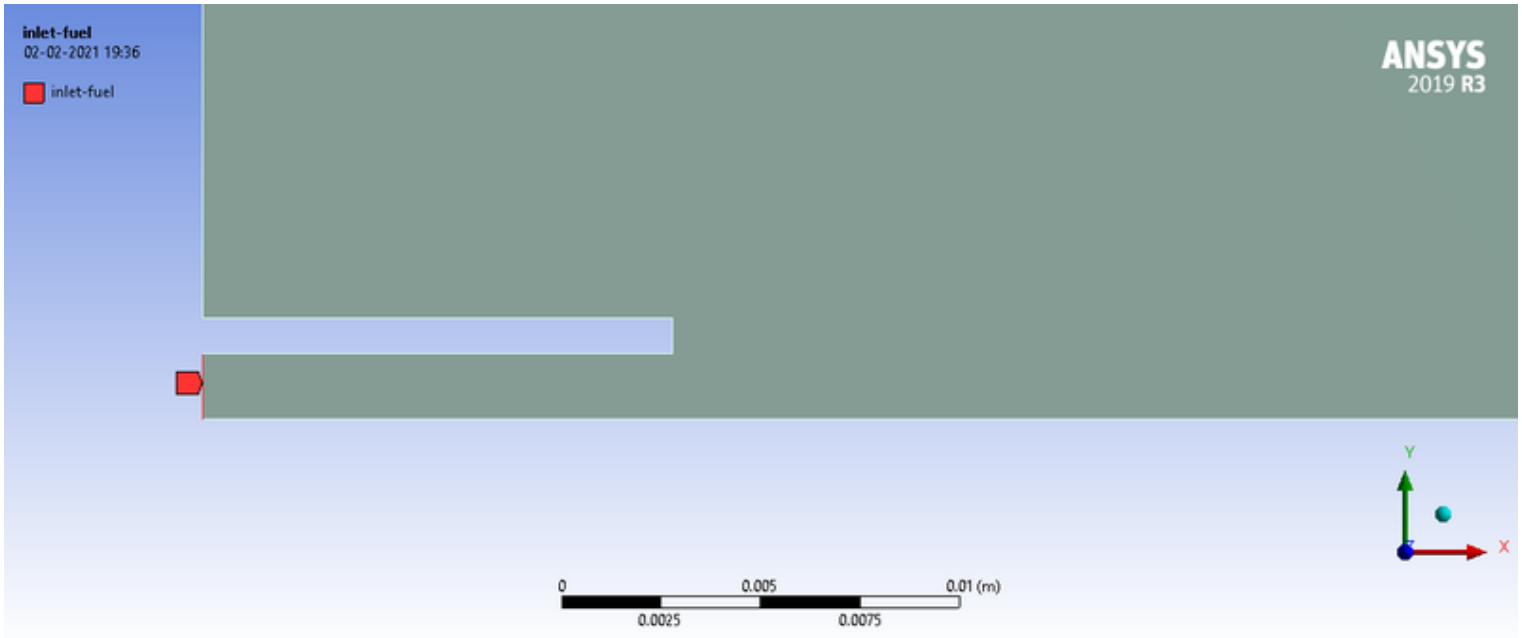
Mesh

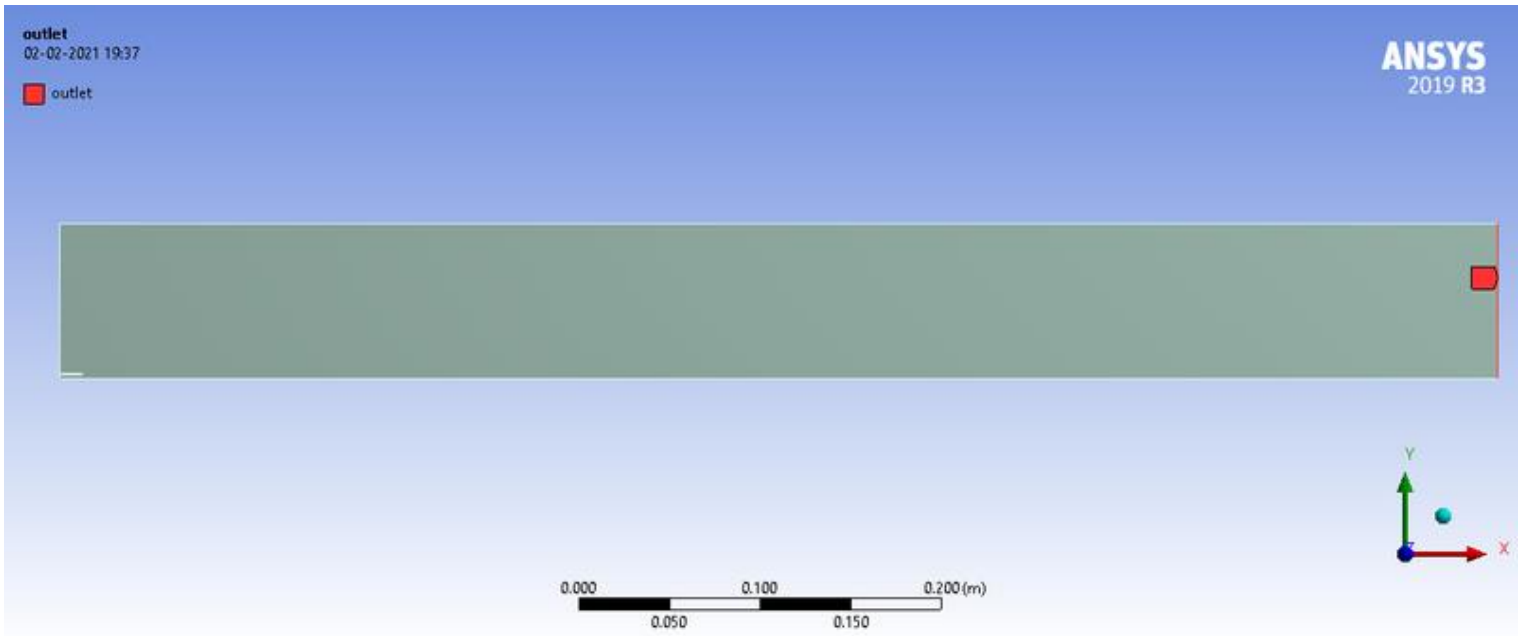


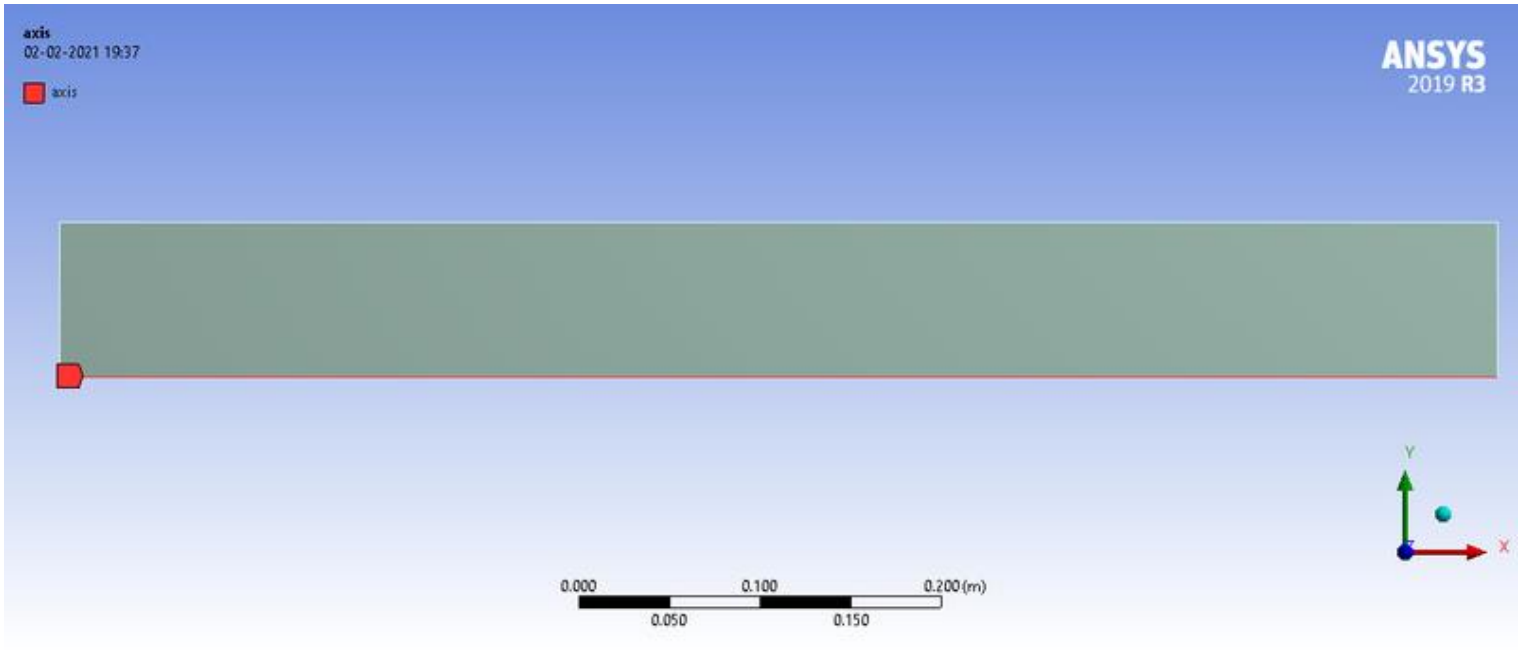


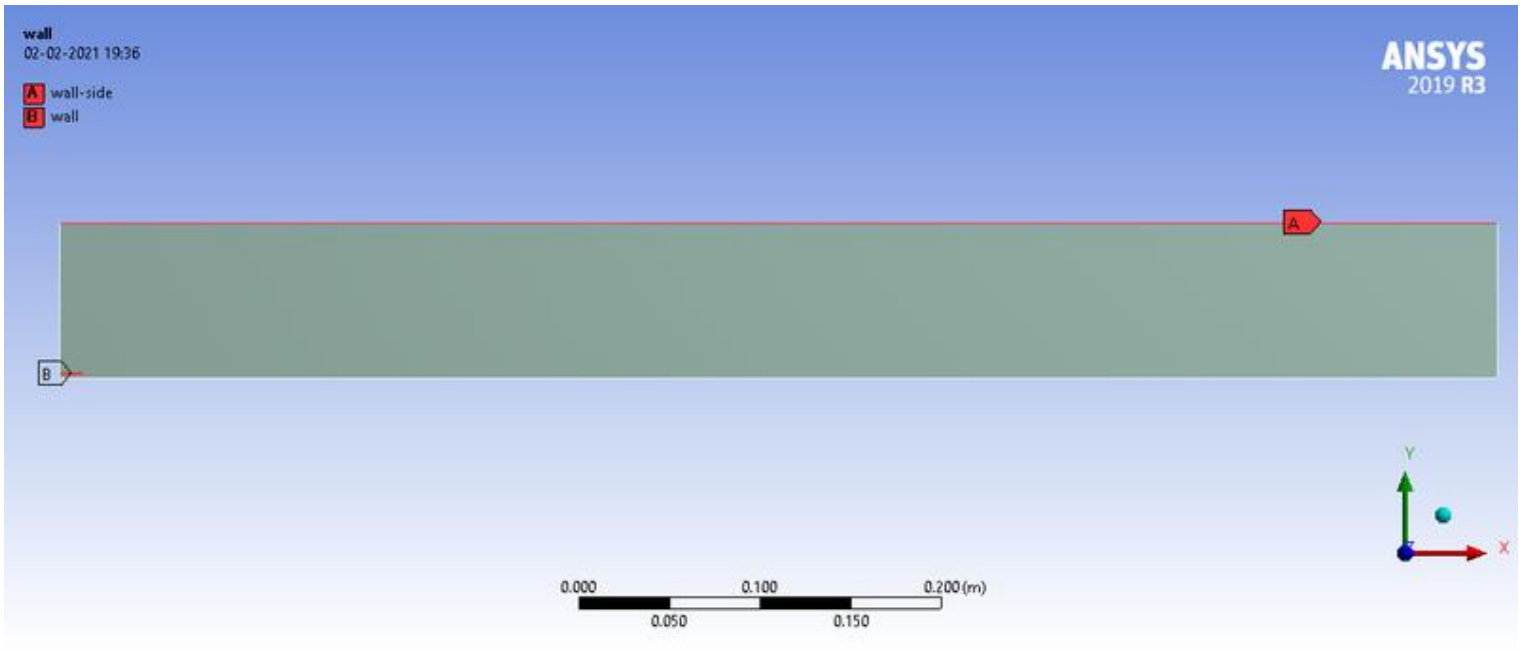
Boundary Condition






outlet
02-02-2021 19:37
outlet
ANSYS
2019 R3
Y
X
0.000
0.100
0.200 (m)
0.050
0.150


axis
02-02-2021 19:37
axis
ANSYS
2019 R3
Y
X
0.000
0.100
0.200 (m)
0.050
0.150

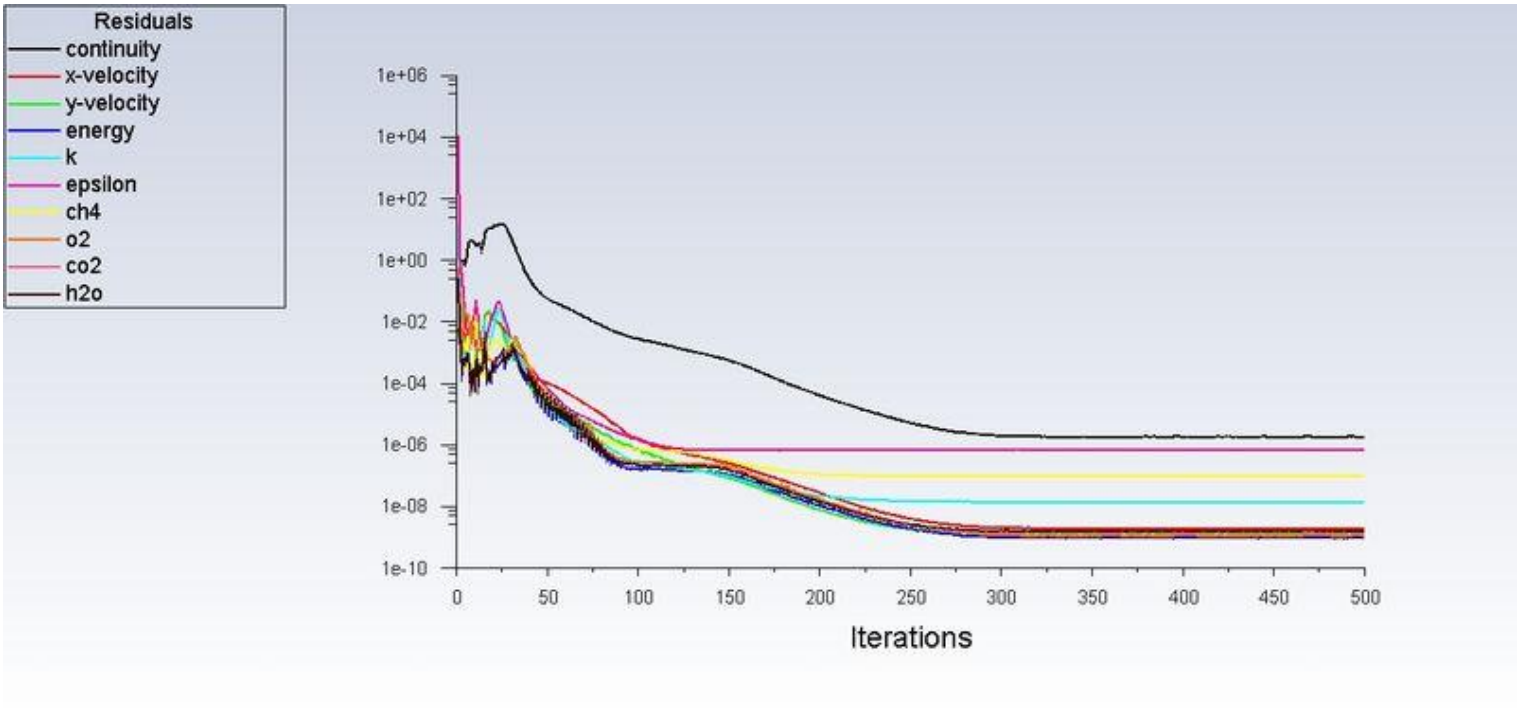

wall
02-02-2021 19:36
A wall-side
B wall
ANSYS
2019 R3
A
B
Y
X
0.000
0.100
0.200 (m)
0.050
0.150

Results :

Part 1: Perform a combustion simulation on the combuster model and plot the variation of the mass fraction of the different species in the simulation using line probes at different locations of the combuster.
The simulation is set up as steady-state, pressure-based with absolute formation. The energy is enabled and standard k-epsilon viscous mode is selected. In the species model, the species transport is selected with volumetric reaction. The inlet diffusion and diffusion energy source is enabled.

