The pressurizer in problem 1 has a total volume of 1800 ft³. At HZP conditions, the pressurizer liquid level is 33%. Assuming an initial primary side liquid mass inventory of 595,000 lbm (not including the pressurizer),

a) How much mass inventory must be let down such that the liquid level is 66% at 100% power? You can assume a constant system pressure of 2250 psia, and the liquid temperature in the pressurizer is that of a saturated liquid at the system pressure.

b) What would be the new liquid level in the pressurizer in the absence of letdown?

**Solution**

a) The mass change in the pressurizer is the difference between the insurge and the letdown.

\[ \Delta M_{PRZ} = \Delta M_{INSURGE} - \Delta M_{LETDOWN} \]

The primary system density at HZP is

\[ \rho_{sys} = \rho @ T = 557 & P = 2250 \]

= 46.3883 lbm

The primary system density at 100% power is

\[ \rho_{sys} = \rho @ T = 590 & P = 2250 \]

= 43.9983 lbm

The liquid density in the pressurizer is given to be a saturated liquid, therefore

\[ \rho_{PRZ} = \rho_f @ P = 2250 \]

= 37.0906 lbm

For the liquid level in the pressurizer to increase from 33% to 66% implies a mass change of

\[ \Delta M_{PRZ} = V_{PRZ} \rho_{PRZ} (\Delta \alpha)_{PRZ} \]

\[ = (1800)(37.0906)(0.33) \]

\[ = 22031.82 \text{ lbm} \]

The insurge due to the change in primary side temperature is

\[ \Delta M_{INSURGE} = V_{SYS} \Delta \rho_{SYS} \]

where the system volume is

\[ V_{SYS} = \frac{M_{SYS}}{\rho_{SYS}} \]

such that

\[ \Delta M_{INSURGE} = \frac{M_{SYS}}{\rho_{SYS}} \left( \rho_{SYS} - \frac{\rho_{SYS}}{\rho_{SYS}} \right) = M_{SYS} \left( 1 - \frac{\rho_{SYS}}{\rho_{SYS}} \right) \]
ΔM_{\text{INSURGE}} = 595,000 \left(1 - \frac{43.9983}{46.3883}\right) = 30655.36 \text{ lbm}

The inventory to be letdown is then

\[ \Delta M_{\text{LETDOWN}} = \Delta M_{\text{INSURGE}} - \Delta M_{\text{PRZ}} \]
\[ = 30655.36 - 22031.82 \]
\[ = 8623.54 \text{ lbm} \]

b) In the absence of letdown, the change in the pressurizer mass inventory is equal to the insurge

\[ \Delta M_{\text{INSURGE}} = \Delta M_{\text{PRZ}} \]

\[ \Delta M_{\text{INSURGE}} = V_{\text{PRZ}} \rho_{\text{PRZ}} (\Delta \alpha_{i})_{\text{PRZ}} \]
\[ 30655.36 = (1800)(37.0906)(\Delta \alpha_{i})_{\text{PRZ}} \]

\[ (\Delta \alpha_{i})_{\text{PRZ}} = 0.4592 \Rightarrow \alpha_{i} = 0.33 + 0.4592 = 0.7892 \]