

Nozzle Flow for sCO₂

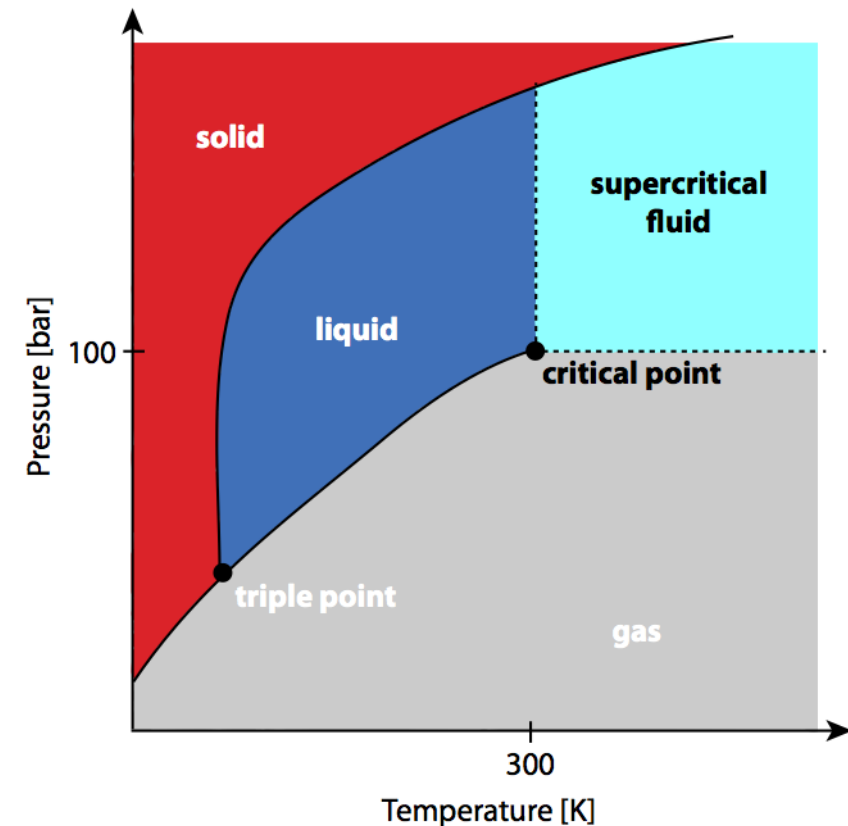
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Material Properties of sCO₂

- A substance is said to be in a supercritical state when its temperature and pressure are above the substance's critical point.
- In the supercritical regime, the substance behaves as a gas and also as a liquid.



Aungier-Redlich-Kwong Equation of State

- Real gases cannot be described by the ideal gas law equation of state (EOS).
- Over the years, many researchers have modified the ideal gas EOS to better describe the behavior of real gases.
- One of the more accurate modifications is the Aungier-Redlich-Kwong (A-R-K) EOS.