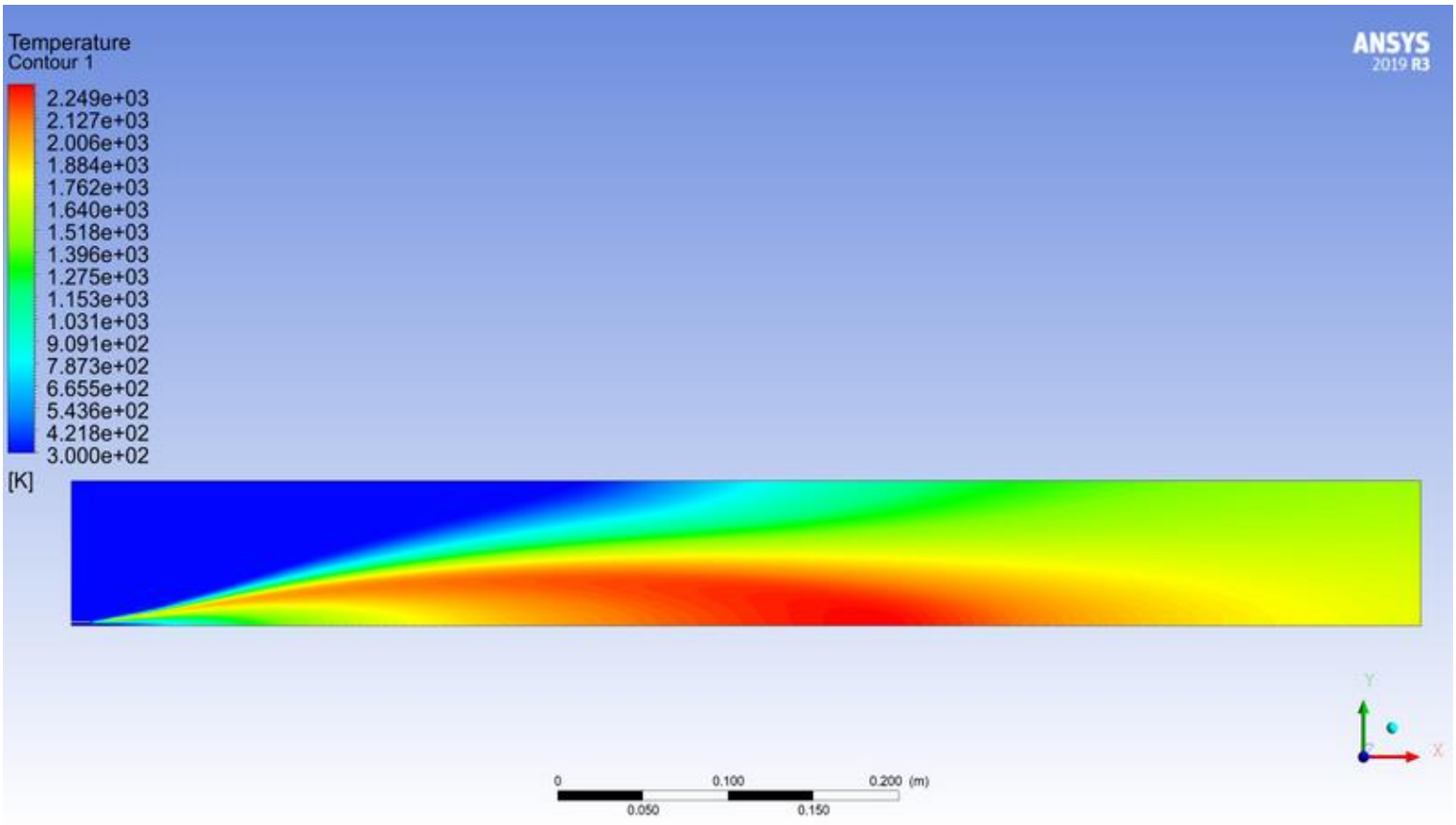
The mixture material used is methane-air And the Turbulence chemistry interaction is set to eddy dissipation.
The Boundary conditions are set as:-
Air inlet - velocity = 0.5m/s ; Temperature = 300k; Species : O2=0.23
Fuel inlet - velocity = 80m/s; Temperature = 300k; Species : Ch4 = 1

Residual

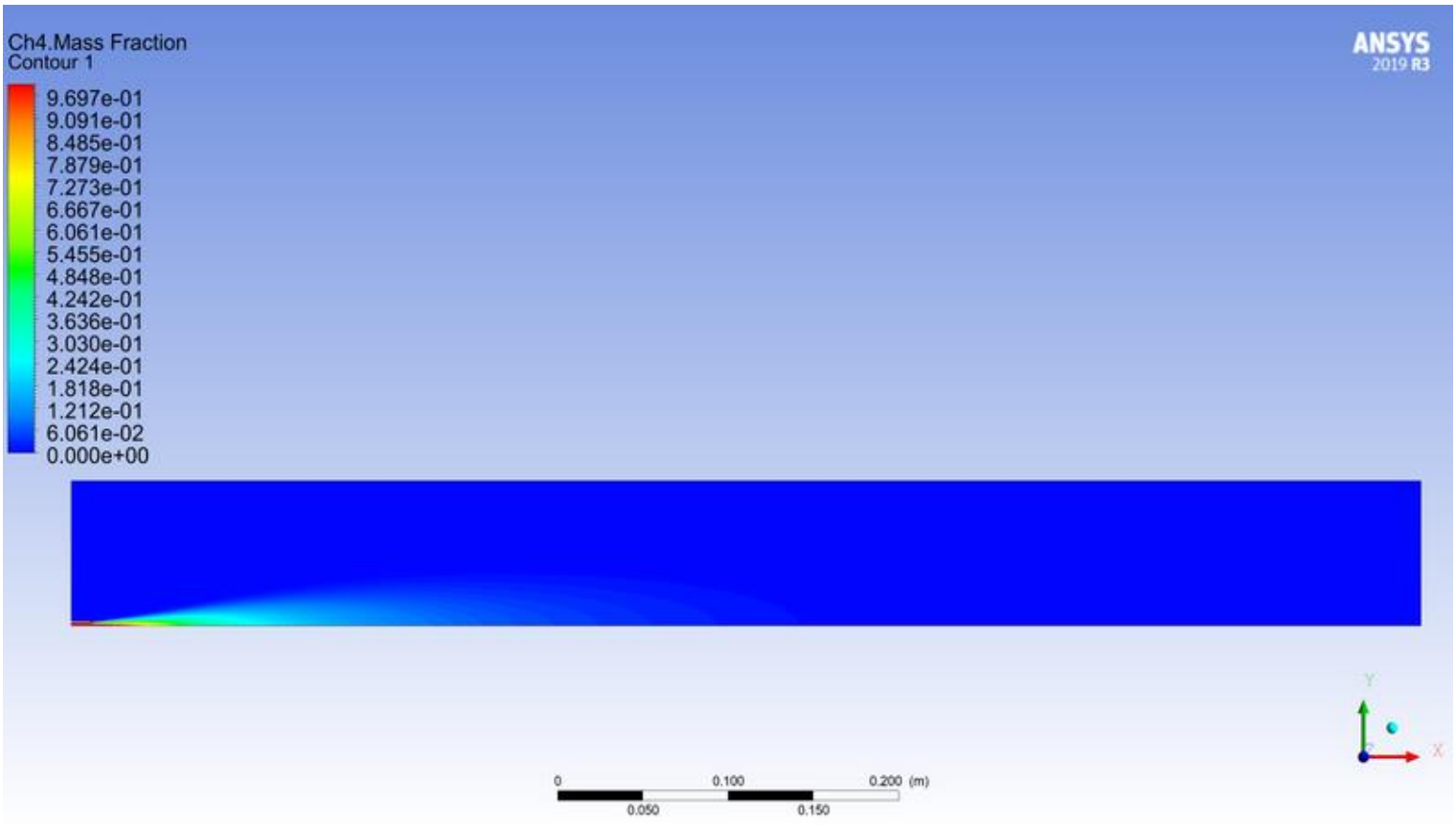


Contour

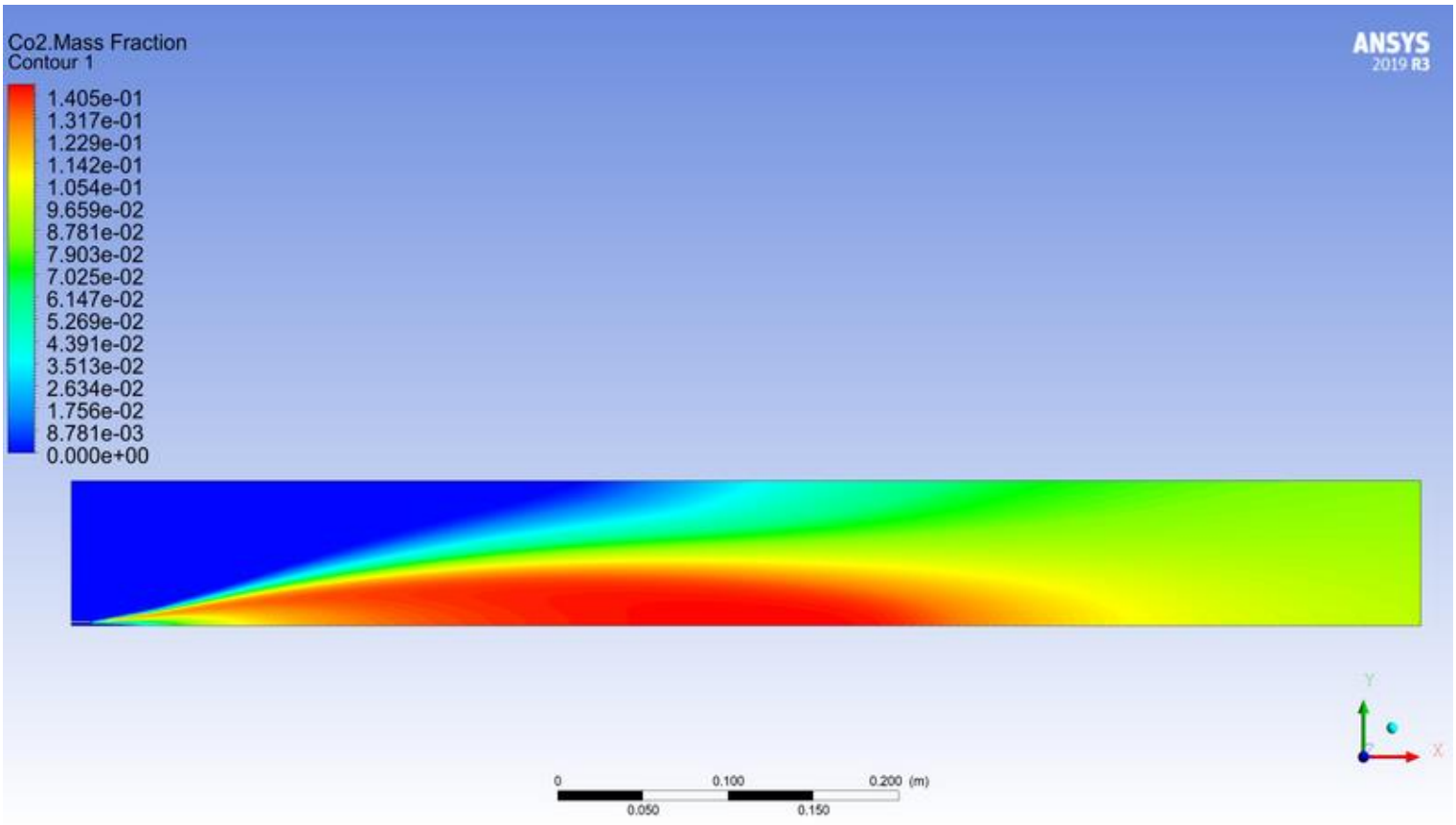
Temperature


Temperature
Contour 1
ANSYS
2019 R3
2.249e+03
2.127e+03
2.006e+03
1.884e+03
1.762e+03
1.640e+03
1.518e+03
1.396e+03
1.275e+03
1.153e+03
1.031e+03
9.091e+02
7.873e+02
6.655e+02
5.436e+02
4.218e+02
3.000e+02
[K]
Y
X
0
0.100
0.200 (m)
0.050
0.150

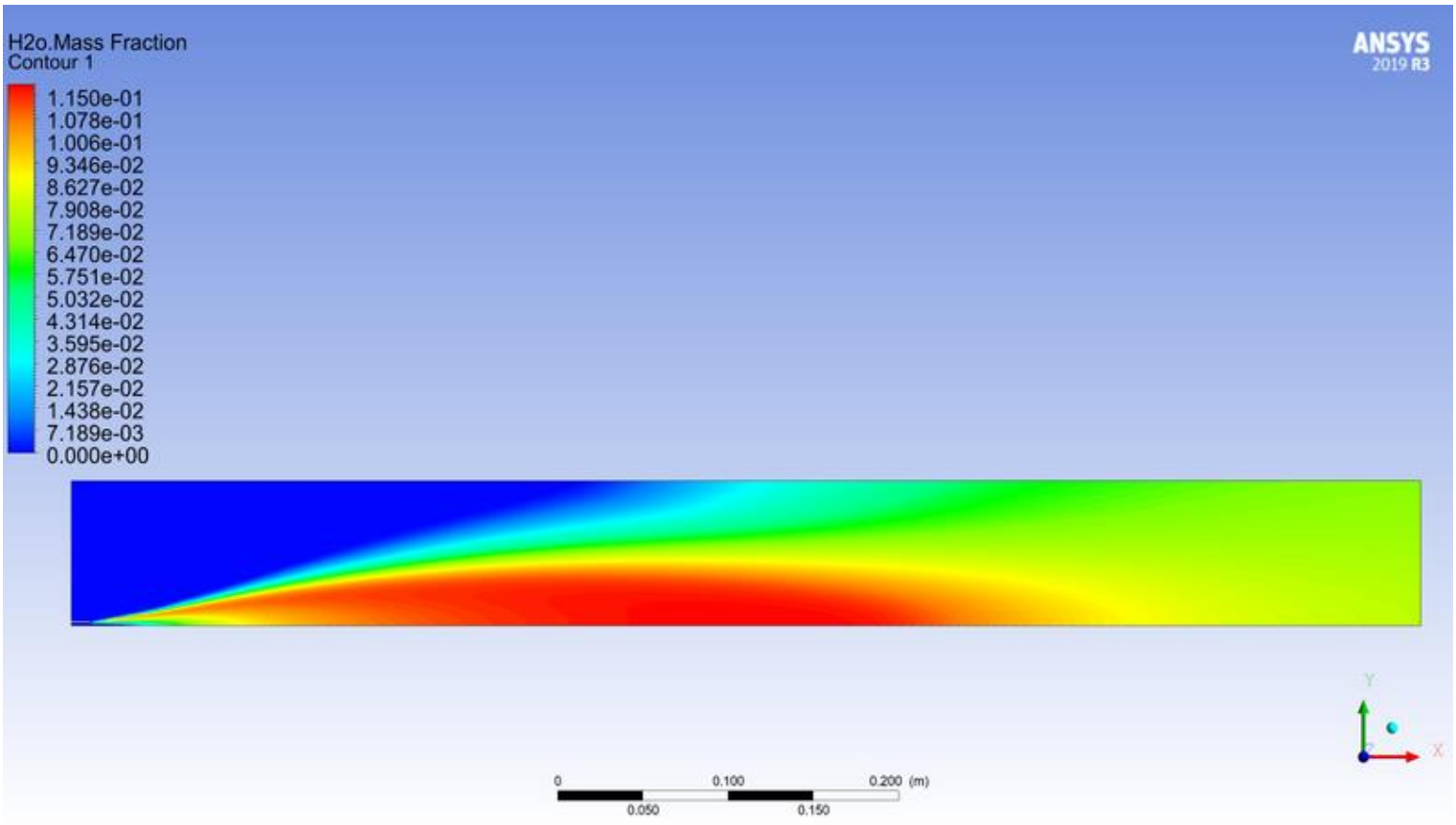
CH4


Ch4.Mass Fraction
Contour 1
ANSYS
2019 R3
9.697e-01
9.091e-01
8.485e-01
7.879e-01
7.273e-01
6.667e-01
6.061e-01
5.455e-01
4.848e-01
4.242e-01
3.636e-01
3.030e-01
2.424e-01
1.818e-01
1.212e-01
6.061e-02
0.000e+00
Y
X
0
0.100
0.200 (m)
0.050
0.150

