HEAT EXCHANGER PERFORMANCE

The purpose of this experiment is to determine the performance of a tube-in-tube type heat exchanger. The heat exchanger will be set up in both counter and parallel flow modes, with the cold water flowing through the outside tube to minimize heat exchange with the environment.

APPARATUS

The heat exchanger is supplied with both cold and hot water by two centrifugal pumps. The cold water is supplied from a reservoir, which is fed from the city main. The valve operation from the water supply to the reservoir has been automated for your convenience. However the manual faucet that supplies water from the city main should always be closed at the end of the experiment. Once the cold water circulates through the heat exchanger it is discharged to a drain. The hot water is re-circulated into a water tank with steam coils that heat the water. A valve controls the flow of steam to the coils in the heating tank.

Two pairs of thermocouples, two for the cold water (inlet and outlet) and two for the hot water (inlet and outlet) measure the temperature. The thermocouples are read in degrees Celsius with the computer data acquisition system.

Both water flows pass through rotary vane flow meters that record the amount of water passing per unit time by sending a proportional AC voltage signal. This signal is then transformed into a DC voltage, which is read by the computer data acquisition system and converted to gallons per minute.

PROCEDURE

Setup: This section is provided for students running the experiment outside the normal schedule

Open the cold water valve from the city main and fill the plastic tank. Make sure the water stops automatically when the level hits the top sensor. Check the hot water tank to make sure the water level is up to the top row of steam coils. Add water through the green hose if you need to. Open the steam valve **slowly** and be careful of steam hammer (the pipes will shake violently, crack and pop and in general create a dangerous area to stand in if the steam valve is opened too quickly, so please don't). The hot water needs to be re-circulated during heat-up, otherwise only the top few inches of the tank will be heated. When running and setting up the experiment the hot temperature of the water might soften the hoses. To avoid any water spillage, make sure the hose clamps are tight throughout the entire experiment. Be cautious with the system. Any abrupt change in water flow can cause the hoses to break loose. In order to avoid accident open and close all valves very slowly. A screwdriver is available for your convenience.

Part A: Parallel-Flow Arrangement

Make sure that the heat exchanger is setup to run in the parallel-flow arrangement with cold water in the outer tube (cold inflow on number 1 and outflow on 3, hot inflow on 2 and outflow on 4). Make sure the insulation is on the pipes. When you are ready to run the experiment, open the water valves, then turn on the pumps and adjust the flow of both the hot and the cold streams to the desired values. You can choose any flow rates you want with guidance from the TA. A good working flow rate setting is about 3.0×10^{-4} m^3/sec (4.7 gal/min) for both streams. Try to keep the water temperature for the hot supply around 50°C by adjusting the steam valve (careful the valve may be hot). Remember when adjusting the hot water temperature it takes a while for the temperature increase/decrease to be noticed at the inlet to the heat exchanger. Wait until a reasonable steady state is achieved, then record your readings. These include four temperatures and two flow rates.

Part B: Counter-Flow Arrangement

Repeat Part A for the counter-flow configuration. This case will be used as a reference since as you will see it is the most ideal arrangement. In order to transform the heat exchanger into a counter-flow system you simply switch the cold flow hoses (cold inflow on 3 and outflow on 1). Be sure to turn off both pumps. Next, detach the hoses and reattach them to the opposite connections. Use the bucket to avoid spilling water on the floor when performing this change, and make sure that the hose connections are tight before turning on the pumps. In your laboratory notes, you also need to acknowledge the hose exchange when recording your temperature readings. Wait until a reasonable steady state is achieved, then record your readings.

CALCULATIONS

1. Calculate q (actual) from the cold flow stream. Calculate q (actual) from the hot flow stream. Compare by calculating percentage difference.
2. Calculate q (max), heat exchanger effectiveness ε, and number of transfer units NTU.
3. Calculate the overall heat transfer coefficient U based on NTU. All of the tube material is copper. Total length of tubing 225 inches. Inside tube: 3/8" ID, ½" OD. Outside tube: 5/8" ID, ¾" OD.
4. Calculate the overall heat transfer coefficient U based on conduction resistance and convection resistances from empirical correlations. Compare this overall heat transfer coefficient with U based on the NTU method.
5. After completing calculations 1-4 for the parallel-flow configuration, repeat the same calculations 1-4 for the counter-flow configuration.

DISCUSSION

In your report discuss the following:

1. The accuracy of temperature and flow rate measurements.
2. The accuracy of calculated q values based on temperature and flow rate measurement errors.
3. The effect of neglecting heat exchange with the environment. Discuss differences between q values calculated from the cold and hot streams.
4. The accuracy of your estimates of h.
5. Discuss differences in the calculated overall heat transfer coefficient U using the NTU method and the resistance method.
6. Discuss differences in heat exchanger effectiveness for parallel flow and counter flow configurations.