Homework #2

Problems 3.1, 3.2 (with extra below), 3.3, & extra problem below.

Extra for 3.2:
What is the relative difference in heat transfer area if you use a 1-2 heat exchanger (1 shell pass, 2 tube passes) instead of pure counter current flow? Consider both the water on shell side in one instance & on the tube side in another instance.

Extra problem:
You'd like to condense 5,000 lb/hr of propane in a 4-pass aerial cooler.

Consider the following:
- You want to condense propane at a sufficient pressure so that it will be saturated at 120°F.
- The propane enters as a saturated gas, exits as a saturated liquid, & there is no pressure drop through the exchanger.
- Ambient air is 85°F. Consider its heat capacity as 0.25 Btu/lb·°F.
- The exchanger should have a minimum 10°F approach temperature.

Answer the following:
- What mass flow rate of air is needed (in lb/hr)?
- If the heat transfer coefficient (based on the extended area) is 3.5 Btu/hr·ft²·°F then what surface area is needed (in ft²)?
FIGURE 3.17 Internal reboiler with directly fired heating.

and glycol regenerators. Internal reboilers in gas plants may use steam, hot oil, or direct fired fire-tube heaters. Firetube heaters are used in nearly all field units.

Internal reboilers are ideal for small units where the kettle forms the bottom of the column and they are less expensive than a separate reboiler shell. Firetube reboilers also have the advantage of easy removal and replacement of the firetube.

DISCUSSION QUESTIONS

1. Which of the three heat transfer modes dominates in most gas processing steps?
2. Why is conduction most important in solids but less important in fluids?
3. What modes of heat transfer are important in the “R-value” of wood and fiberglass insulation?
4. Give some examples where natural convection is important.
5. Give some examples where radiation is important.
6. What is meant by having one side “controlling” the heat transfer and why is this concept important?
7. How does boiling at a surface affect the heat transfer coefficient?
8. What are the relative merits of the types of the heat exchangers discussed in Section 3.4?
9. What are the advantages and disadvantages of using water as a heating or cooling fluid?
10. Figure 3.12 shows the temperature profiles in a condenser. What would the temperature profiles look like in a reboiler with the heating source being steam or hot oil?

EXERCISES

3.1 What is the heat loss, in Btu/h-ft (W/m) from a 40 psig (2.76 barg) saturated steam line assuming an outer wall temperature of 100°F (37.8°C)? The line has an outer diameter of 8.625 in (219 mm) and there are 2 in. (50.8 mm) of insulation with a thermal conductivity of 0.03 Btu/h-ft·°F (0.05 W/m-K). Assume the inside and outside pipe wall temperatures are the same.

3.2 A heat exchanger is being designed to cool a gas stream from 140°F (60°C) to 80°F (27°C) using cooling water that enters at 60°F (15.6°C) and exits at 70°F (21°C). Assuming heat duty and overall heat transfer coefficients are constant over the temperature ranges for both gas and water, what will be the relative difference in heat transfer area required if cocurrent flow is selected instead of counter current flow?
3.3 A condensate stabilizer column has a 300°F (149°C) bottom temperature and the partially vaporized condensate leaves the reboiler at 350°F (176°C). The designed hot oil rate to the reboiler is 500,000 lb/hr (63 kg/s) and the oil temperature changes from 450°F to 360°F (232°C to 182°C). The heat capacity of the hot oil is 0.55 Btu/lb°F (2.3 J/g°C). After 6 months in service the condensate inlet and outlet temperatures are 305°F and 350°F (153°C and 177°C) and hot oil inlet and exit temperatures are 450°F and 370°F (232°C and 188°C) with a hot oil flow rate of 527,000 lb/hr (66.5 kg/s). What is the percentage change in the UA for the reboiler?

REFERENCES


Engineering Data Book, Section 11, Cooling towers, Gas Processors Suppliers Association, Tulsa, OK, 2004d.


