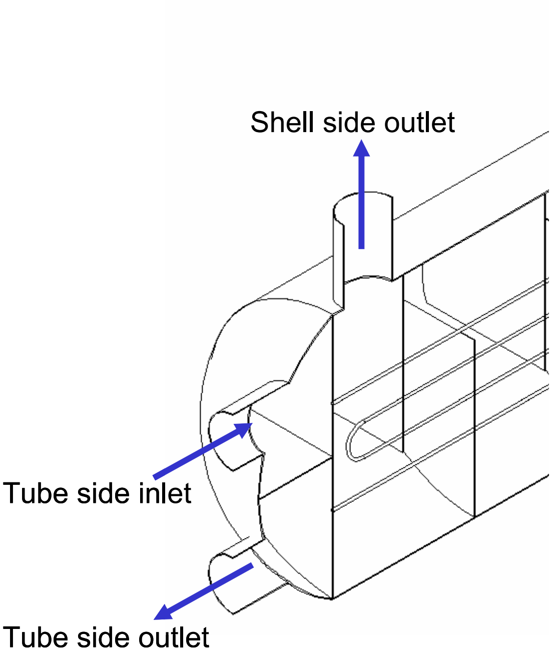
Shell and tube heat exchanger steady-state

General Industry

Challenge: The objective of the simulation is to simulate the shell and tube heat exchanger to determine the tube wall temperature variation along the flow length and the pressure difference across the tube wall.

Benefits: This case study demonstrates the steady-state thermal fluid simulation of a shell and tube heat exchanger. The shell and tube heat exchanger model can also be used in cycle analysis where it is used in conjunction with other models (See “Start-up of two-shaft High-Temperature Gas-Cooled Nuclear Power plant” case study).

Solution: The thermal fluid steady-state simulation of a shell and tube heat exchanger was discussed. The results provided for the incremented heat exchanger network can be used to do material selection or assess the design of a heat exchanger under certain conditions.



General Industry

Shell and tube heat exchanger – steady-state

Introduction

This case study demonstrates the steady-state thermal fluid simulation of a shell and tube heat exchanger. The shell and tube heat exchanger model can also be used in cycle analysis where it is used in conjunction with other models (See "Start-up of two-shaft High-Temperature Gas-Cooled Nuclear Power plant" case study).

System Description

The thermal hydraulic conditions of a typical shell and tube heat exchanger are simulated. Figure 1 shows a schematic of a typical shell and tube heat exchanger. It is assumed that the outside of the heat exchanger is adiabatic.