Ideal gas

$$P = \frac{R_s T}{V_{s,m}}$$



Aungier-Redlich-Kwong

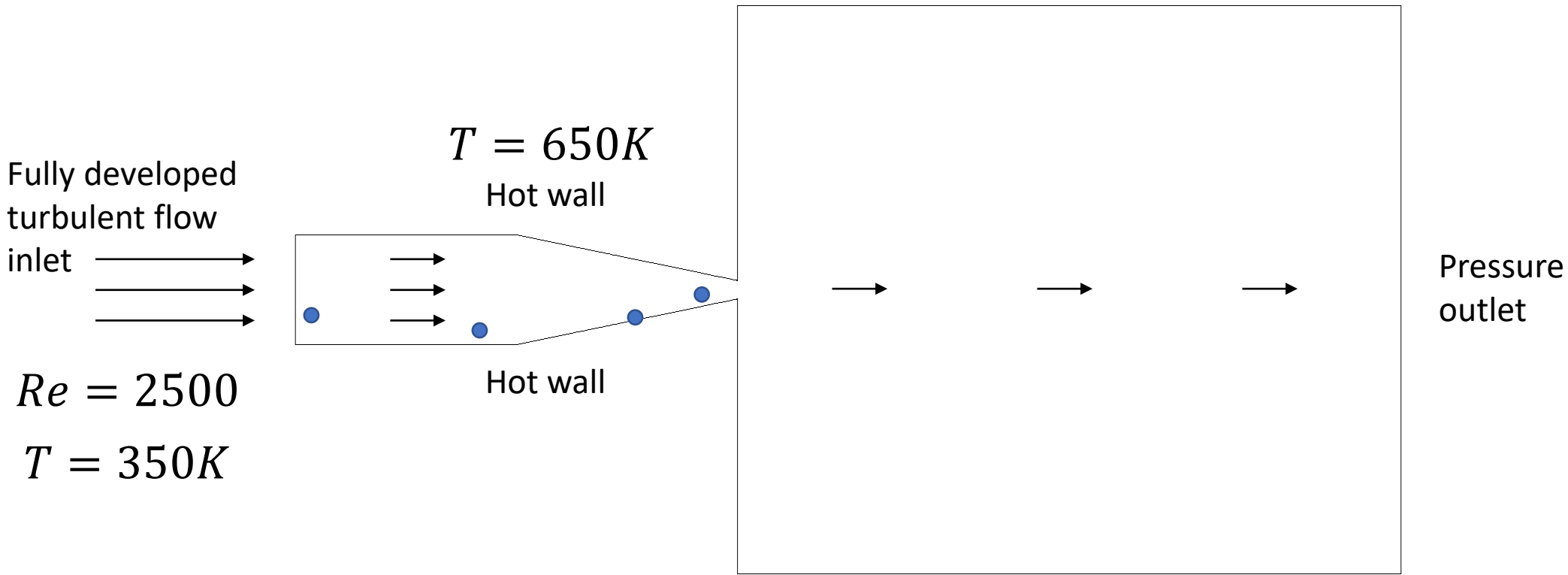
$$P = \frac{R_s T}{V_{s,m} - b + c} - \frac{\alpha}{V_{s,m}(V_{s,m} + b)}$$

constants

$$\begin{aligned} a_0 &= 0.42747 \frac{(RT_c)^2}{P_c} \\ b &= 0.08664 \frac{RT_c}{P_c} \\ c &= \frac{RT_c}{P_c + \frac{a_0}{V_c^2 + V_c b}} + b - V_c \\ \alpha(T) &= a_0 \left(\frac{T}{T_c} \right)^{-n} \\ n &= 0.4986 + 1.1735\omega + 0.4754\omega^2 \\ \omega &= 0.22394 \end{aligned}$$

2D Geometry of Nozzle Flow Domain

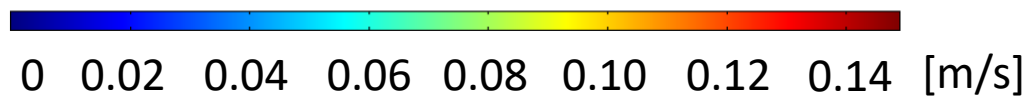
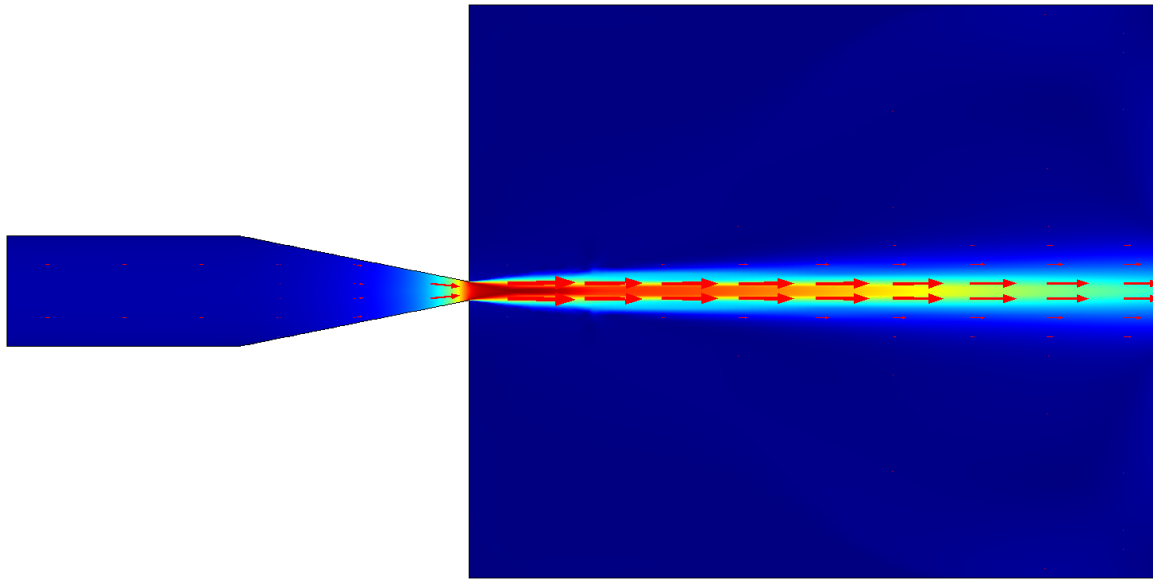
- Simulation of flow through nozzle solved using COMSOL Multiphysics



