

# Shell and Tube Heat Exchanger

## User's Manual

**Brigham Young University**

**Unit Operations Laboratory**

**Revision 97.5**

### **Introduction**

The Shell and Tube Heat Exchanger is a small model of a typical industrial heating scheme. Water is heated by steam through a single pass heat exchanger with the water on the tube side. The apparatus is connected to the [Bailey Network 90](#) which allows real-time data collection and overall process control. The apparatus is designed to allow students to perform heat transfer experiments with confidence and accuracy.

This User's Manual describes the entire experimental apparatus and gives instructions for start-up, data acquisition, and shut-down. The equipment should not be operated by anyone unfamiliar with the apparatus or these instructions because serious injury or damage could occur.

### **Experimental Apparatus**

[Figure 1](#) shows the schematic of the Shell and Tube Heat Exchanger apparatus. Water from the large Water Storage Tank is pumped through a flow regulating control valve to the shell and tube heat exchanger. The heat exchanger is a single pass exchanger with water on the tube side. Table 1 lists pertinent characteristics of the heat exchanger. Steam is obtained from the University's house steam supply to the Clyde Building. After the heat exchanger the water flows through an Anubar Flowmeter which measures the volumetric flowrate. The water then is returned to the Water Storage Tank or is diverted to the

drain. Make-up water is supplied to the Water Storage Tank by a manual valve which opens the house water supply. The best data is obtained when the level of water is above the inlet pipes so as to prevent air bubbles.

**Table 1: Characteristics of the Shell and Tube Heat Exchanger**

Manufacturer	
Model Number	
Tube Side	Water
Shell Side	Steam
# of passes	One with 1.5" baffles
# of tubes	56
Tube material	316 Stainless steel
Tube diameter	1/4" 24 gauge

The experiment is connected to the Bailey system which allows control and operation of several key process variables. Three control loops are used: the flow loop, the level loop, and the temperature loop. Depending on the operation these loops may be used independently or in conjunction with one another.

### The Flow Loop

The flow loop controls the flow of water through the heat exchanger. It is the basic level of control and should be invoked whenever the apparatus is used. The flow loop allows the operator to turn on the pump from the Bailey control terminals and regulate the volumetric flowrate. When the pump is operated the mixer automatically starts (unless the manual switch has been turned off) so caution must be exercised to ensure that all persons and other objects are out of the way. By specifying the desired flowrate the Bailey pneumatically adjusts the control valve position according to feedback received from the Anubar Flowmeter. The operator is able to see the flow variation on the Bailey control terminals. The entire 0-100% open range on the valve is available for normal use.

While the flow is essential for operation of the apparatus, the operator can choose to override the control software. This is done by changing the control valve to manual control and entering a desired percentage open of the flowvalve. This is

described in greater detail in the Startup and Data Acquisition section.

### The Level loop

The level loop controls the amount of water in the Water Storage Tank. For best operation the make-up water valve should be manually opened so that additional water is always entering the system (depending on the application desired this water may be set at full open continually). The capacitance level meter senses the water level and sends the information to the Bailey system. According to this information, the Bailey automatically adjusts the position on the drain control valve. When the water level is increasing within the tank to reach a desired setpoint, or when the water has reached the desired setpoint, the drain control valve will be closed. If the water level is above the desired setpoint, the Bailey will automatically open the drain control valve.

It is recommended that the flow loop always be used with additional make-up water entering the Water Storage Tank. This assures that there is always enough water to pump and that the tank doesn't overflow. The level control can be overridden by the operator. This is done by changing the loop to manual control then setting a desired percent open of the drain control valve. This practice is not recommended except in rare circumstances since it could result in the tank running out of water or running over.

### The Temperature loop

The temperature loop controls the temperature of the water leaving the heat exchanger. To use the temperature loop, the steam must first be turned on manually by the operator after flow has started through the heat exchanger. The steam arrives at the steam control valve completely saturated. The Bailey reads the water temperature from the thermocouple after the heat exchanger and regulates the steam pressure within the exchanger by adjusting the percent open of the steam control valve. When the actual temperature is below the desired temperature, the steam pressure within the heat exchanger will increase. The opposite is true when the outlet temperature is above the desired temperature. The pressure within the heat exchanger can only be as great as the house steam pressure on any given day.

As with the other two loops, the temperature loop can be overridden by the operator. The control may be set to manual and the steam pressure control valve be set to a certain percentage open. This allows constant steam pressure to be maintained within the heat exchanger. More information on this procedure is contained in the Startup and Data Acquisition section.

## Start Up & Data Acquisition

### A. Startup

The following steps should be taken by the students before the shell and tube heat exchanger is started.

- 1) Make sure the water tank has water in it.
- 2) Confirm that the two inch ball valve between the pump and the water tank is open.
- 3) For normal operation turn the three-way valve to connect the tank inlet and drain valve. For level control only (ChE 336) turn the three-way valve to connect the pump inlet and drain valve.
- 4) Turn on the house air supply. The air is turned on by opening the ball valve labeled **AIR** on the copper air line on the north side of the finned tube heat exchanger experiment.

**note: DO NOT turn on the steam or the inlet water (except to initially fill the tank) until the pump is on and water is flowing through the system. The steam and inlet water should be turned off before the pump is turned off!**

### B. Shut-down Procedures

- 1) Turn off the house steam supply. The steam is turned off by closing the ball valve on the steam line.
- 2) Let the equipment run several minutes to cool down.
- 3) Turn off the inlet water. The inlet water is turned off by closing the ball valve on the copper line over the water tank.
- 4) Turn off the pump.

5) Turn off the house air supply.