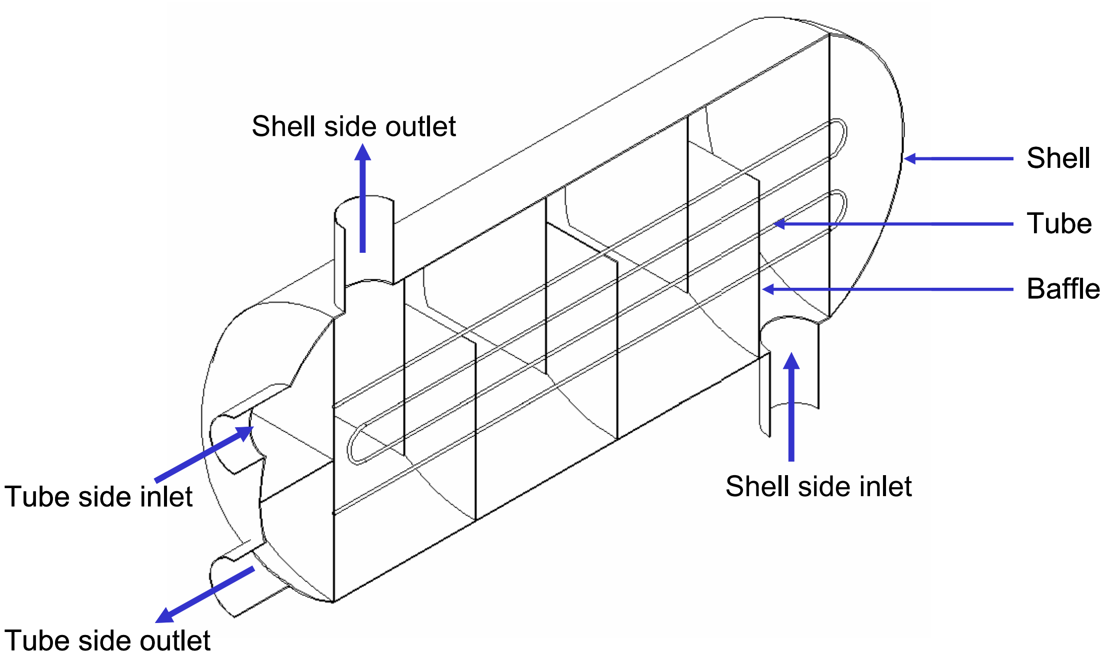


Figure 1: Schematic layout of a typical shell and tube heat exchanger.

Objective of simulation

The objective of the simulation is to simulate the shell and tube heat exchanger to determine the tube wall temperature variation along the flow length and the pressure difference across the tube wall.

Flownex model

The Flownex model on the graphical user interface is shown in Figure 2.

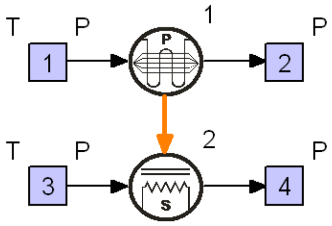


Figure 2: **Flownex shell and tube heat exchanger graphical user interface representation.**

The Flownex shell and tube heat exchanger model is a distributed model that is build up from an integrated network of one-dimensional elements. These elements represent either the flow paths on the shell or tube side or the heat transfer from the fluid on the tube side, through the tube wall to the fluid on the shell side. In Figure 3 it is shown that each intersection between the shell side fluid path and the tube side fluid path is considered as a control volume and the typical element network of a single control volume is shown. The thermal inertia of the solid tube wall material and fluid volume are taken into account in the modeling of transient simulations.

