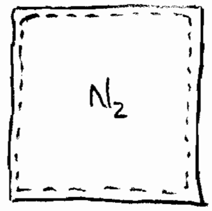
Given: Nitrogen in a closed, rigid tank



$T_1 = 440°F$
$p_1 = 14.5$ psia
$p_2 = 50$ psia

Find: T_2, Δu using a) The ideal gas model
b) The real-fluid model

Solution: a) Using the ideal gas model,

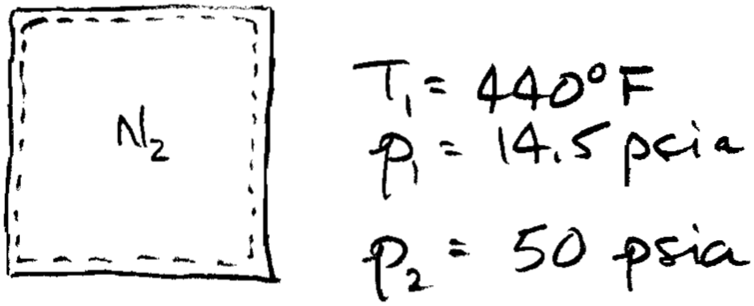
$$\left.\begin{aligned} p_1 v_1 &= RT_1 \\ p_2 v_2 &= RT_2 \end{aligned}\right\} \quad v_2 = v_1 \text{ therefore } T_2 \text{ can be found!}$$

$\Delta u_i = u_2 - u_1$ The ideal gas Δu can be found using 'N2' as the fluid in EES!

b) Using the real fluid model,

$$\left.\begin{aligned} p_1 &= p(v_1, T_1) \\ p_2 &= p(v_2, T_2) \end{aligned}\right\} \quad v_2 = v_1 \text{ Therefore } T_2 \text{ can be found!}$$

$\Delta u_r = u_2 - u_1$ The real-fluid Δu can be found using 'nitrogen' as the fluid in EES!



GIVEN: Nitrogen in a closed, rigid tank

$T_1 = 440$ [F]

$p_1 = 14.5$ [psia]

$p_2 = 50$ [psia]

FIND: T_2 and the change in internal energy of the nitrogen using the ideal gas model and the real fluid model. How do they compare? (Refelction)

SOLUTION:

(a) - The ideal gas properties for nitrogen can be accessed using the fluid 'N2'

The final temperature can be found by equating the specific volumes at states 1 and 2

$v_{1,i} = \mathbf{v}\left[\text{'N2'}, T = T_1, P = p_1 \right]$

$v_{2,i} = v_{1,i}$

$v_{2,i} = \mathbf{v}\left[\text{'N2'}, T = T_{2,i}, P = p_2 \right]$

The change in internal energy of the nitrogen is,

$u_{1,i} = \mathbf{u}\left[\text{'N2'}, T = T_1 \right]$

$u_{2,i} = \mathbf{u}\left[\text{'N2'}, T = T_{2,i} \right]$

$\Delta u_i = u_{2,i} - u_{1,i}$

(b) - The real fluid properties for nitrogen can be found using fluid 'nitrogen'

$v_{1,r} = \mathbf{v}\left[\text{'Nitrogen'}, T = T_1, P = p_1 \right]$

$v_{2,r} = v_{1,r}$

$v_{2,r} = \mathbf{v}\left[\text{'Nitrogen'}, T = T_{2,r}, P = p_2 \right]$

The change in internal energy of the nitrogen using real fluid behavior is,

$u_{1,r} = \mathbf{u}\left[\text{'Nitrogen'}, T = T_1, P = p_1\right]$

$u_{2,r} = \mathbf{u}\left[\text{'Nitrogen'}, T = T_{2,r}, P = p_2\right]$

$\Delta u_r = u_{2,r} - u_{1,r}$

SOLUTION

Unit Settings: Eng F psia mass deg

Δu_i = 462.9 [Btu/lb$_m$]	Δu_r = 463 [Btu/lb$_m$]
p_1 = 14.5 [psia]	p_2 = 50 [psia]
T_1 = 440 [F]	$T_{2,i}$ = 2643 [F]
$T_{2,r}$ = 2642 [F]	$u_{1,i}$ = 26.83 [Btu/lb$_m$]
$u_{1,r}$ = 159.9 [Btu/lb$_m$]	$u_{2,i}$ = 489.7 [Btu/lb$_m$]
$u_{2,r}$ = 622.9 [Btu/lb$_m$]	$v_{1,i}$ = 23.77 [ft^3/lb$_m$]
$v_{1,r}$ = 23.78 [ft^3/lb$_m$]	$v_{2,i}$ = 23.77 [ft^3/lb$_m$]
$v_{2,r}$ = 23.78 [ft^3/lb$_m$]	

No unit problems were detected.

KEY VARIABLES

$T_{2,i}$ = 2643 [F]	(a) T_2 using the ideal gas model
Δu_i = 462.9 [Btu/lb$_m$]	*(a) change in internal energy using the ideal gas model*
$T_{2,r}$ = 2642 [F]	*(b) T_2 using the real fluid model*
Δu_r = 463 [Btu/lb$_m$]	*(b) change in internal energy using the real fluid model*

REFLECTION:

Nitrogen (and many other substances) are included in EES as ideal gases AND real fluids! Using the ideal gas fluid, there is no need to write out the ideal gas EOS! It is contained in the property call.

In this case, the ideal gas model and the real fluid model give answers that are very close! This means that the ideal gas model appears to be a valid approximation to the real fluid behavior for this problem.

Did you notice that the *absolute* values of u_1 and u_2 for the two models are not the same? For example, u_1_i = 26.83[Btu/lbm] and u_1_r = 159.9[Btu/lbm]! However, when you look at the *change* in internal energy, the values are nearly the same!!