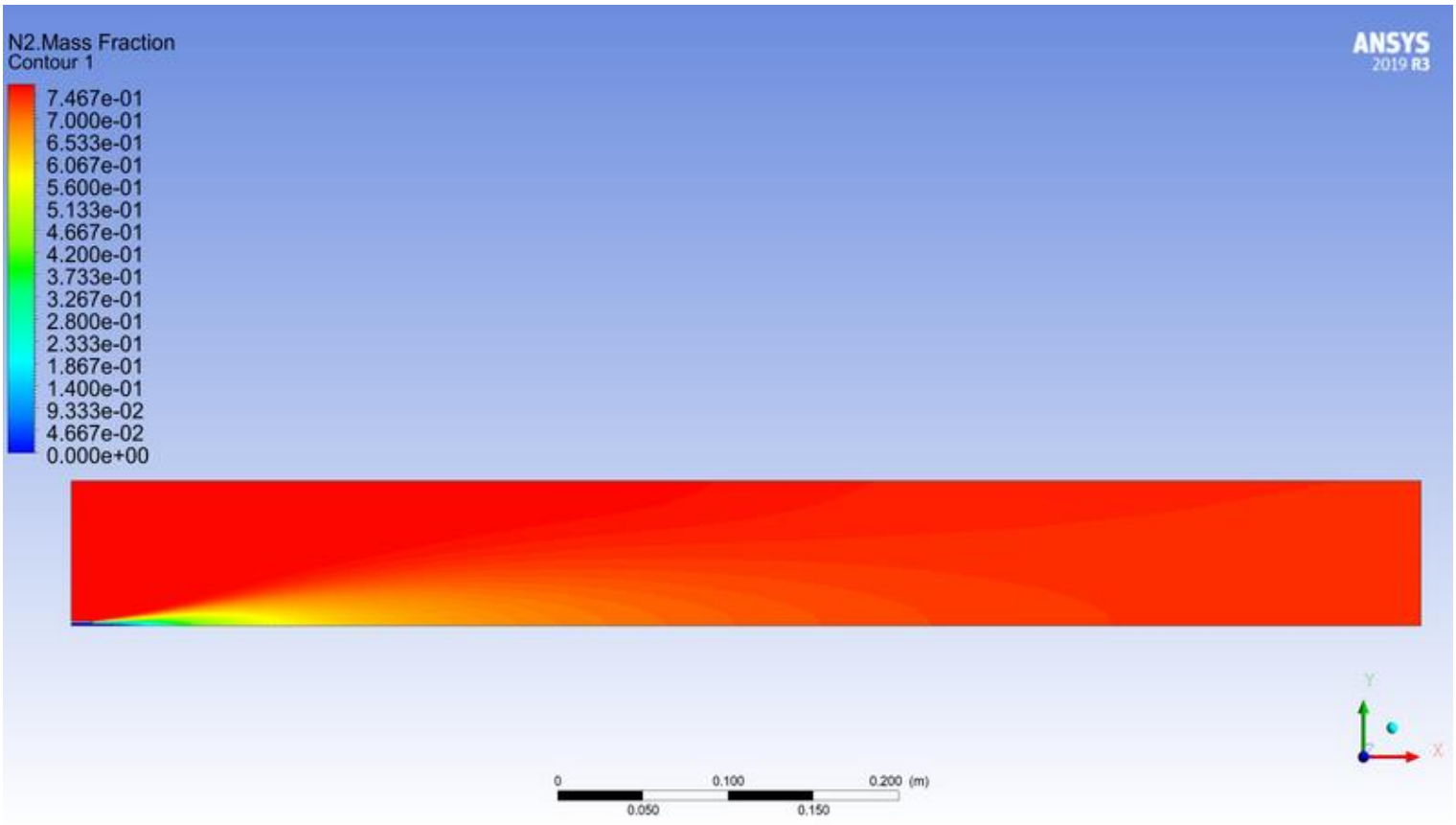
CO2


Co2.Mass Fraction
Contour 1
1.405e-01
1.317e-01
1.229e-01
1.142e-01
1.054e-01
9.659e-02
8.781e-02
7.903e-02
7.025e-02
6.147e-02
5.269e-02
4.391e-02
3.513e-02
2.634e-02
1.756e-02
8.781e-03
0.000e+00
ANSYS
2019 R3
Y
X
0
0.100
0.200 (m)
0.050
0.150

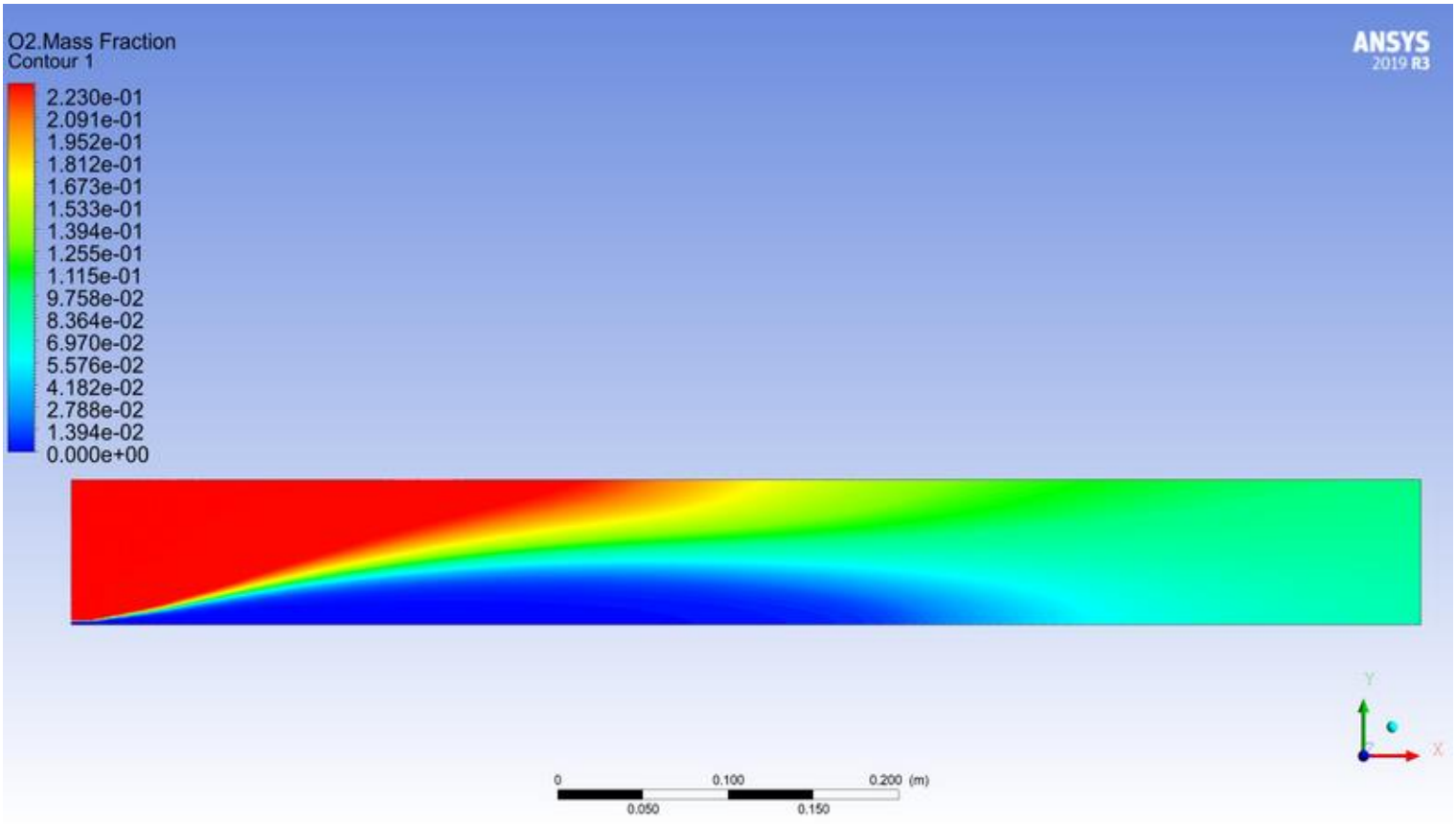
H2O


H2o.Mass Fraction
Contour 1
1.150e-01
1.078e-01
1.006e-01
9.346e-02
8.627e-02
7.908e-02
7.189e-02
6.470e-02
5.751e-02
5.032e-02
4.314e-02
3.595e-02
2.876e-02
2.157e-02
1.438e-02
7.189e-03
0.000e+00
ANSYS
2019 R3
Y
X
0
0.100
0.200 (m)
0.050
0.150

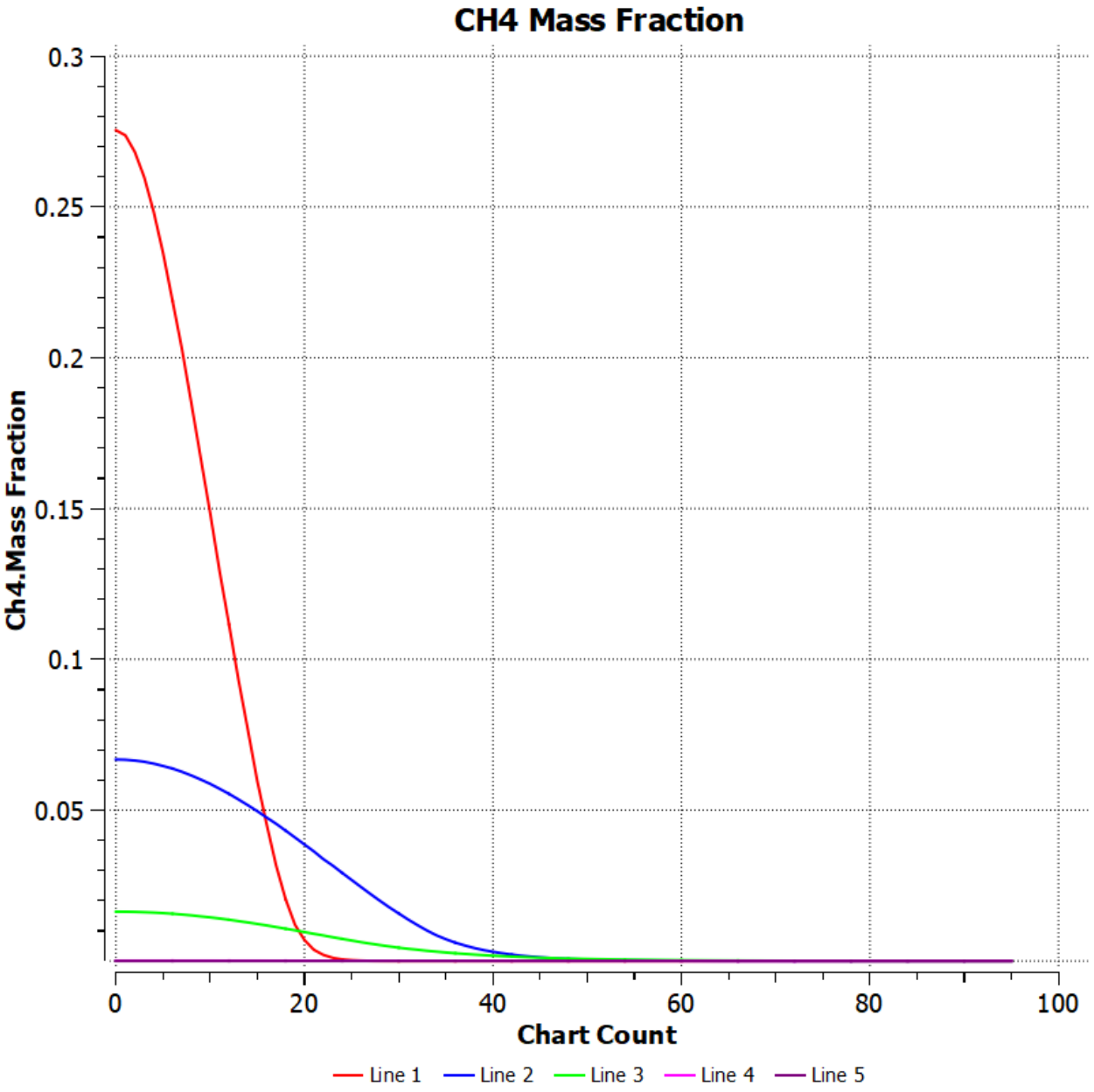
N2

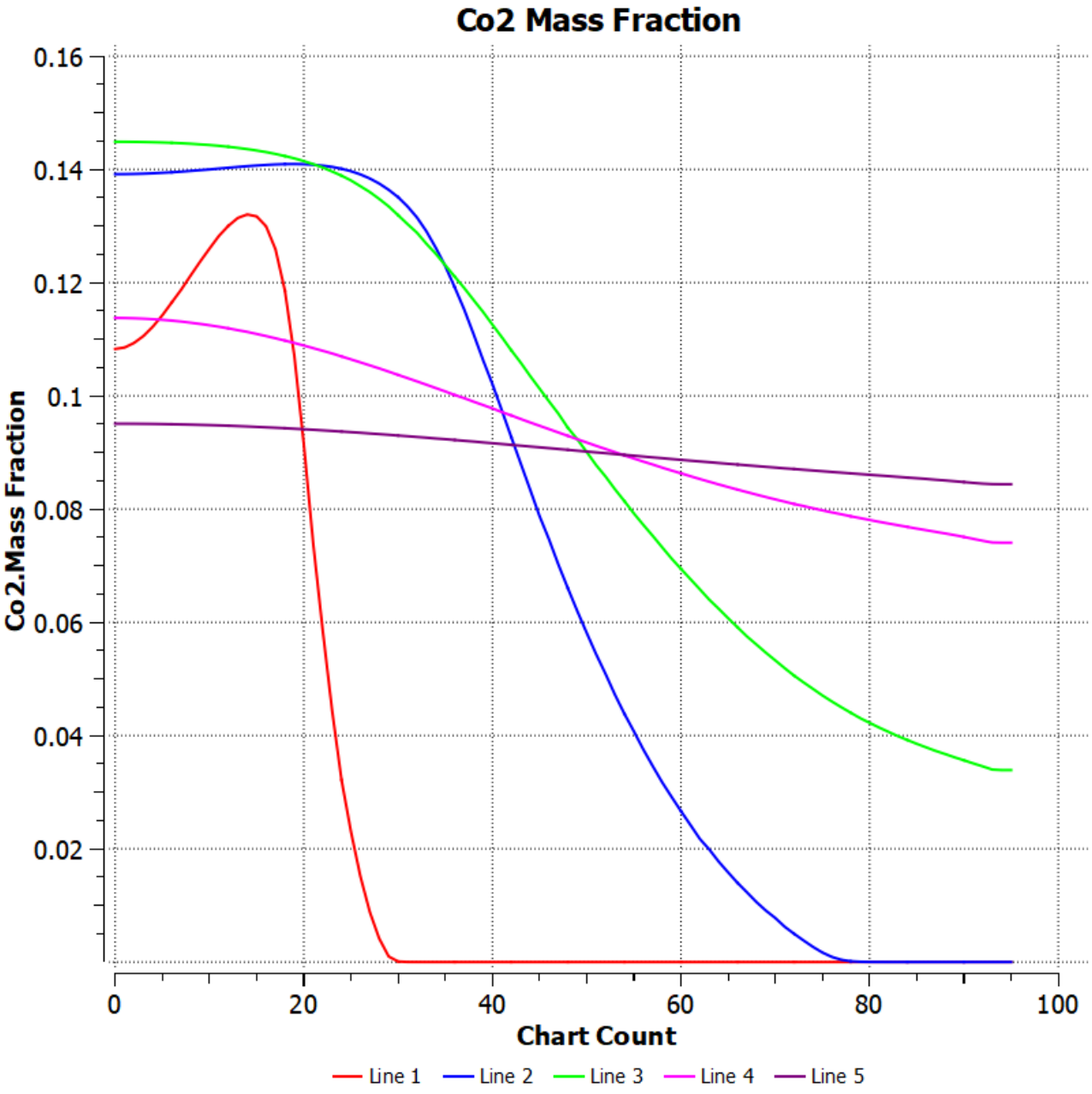

N2.Mass Fraction
Contour 1
7.467e-01
7.000e-01
6.533e-01
6.067e-01
5.600e-01
5.133e-01
4.667e-01
4.200e-01
3.733e-01
3.267e-01
2.800e-01
2.333e-01
1.867e-01
1.400e-01
9.333e-02
4.667e-02
0.000e+00
ANSYS
2019 R3
0
0.100
0.200 (m)
0.050
0.150
Y
X