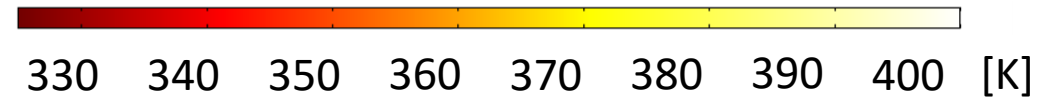
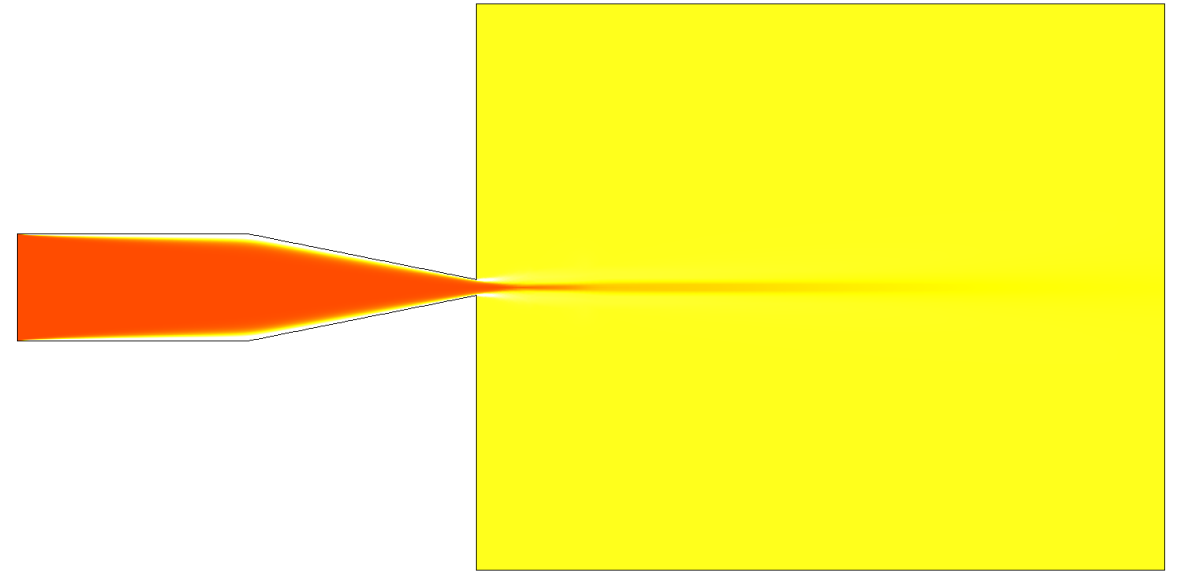
• Points at which density is measured

Temperature and Velocity Plots in Domain

Velocity



Temperature



Density Comparison in Domain

- We verified that the COMSOL sCO₂ density for multiple points in the domain is equivalent to the density calculated from the A-R-K EOS.

