

(100) 3. Comparison of the Direct and Indirect Methods for Continuous Hot Water Supply

Recently, Sutter and Heaters touted the advantages of direct steam injection (DSI) for providing a continuous (steady) supply of hot water (P. Sutter, P Heaters, "Producing Hot Water by Direct Steam Injection," Chemical Engineering Progress, 48-51, May 2010). The alternative is to heat water by indirect steam heating as in a cladded vessel. Figures 2A (indirect heating) and 2B (direct heating) illustrate the two methods. A fixed, steady supply of hot water at mass flow rate \dot{m}_w and temperature T_∞ is desired. With indirect heating in Figure 2A, steam heats the water externally by condensing in the steam chest. Conversely, with direct heating in Figure 2B, inlet steam is mixed directly into the heated water. Assume in both Figures 2A and 2B that steam is completely condensed and that the water heat capacity, \hat{C}_{pw} is constant. Assume also that the cost of producing steam is the gauge of efficiency. Label the inlet water temperature as T_o and the steam condensation temperature as T_s . In both cases, inlet steam is fully saturated vapor. Denote the mass enthalpy of vaporization of water as $\Delta\hat{H}_{vap}$

- (20) a. Explain physically why direct hot water heating is more efficient than indirect heating (no equations!).
- (25) b. Perform mass and energy balances for the indirect heating method to find an expression for the mass steam rate \dot{m}_s .
- (25) c. Perform mass and energy balances for the direct heating method to find an expression for the mass steam rate \dot{m}_s .
- (20) d. Use the results in parts b and c to obtain an expression for the ratio of efficiencies for the two processes. Is the direct method actually more efficient?
- (10) e. List disadvantages of the direct method as pictured in Figure 2B.

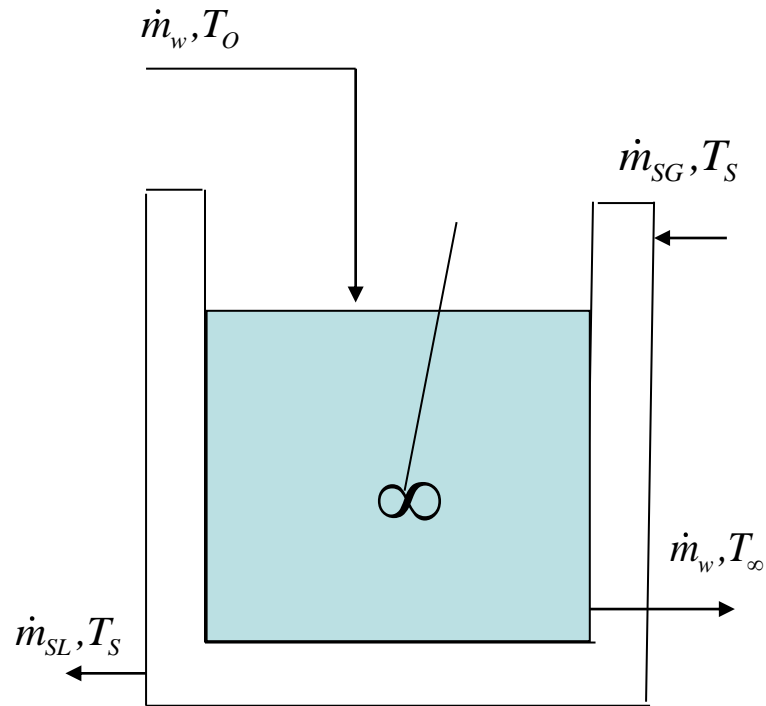


Figure 2A Steady Indirect Heating of Water (steam cladding). All steam condenses in the cladding chest.

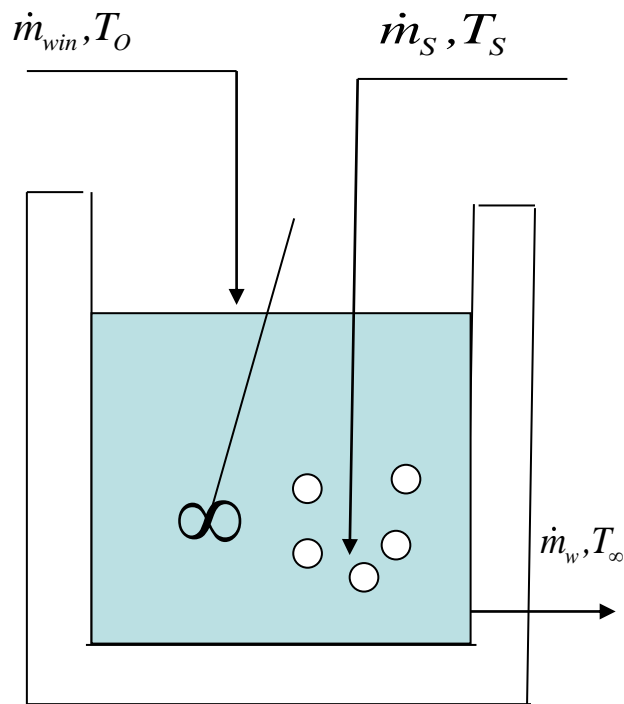


Figure 2B. Steady Direct Heating of Water (DSI). Vapor bubbles completely condense and the cladding chest is not used.