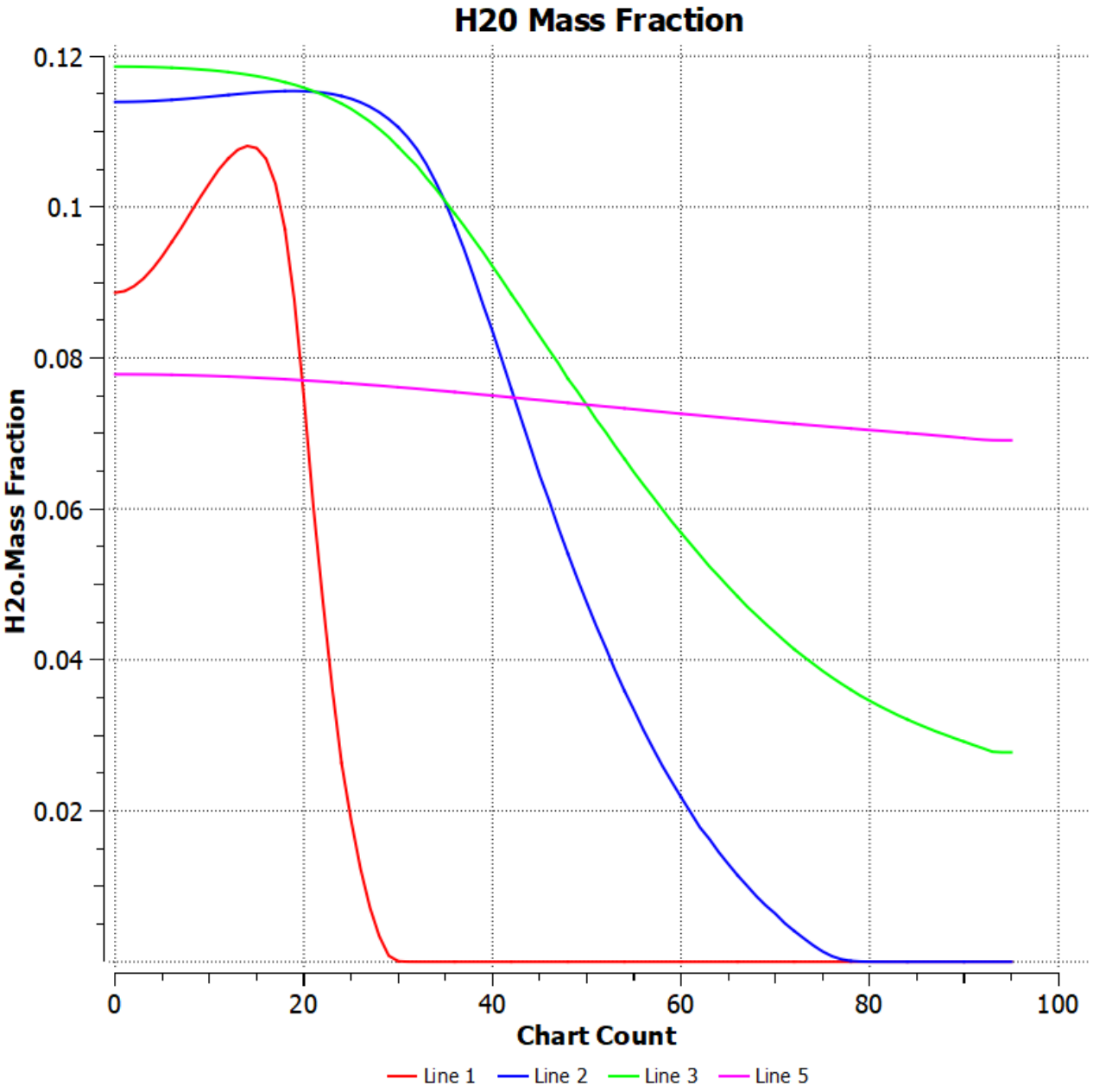
O2

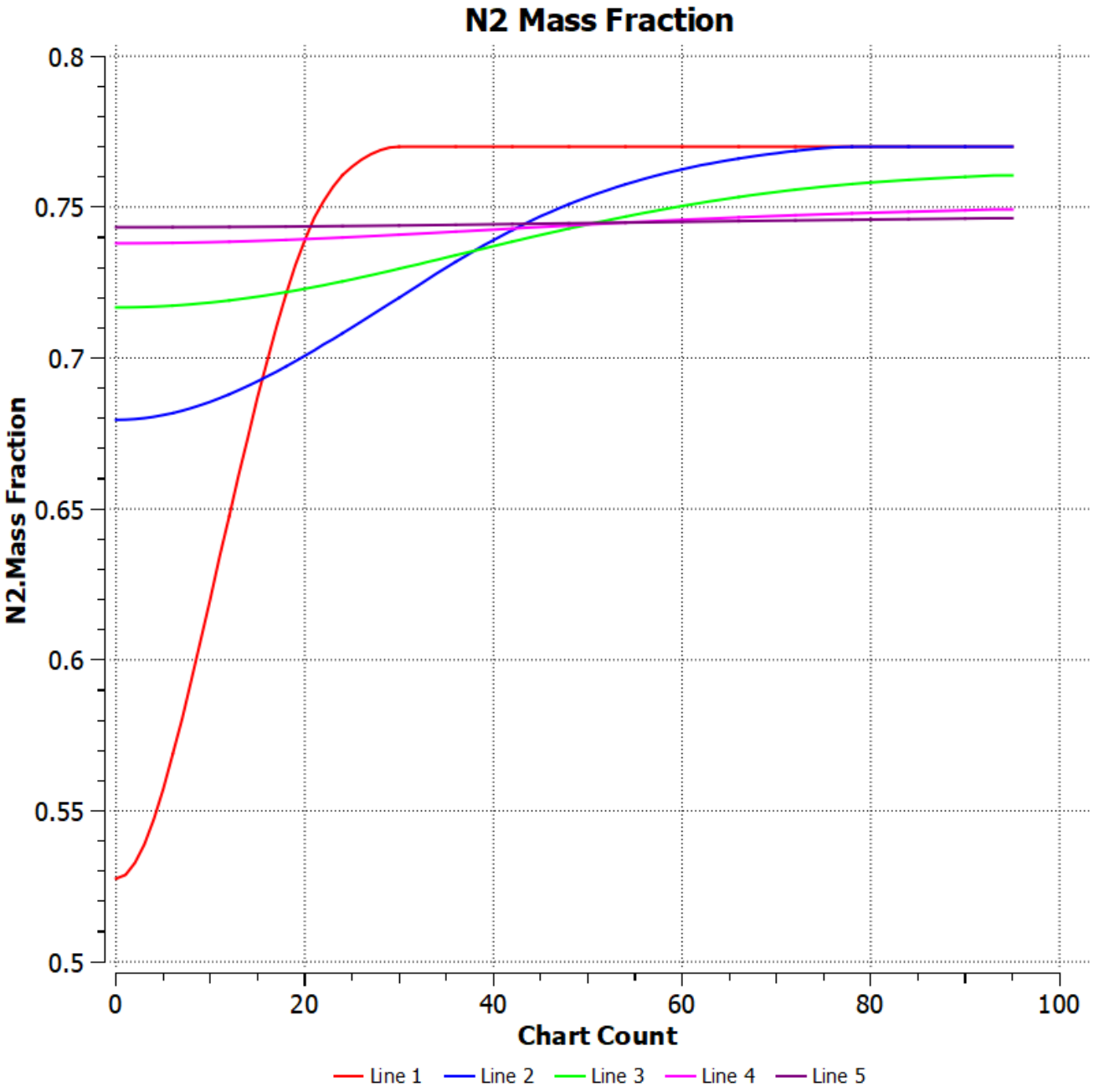

O2.Mass Fraction
Contour 1
2.230e-01
2.091e-01
1.952e-01
1.812e-01
1.673e-01
1.533e-01
1.394e-01
1.255e-01
1.115e-01
9.758e-02
8.364e-02
6.970e-02
5.576e-02
4.182e-02
2.788e-02
1.394e-02
0.000e+00
ANSYS
2019 R3
0
0.100
0.200 (m)
0.050
0.150
Y
X

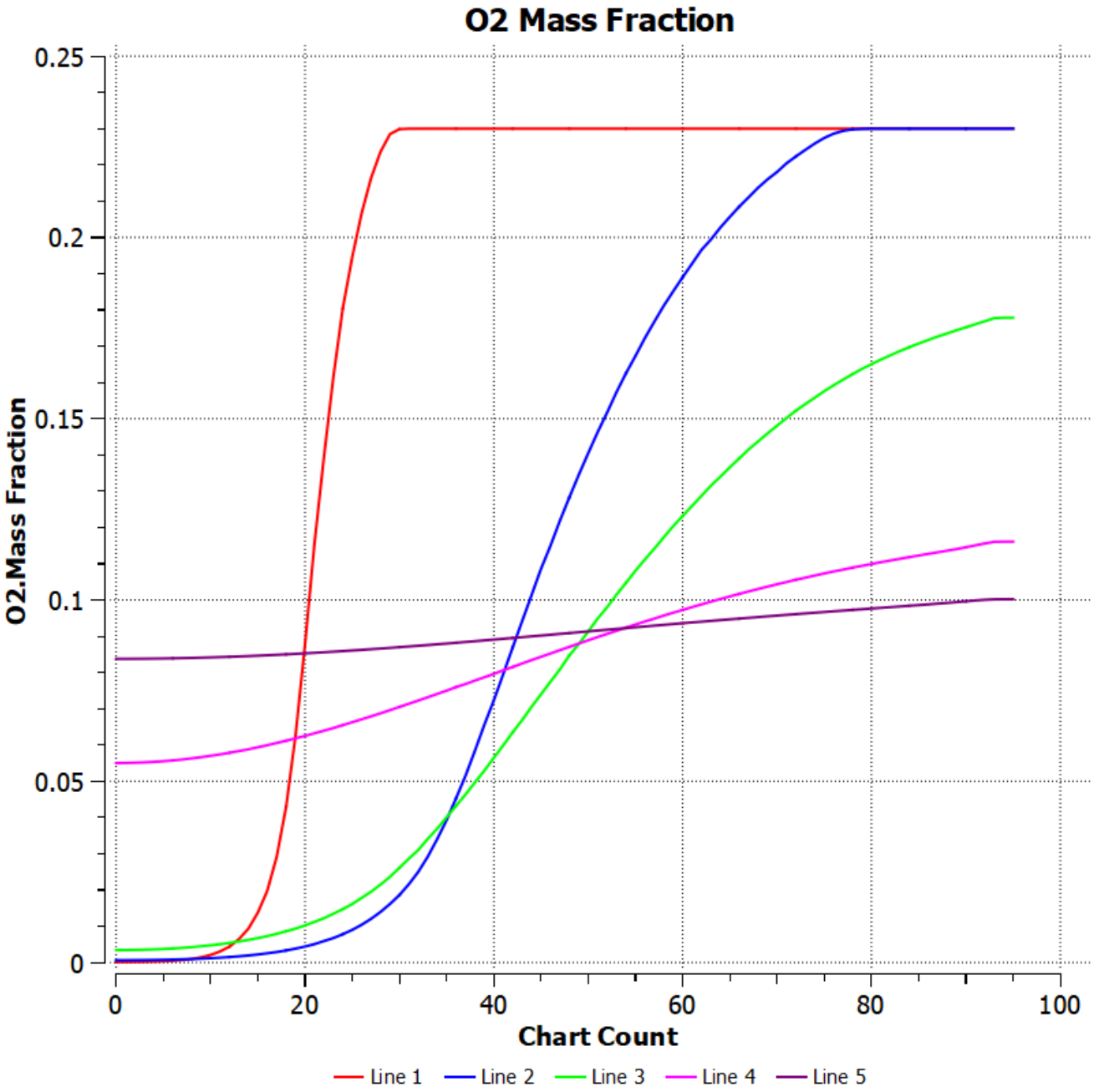
Graphs


CH4 Mass Fraction
Ch4.Mass Fraction
0.3
0.25
0.2
0.15
0.1
0.05
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 4
Line 5


Co2 Mass Fraction
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Co2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 4
Line 5


H20 Mass Fraction
0.12
0.1
0.08
0.06
0.04
0.02
H2o.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

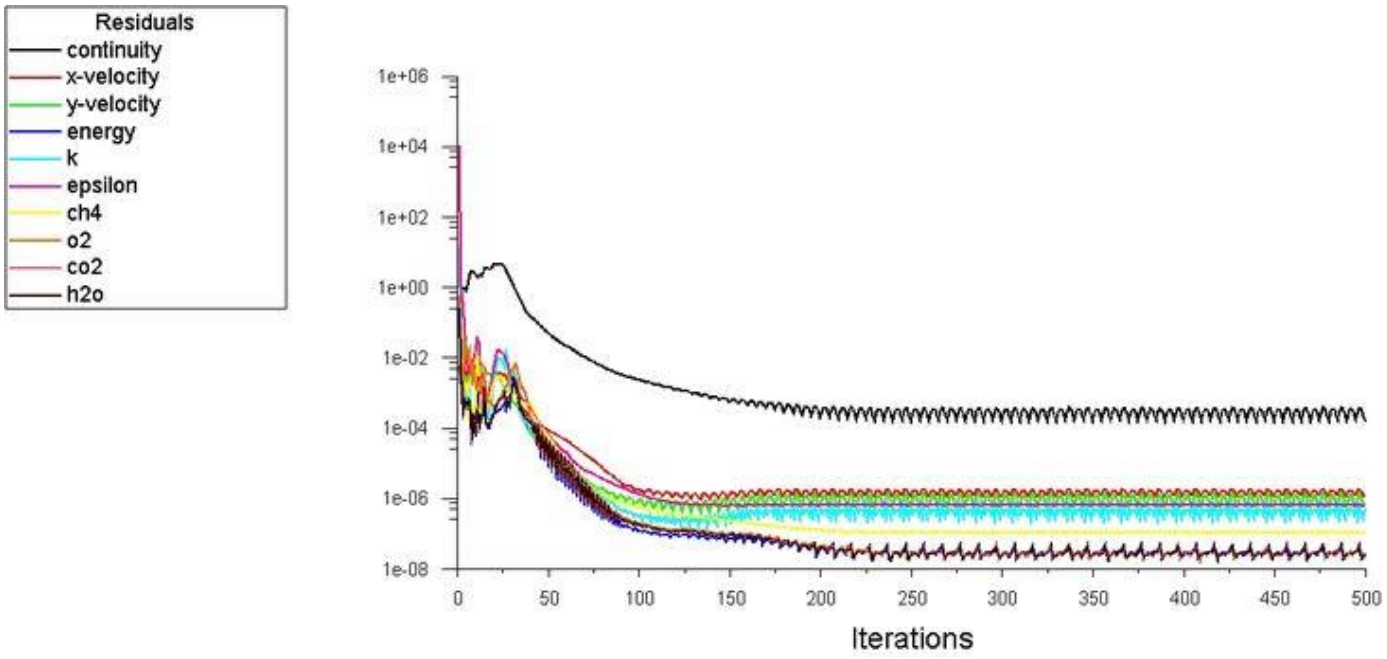

N2 Mass Fraction
N2.Mass Fraction
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 4
Line 5

