Critical heat flux for the BWR in problem 1) has been correlated according to a critical boiling length correlation of the form

\[ x_{\text{crit}} = \frac{aL_{\text{crit}}}{b + L_{\text{crit}}} \]

Show how you would determine the critical power ratio for this reactor. Give all equations. Terms involving integrals may be left in integral form. If the solution requires iteration, it is sufficient to give the iteration equation (s), state which variable (s) is to be solved for and state to solve iteratively. If needed, the following additional information can be assumed known

**Problem Data**

<table>
<thead>
<tr>
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<th>( \hat{Q}_{\text{th}} )</th>
<th>( F_q )</th>
<th>( F_z )</th>
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</thead>
<tbody>
<tr>
<td>Total Thermal Output</td>
<td>( \hat{Q}_{\text{th}} )</td>
<td></td>
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<tr>
<td>Total Power Peaking Factor</td>
<td>( F_q )</td>
<td></td>
<td></td>
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<tr>
<td>Axial Peaking Factor</td>
<td>( F_z )</td>
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**SOLUTION**

The core wide maximum heat flux is related to the thermal power by

\[ q_{\text{max}}^* = \frac{\hat{Q}_{\text{th}}^*}{F_q \pi DH} \]

where \( n \) is the total number of heated rods in the core and given by

\[ n = n_{\text{heated}} \times n_{\text{cans}} \]

The magnitude of the heat flux in the hot channel is related to the core wide maximum heat flux by

\[ q_{\text{max}}^* = q_{\text{hot}}^*(z_{\text{max}}) = q_{\text{hot}}^* Z(z_{\text{max}}) \]

where \( z_{\text{max}} \) satisfies

\[ \frac{dq_{\text{crit}}^*}{dz} \bigg|_{z_{\text{max}}} = 0 \]

If the critical power ratio is

\[ CPR = \frac{\hat{Q}_{\text{crit}}}{\hat{Q}_{\text{th}}} \]

where \( \hat{Q}_{\text{crit}} \) is the thermal power at which dryout would occur in any channel in the reactor, then assuming dryout occurs in the highest powered rod, and the highest powered rod is the same as the rod with the highest heat flux, then as shown above the critical power in the reactor is proportional to the magnitude of the heat flux in the critical channel. Similarly, the magnitude of the heat flux in the hot channel is proportional to the magnitude of the heat flux in the hot channel, where the proportionality constants are the same. Therefore
i.e. the critical power ratio for the reactor is equal to that of the hot channel. For critical heat flux correlated in terms of a critical boiling length correlation of the form

\[ \frac{aL_{\text{crit}}}{b + L_{\text{crit}}} \]

The magnitude of the critical heat flux then satisfies

1) \[ x_{\text{crit}} = \frac{aL_{\text{crit}}}{b + L_{\text{crit}}} = \frac{a(H - H_o)}{b + H - H_o} = \frac{\pi D}{\dot{m}f h_{fg}} \int_0^H q_{0,\text{crit}}^* Z(z) dz \]

where the non boiling height satisfies

2) \[ \dot{m}(h_f - h_{in}) = \frac{\pi D}{\gamma_f} \int_0^H q_{0,\text{crit}}^* Z(z) dz \]

and \[ \dot{m} = G_{hot} A_s = G_{hot} \left[ S^2 - \frac{\pi}{4} D^2 \right] \]

Solving Equation 2 for \( q_{0,\text{crit}}^* \)

3) \[ q_{0,\text{crit}}^* = \frac{\dot{m}(h_f - h_{in})}{\pi D} \int_0^H Z(z) dz \]

and substituting into Equation 1) gives a single non linear equation in the non boiling height

4) \[ \frac{a(H - H_o)}{b + H - H_o} = \frac{h_f - h_{in}}{h_{fg}} \int_0^H Z(z) dz \]

Equation 4) can be solved iteratively for \( H_o \). Given \( H_o \), the magnitude of the critical heat flux can be obtained directly from Equation 3. The critical power ratio is then

\[ \text{CPR} = \frac{q_{0,\text{crit}}^*}{q_{0,\text{hot}}^*} \]