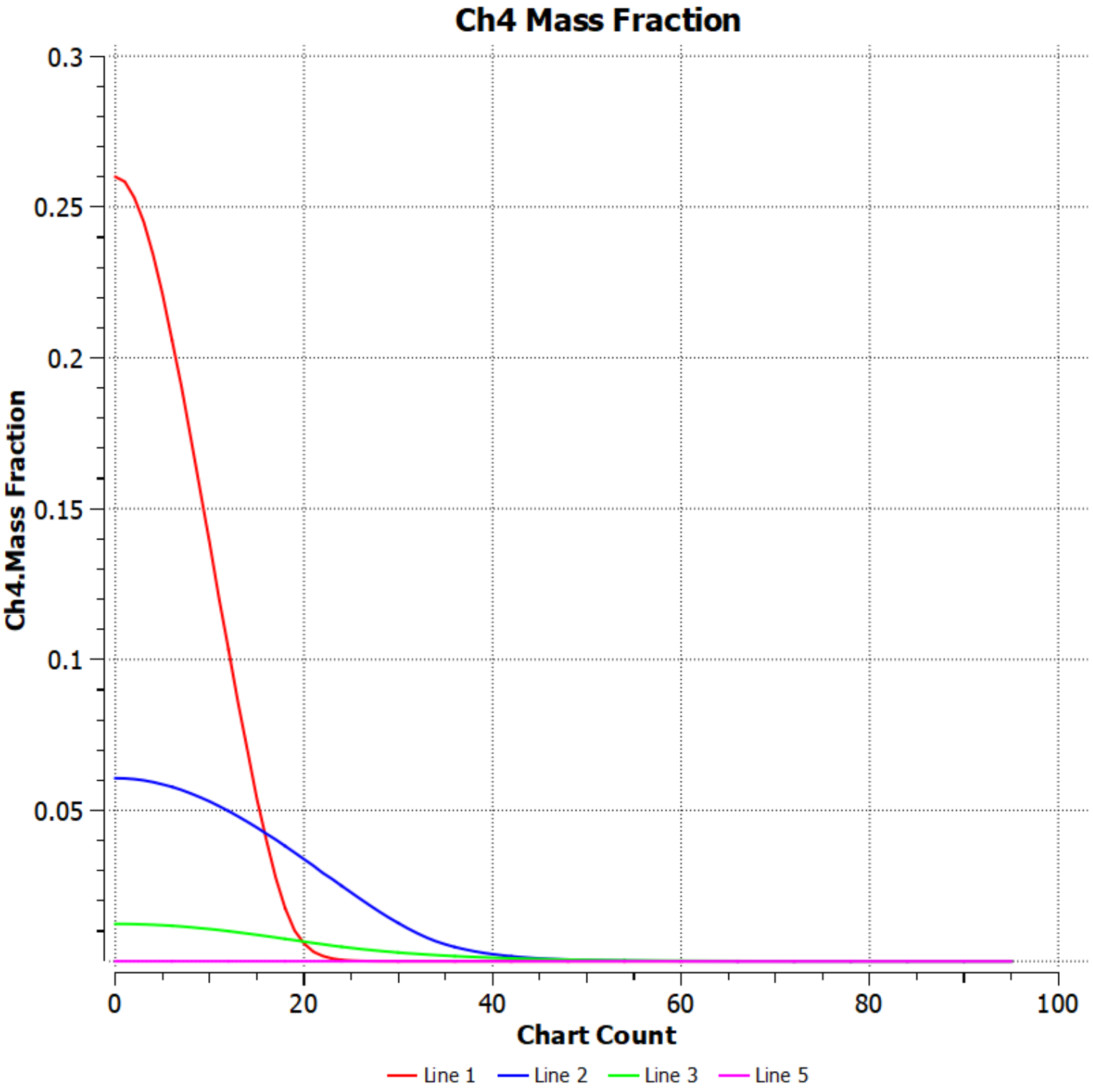


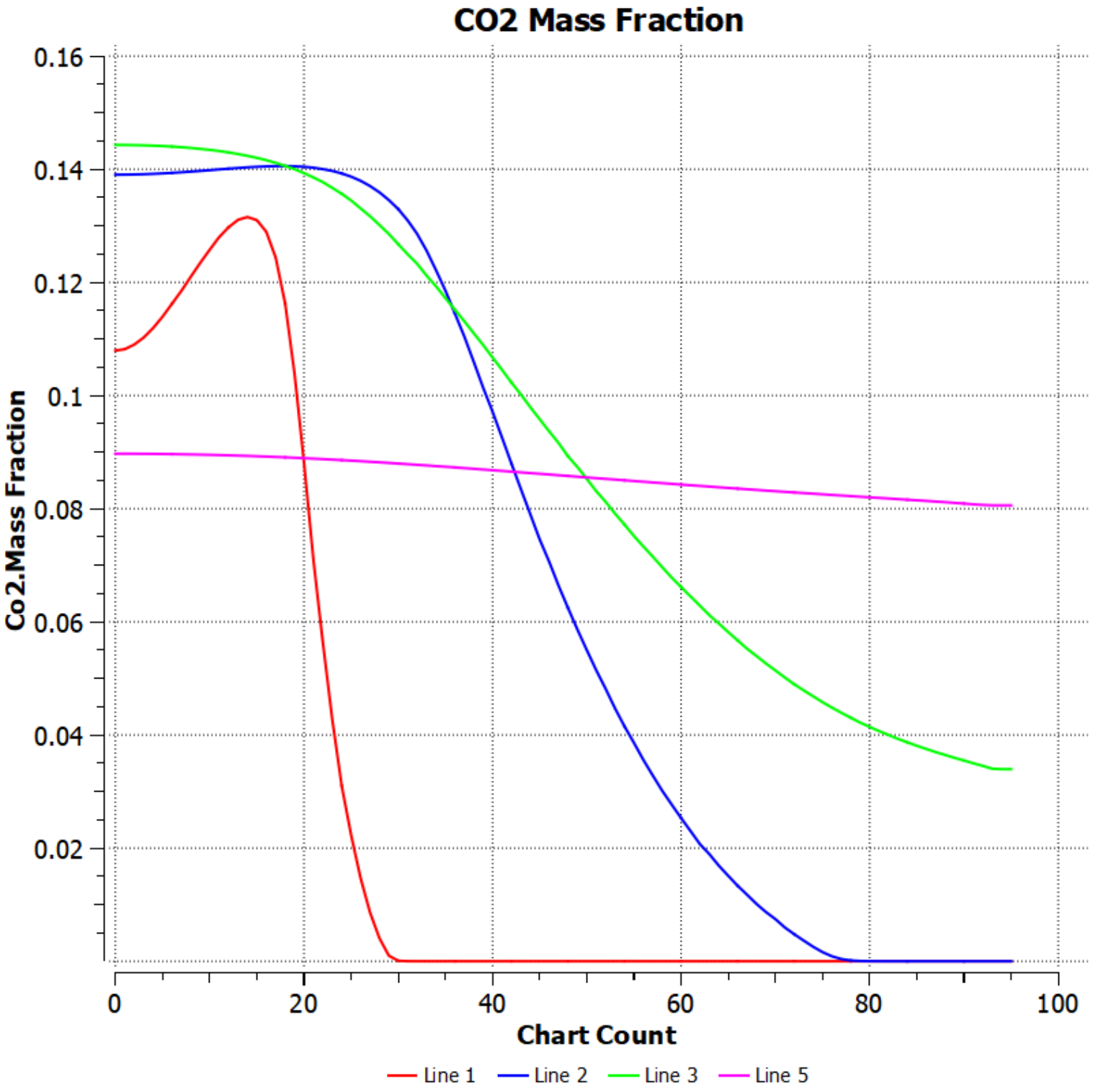
Part - II

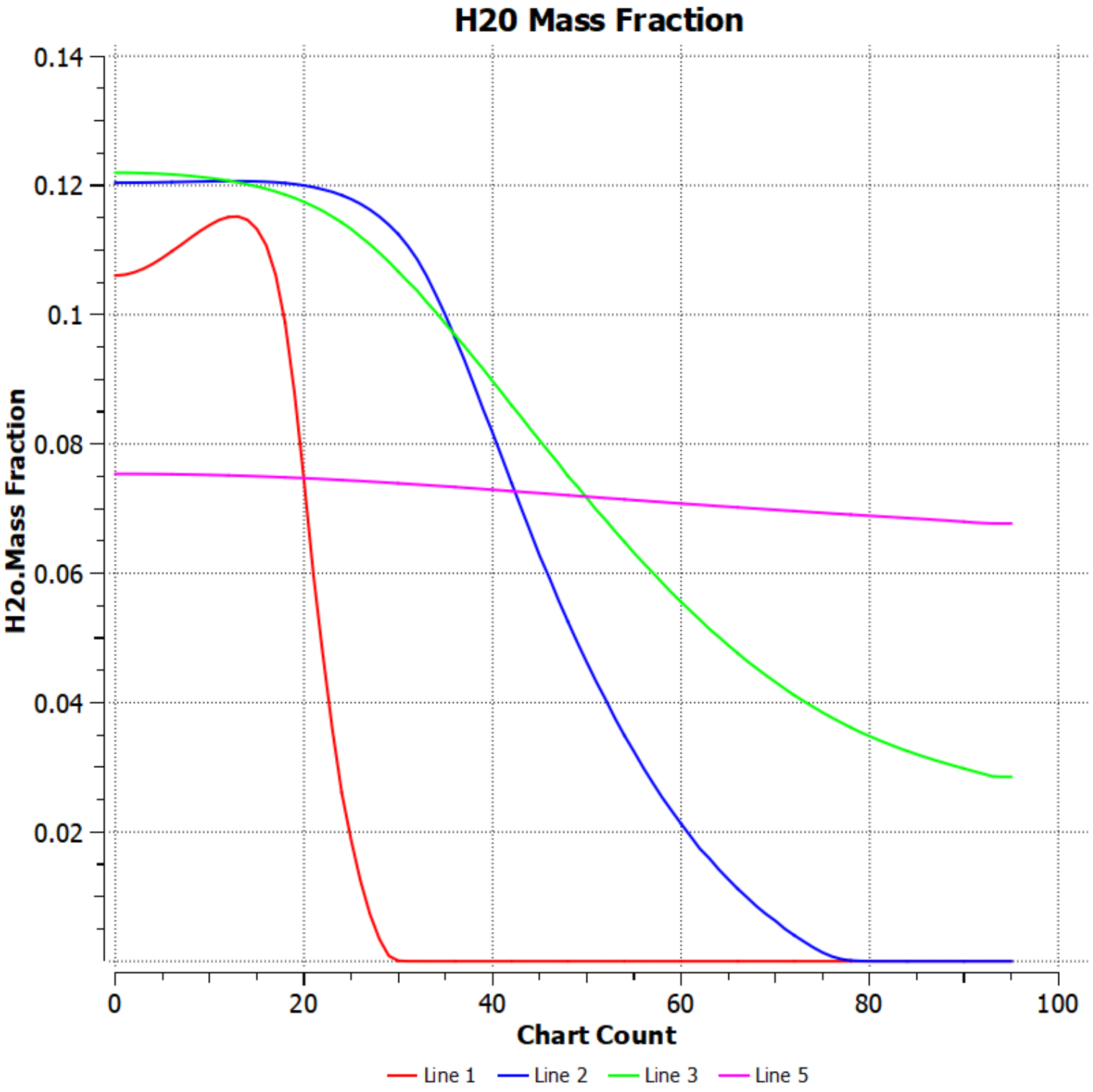
H2O - fraction 5 %

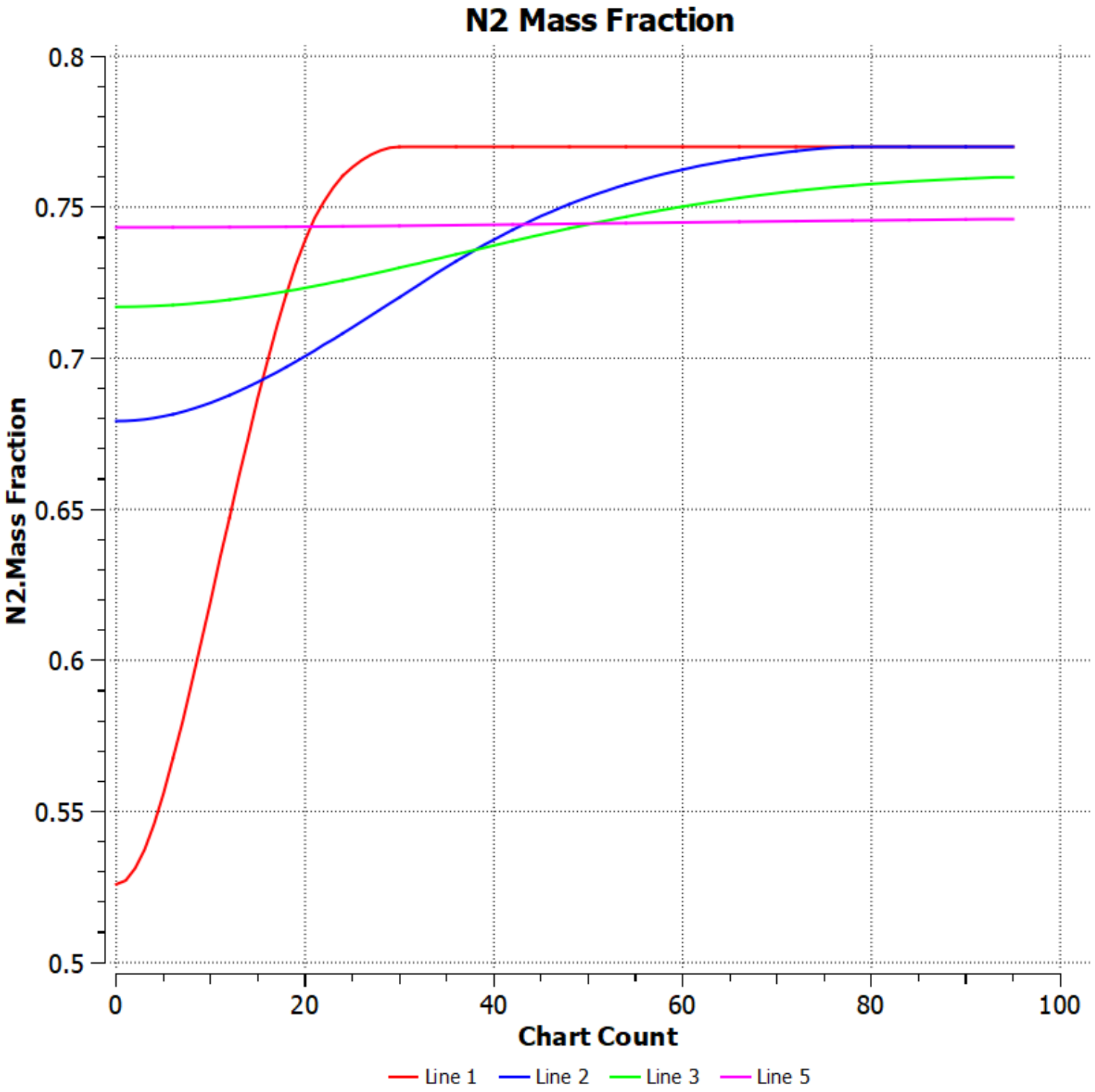
Residual

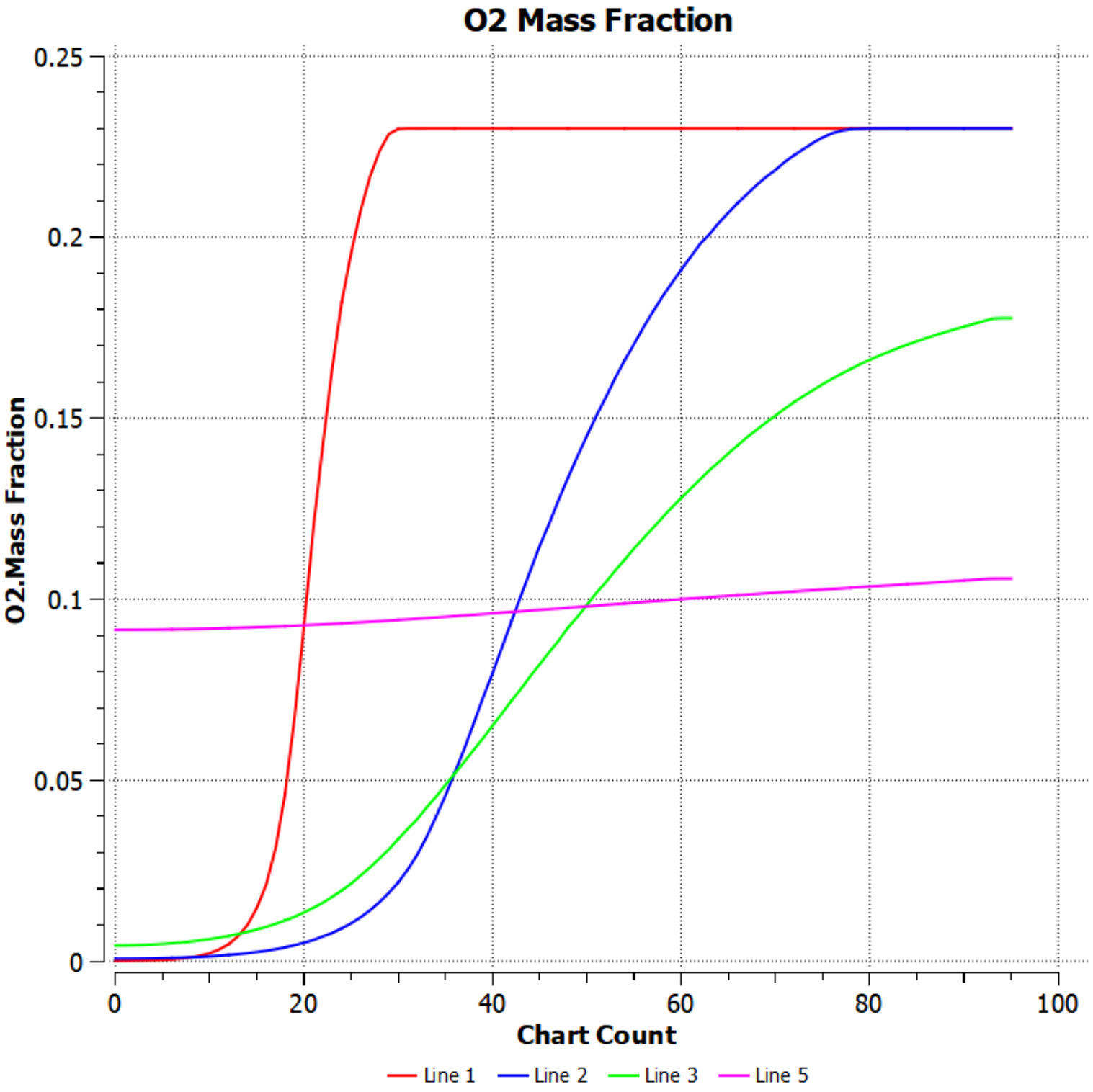

Residuals
continuity
x-velocity
y-velocity
energy
k
epsilon
ch4
o2
co2
h2o
1e+06
1e+04
1e+02
1e+00
1e-02
1e-04
1e-06
1e-08
0
50
100
150
200
250
300
350
400
450
500
Iterations


Ch4 Mass Fraction
0.3
0.25
0.2
0.15
0.1
0.05
Ch4.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

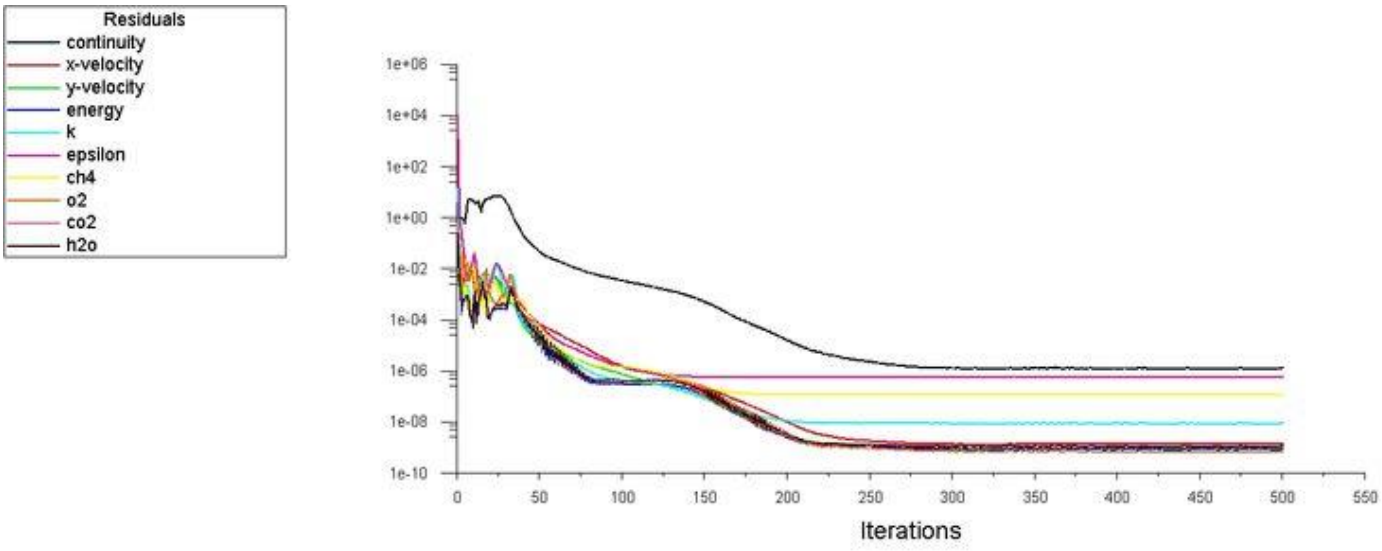

CO2 Mass Fraction
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Co2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

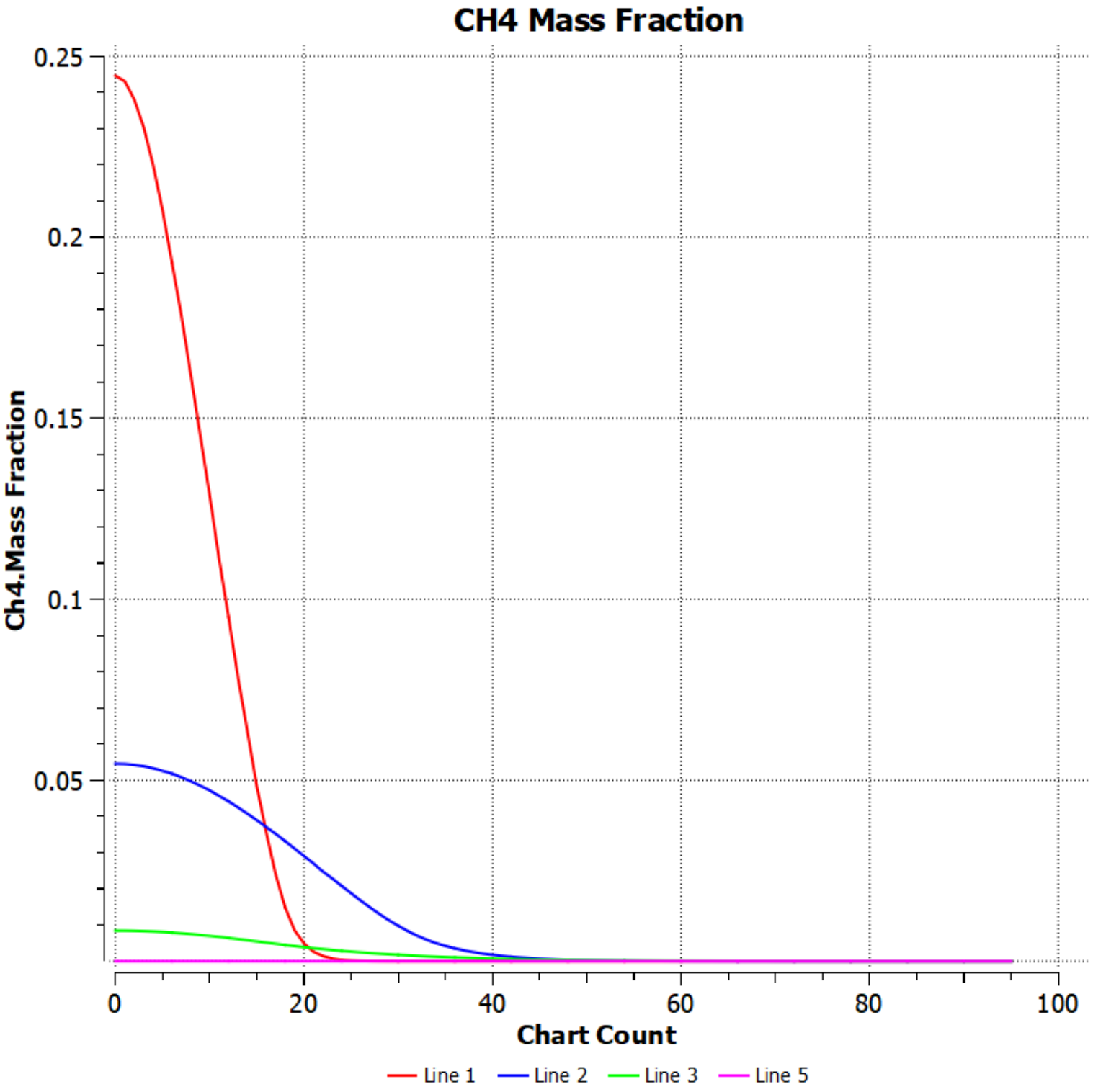

H20 Mass Fraction
0.14
0.12
0.1
0.08
0.06
0.04
0.02
H2o.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

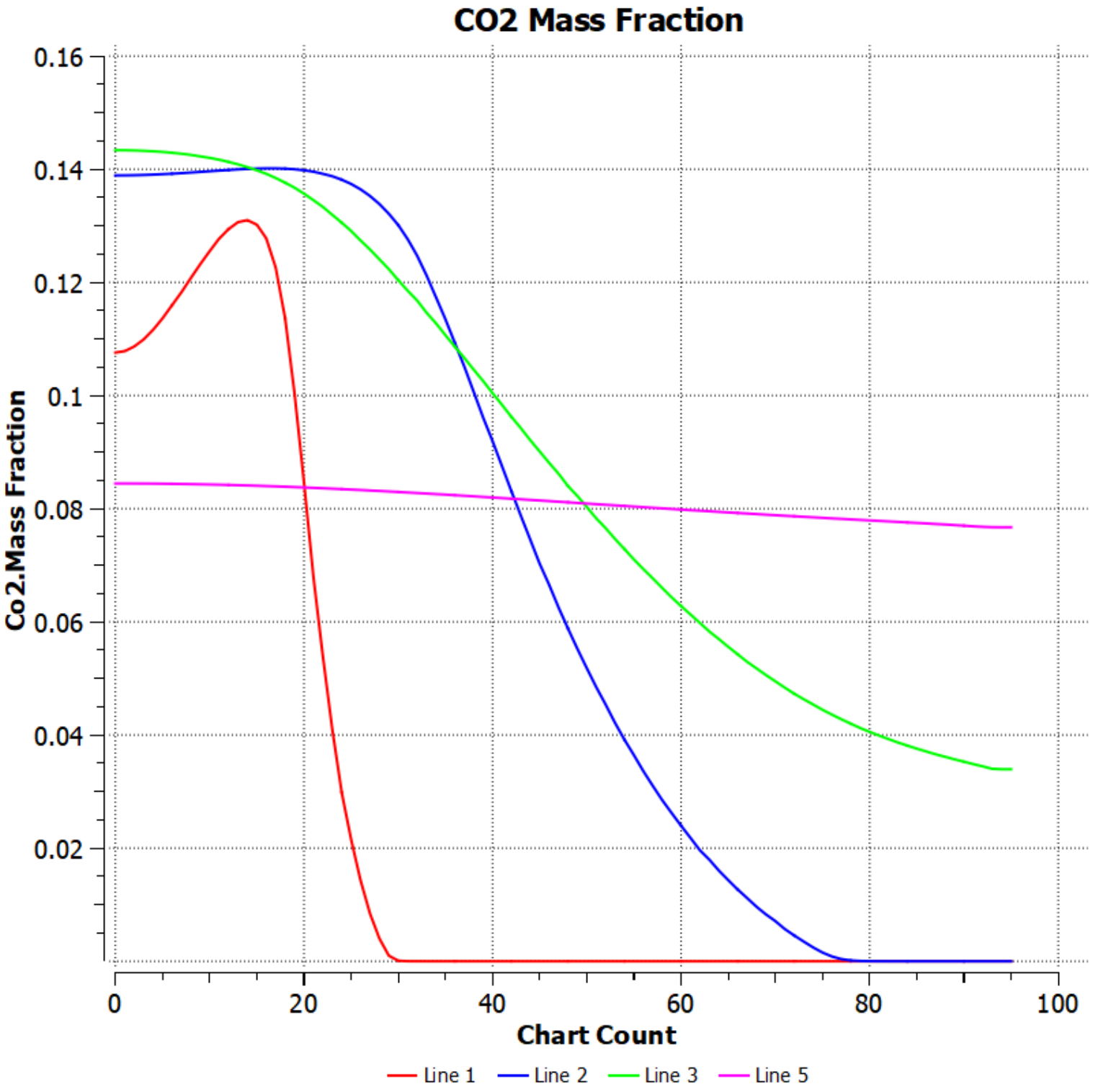

N2 Mass Fraction
0.8
0.75
0.7
0.65
0.6
0.55
0.5
N2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

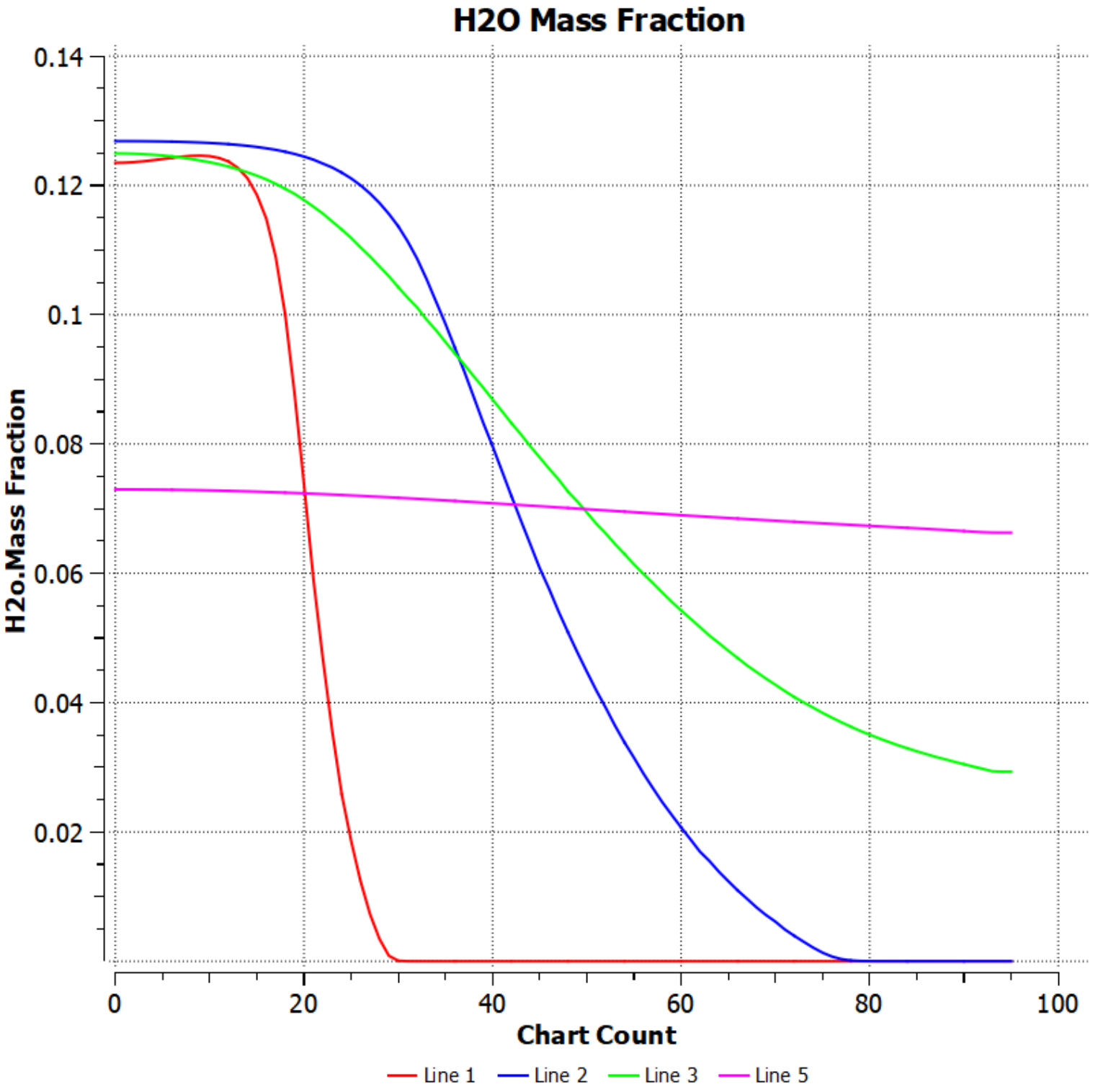


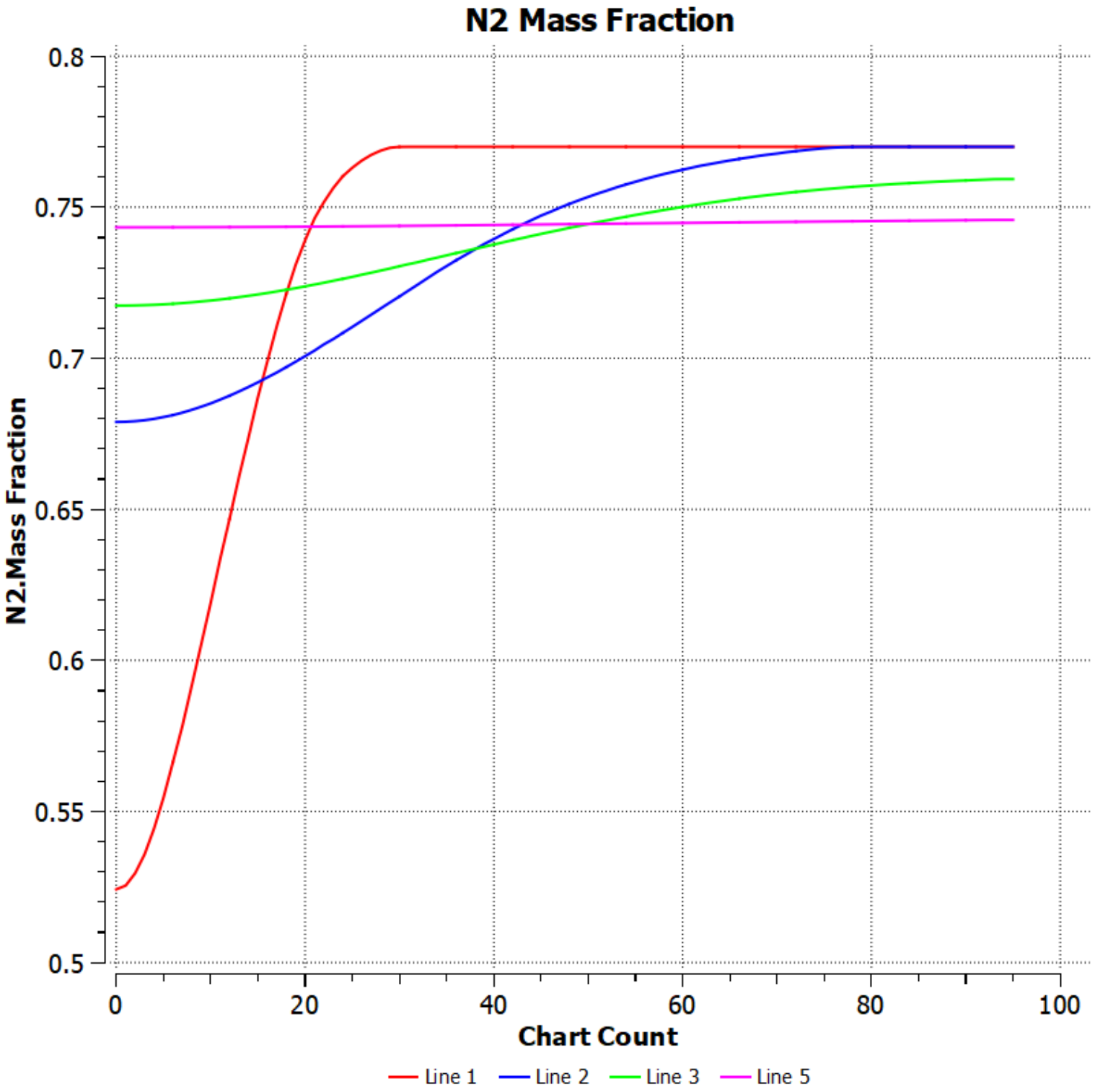
H2O - fraction - 10%

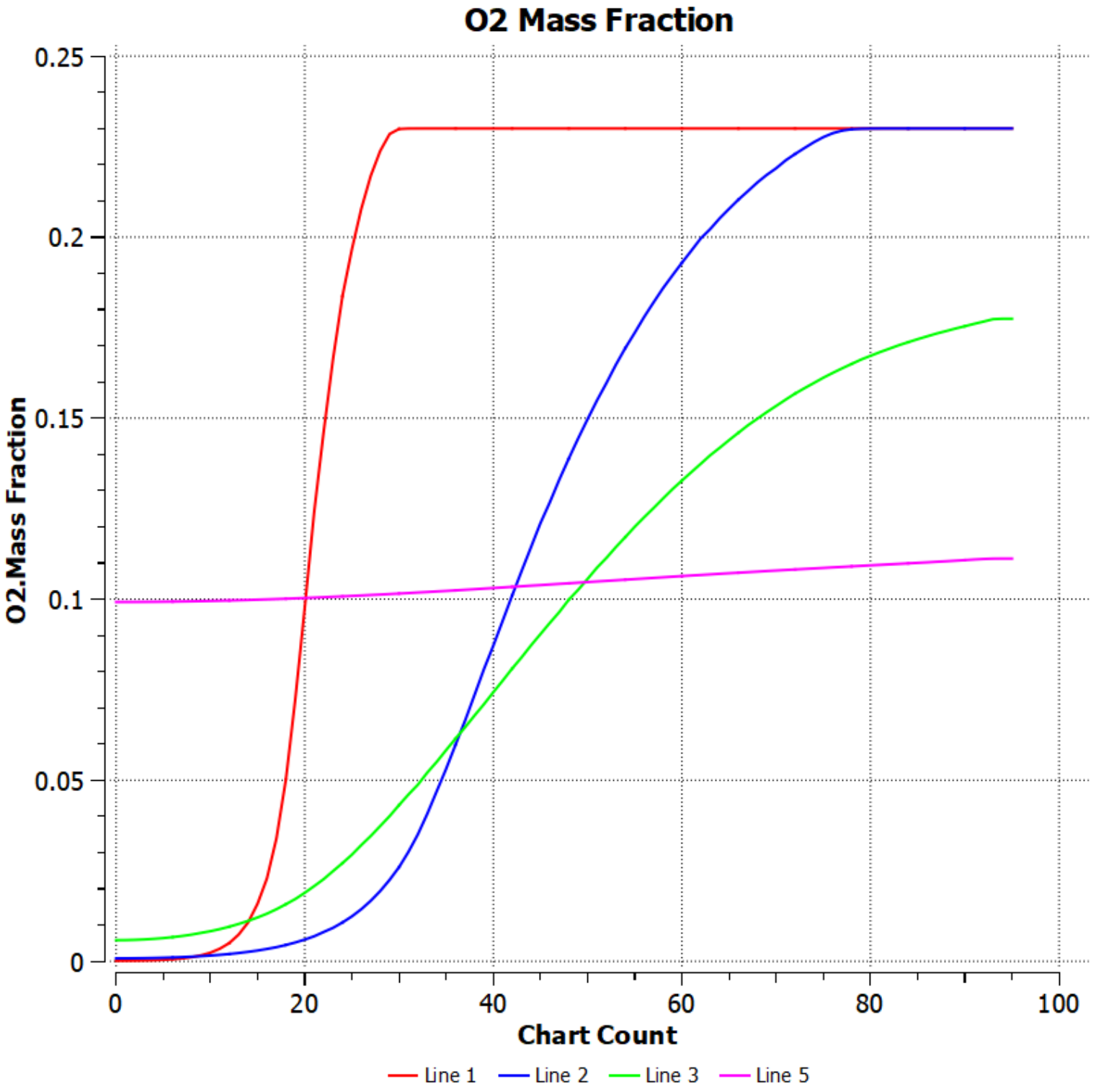

Residuals
continuity
x-velocity
y-velocity
energy
k
epsilon
ch4
o2
co2
h2o
1e+06
1e+04
1e+02
1e+00
1e-02
1e-04
1e-06
1e-08
1e-10
0
50
100
150
200
250
300
350
400
450
500
550
Iterations


CH4 Mass Fraction
0.25
0.2
0.15
0.1
0.05
Ch4.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5


CO2 Mass Fraction
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Co2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

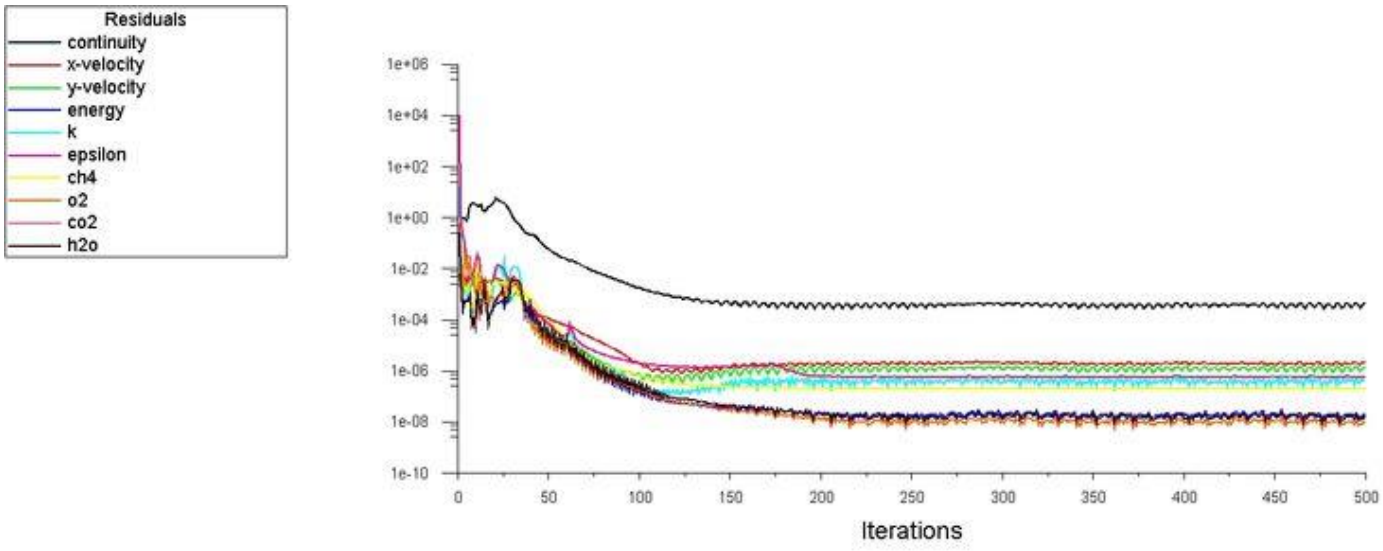

H2O Mass Fraction
0.14
0.12
0.1
0.08
0.06
0.04
0.02
H2o.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

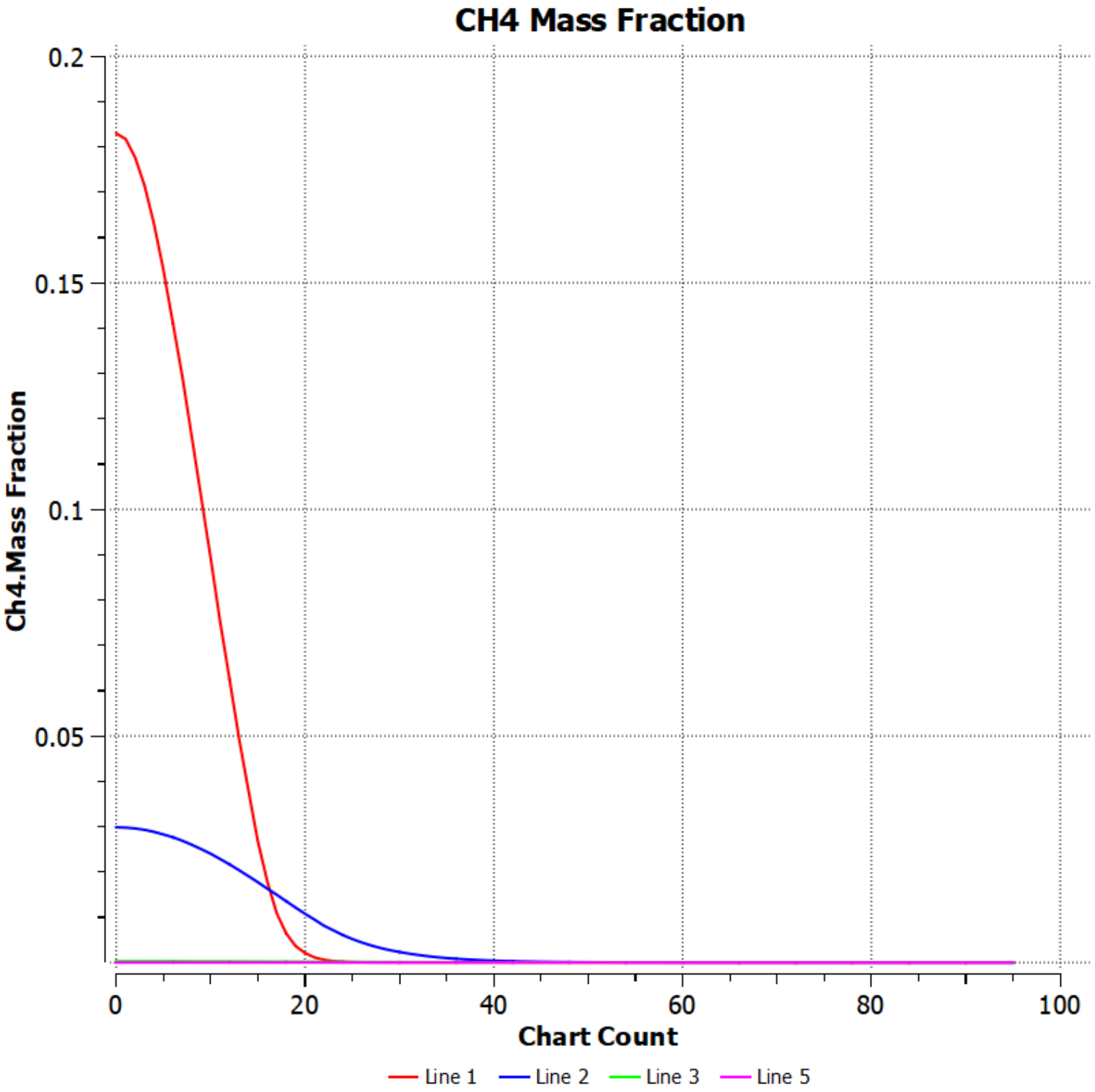

N2 Mass Fraction
0.8
0.75
0.7
0.65
0.6
0.55
0.5
N2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5

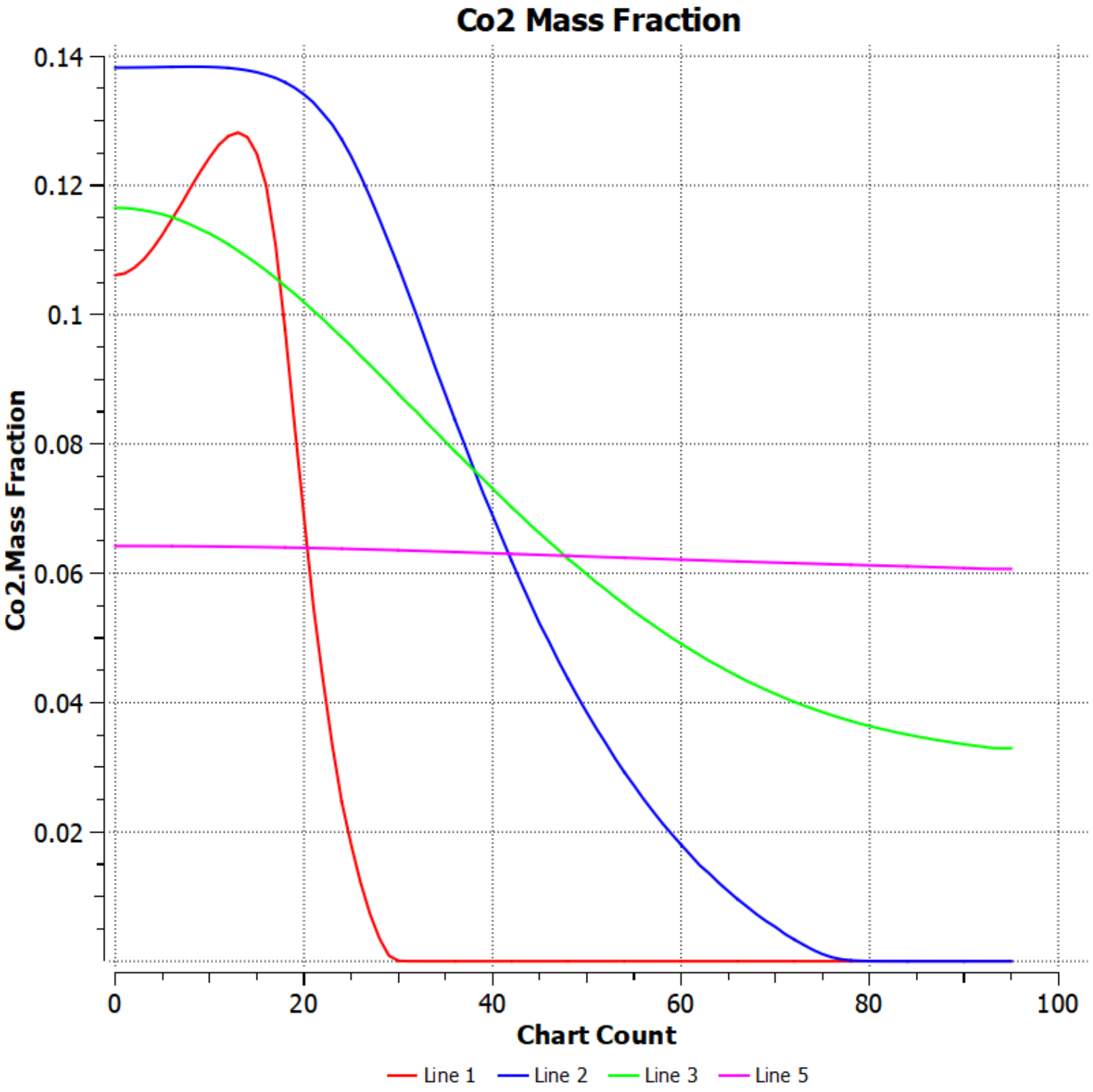


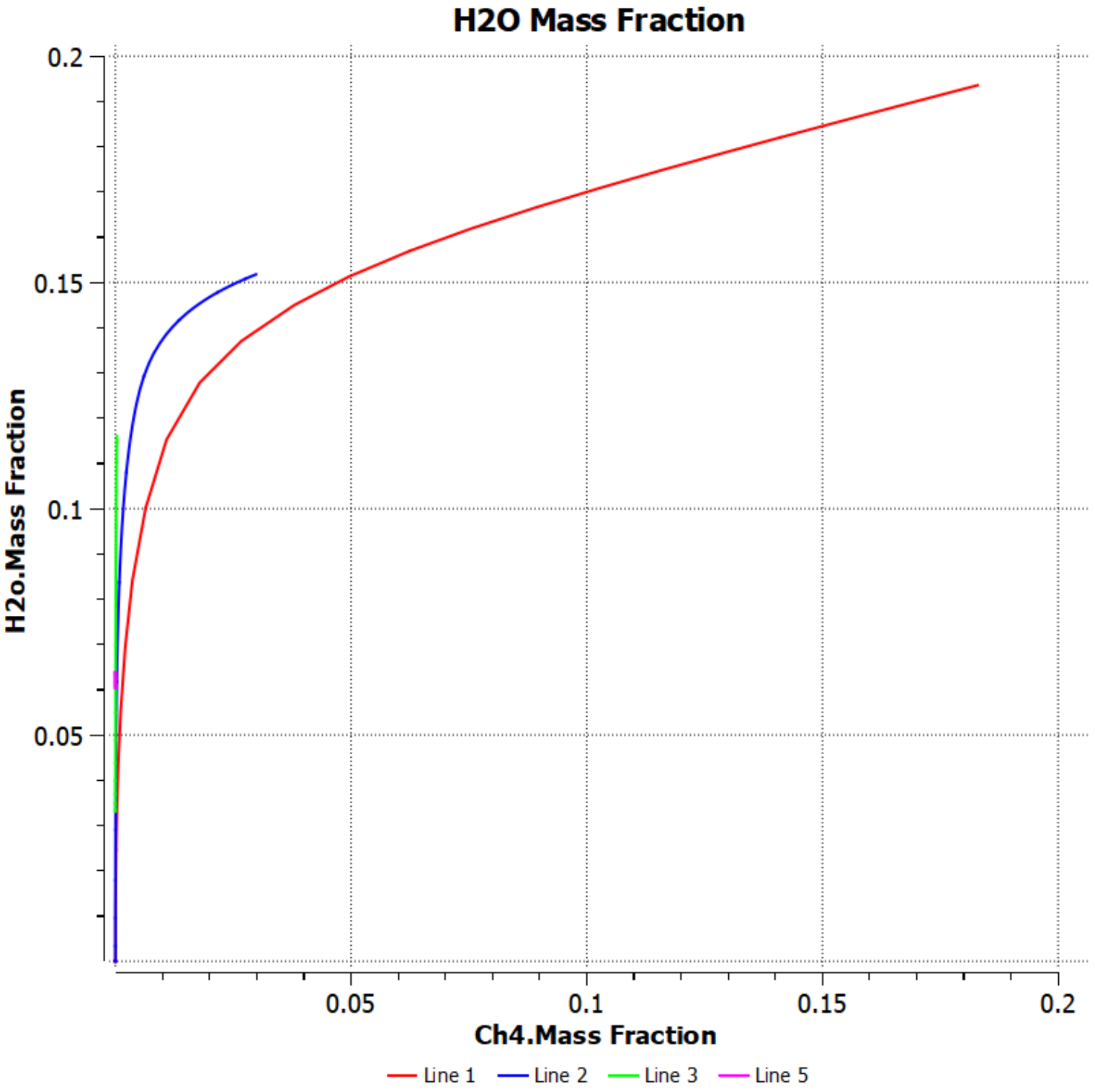
H20 - fraction - 30%

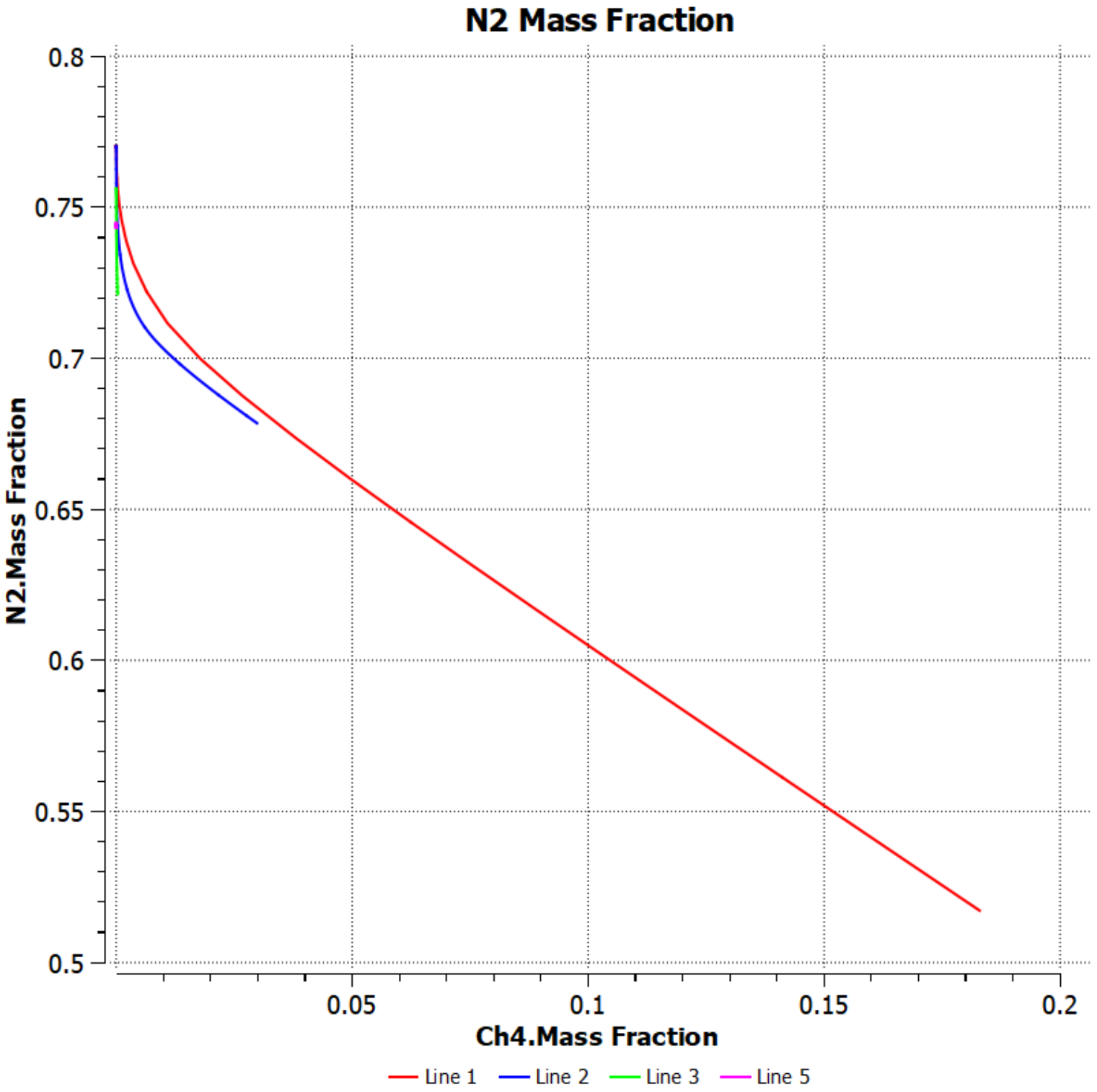
Residual

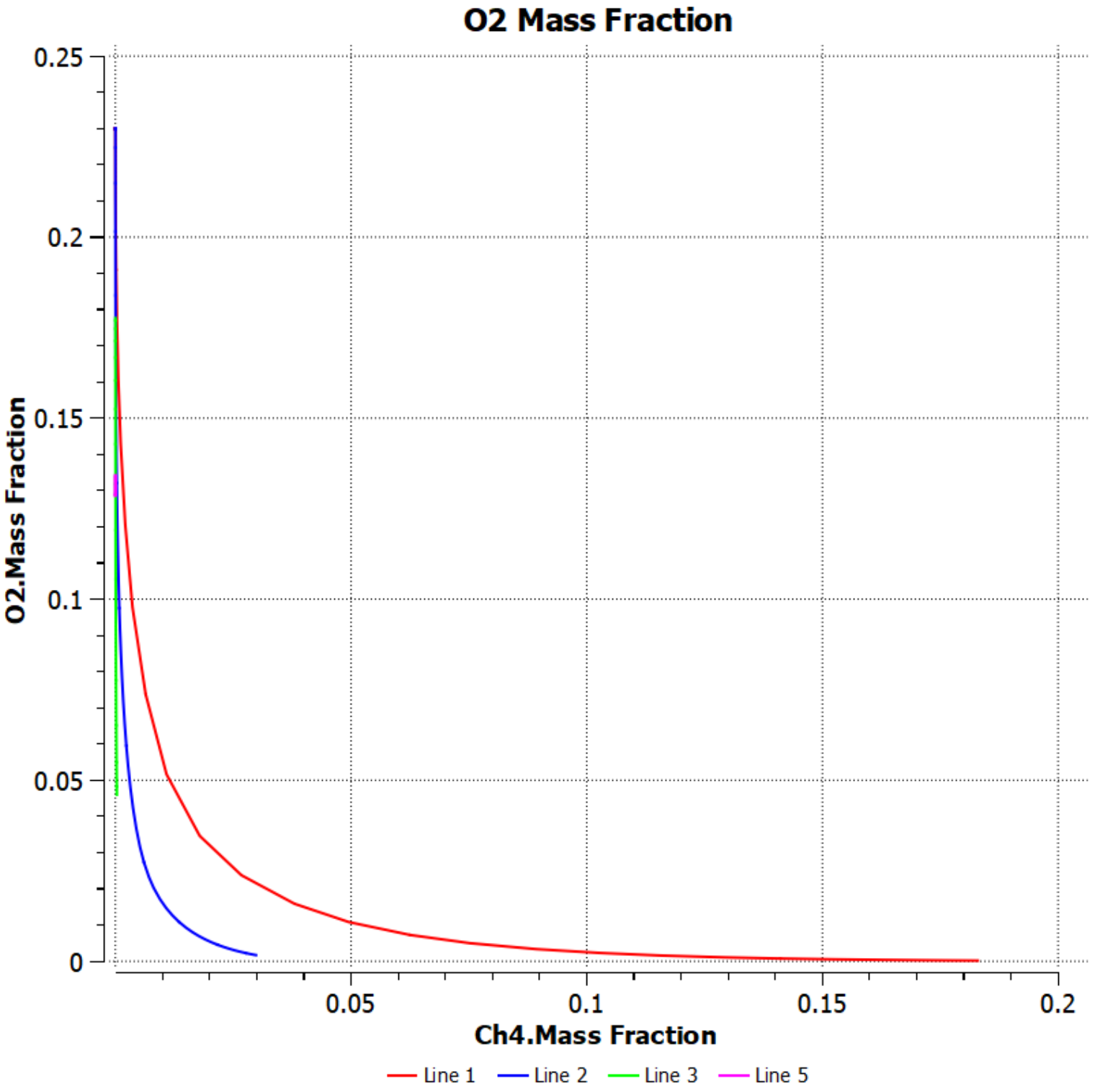

Residuals
continuity
x-velocity
y-velocity
energy
k
epsilon
ch4
o2
co2
h2o
1e+06
1e+04
1e+02
1e+00
1e-02
1e-04
1e-06
1e-08
1e-10
0
50
100
150
200
250
300
350
400
450
500
Iterations


CH4 Mass Fraction
0.2
0.15
0.1
0.05
Ch4.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5


Co2 Mass Fraction
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Co2.Mass Fraction
0
20
40
60
80
100
Chart Count
Line 1
Line 2
Line 3
Line 5


H2O Mass Fraction
0.2
0.15
0.1
0.05
H2o.Mass Fraction
0.05
0.1
0.15
0.2
Ch4.Mass Fraction
Line 1
Line 2
Line 3
Line 5


N2 Mass Fraction
0.8
0.75
0.7
0.65
0.6
0.55
0.5
N2.Mass Fraction
0.05
0.1
0.15
0.2
Ch4.Mass Fraction
Line 1
Line 2
Line 3
Line 5


O2 Mass Fraction
0.25
0.2
0.15
0.1
0.05
0
O2.Mass Fraction
0.05
0.1
0.15
0.2
Ch4.Mass Fraction
Line 1
Line 2
Line 3
Line 5