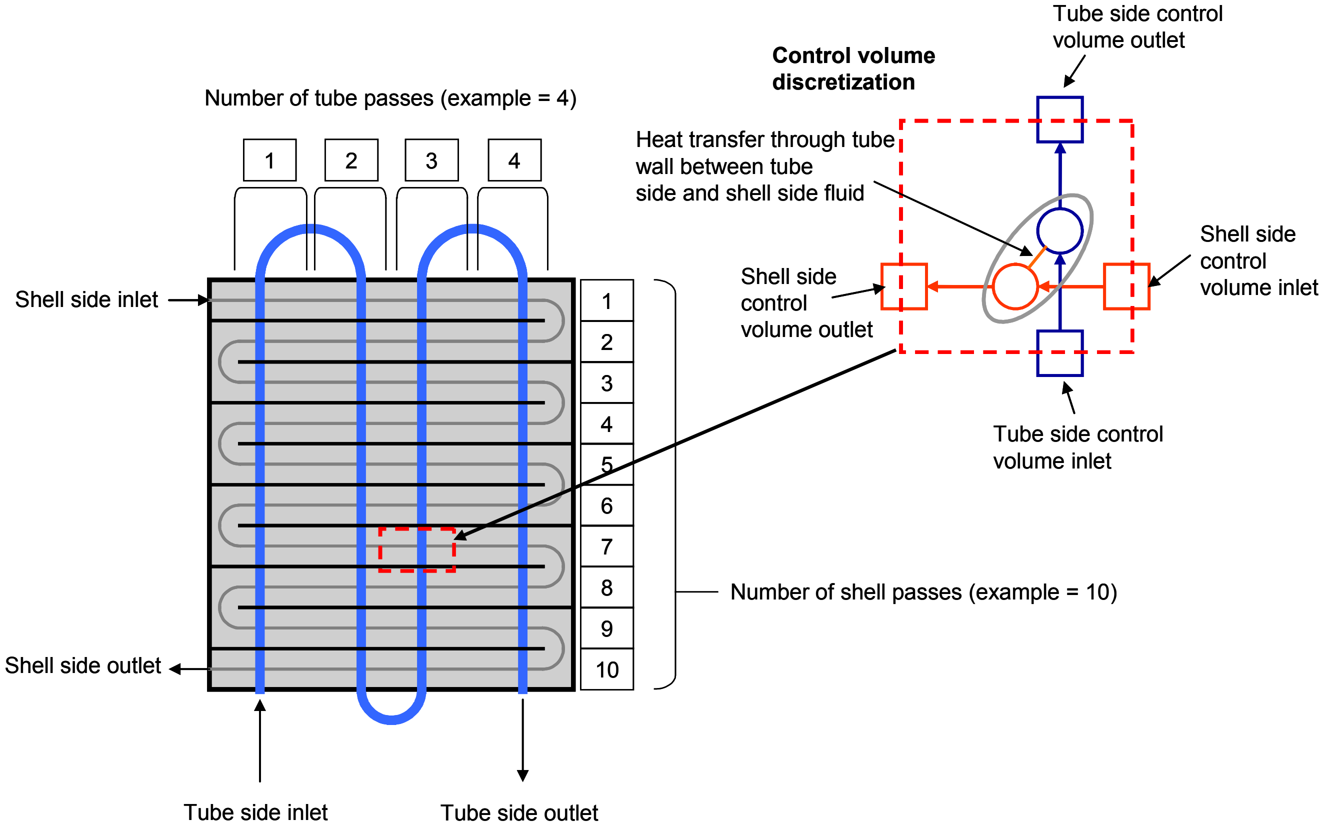


Figure 3: **Discretised Flownex shell and tube heat exchanger model.**

Description of simulation

In this case a shell and tube heat exchanger with four tube passes (120 tubes per pass) and five shell side passes were simulated. Both sides use air as working fluid. The inlet temperature and pressure of the air on the shell side is 150 °C and 350 kPa respectively. The inlet temperature and pressure of the air on the tube side is 30 °C and 350 kPa respectively. The shell side has a pressure drop of 50 kPa and the tube side has a pressure drop of 10 kPa.

Results

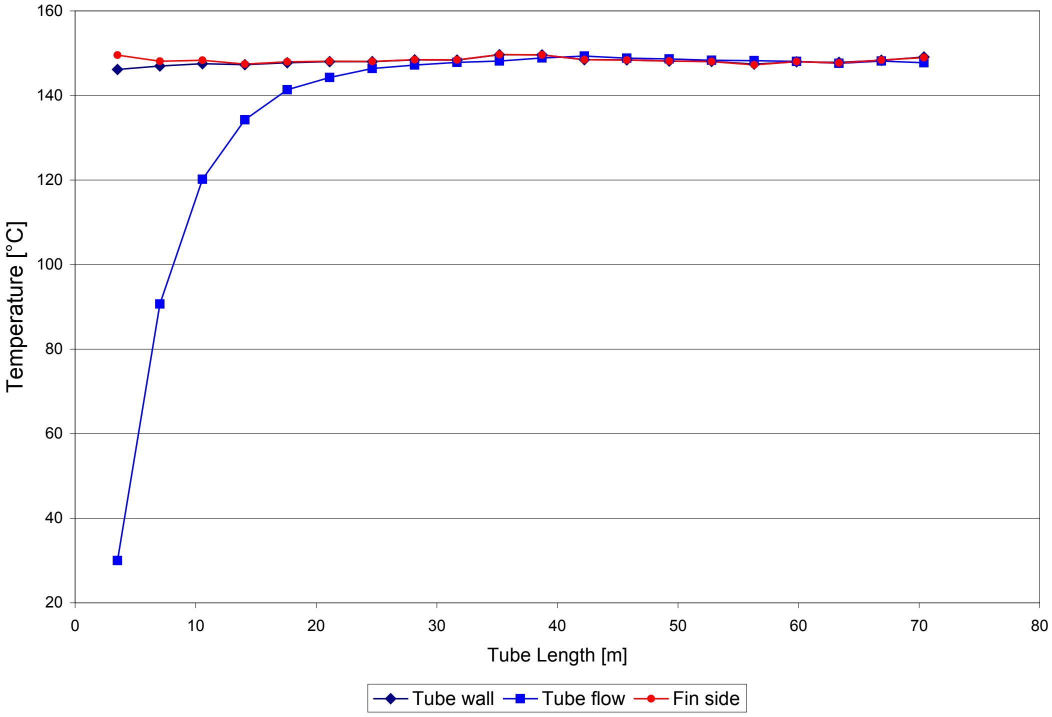


Figure 4: **Temperature distribution along the flow length of the tube.**

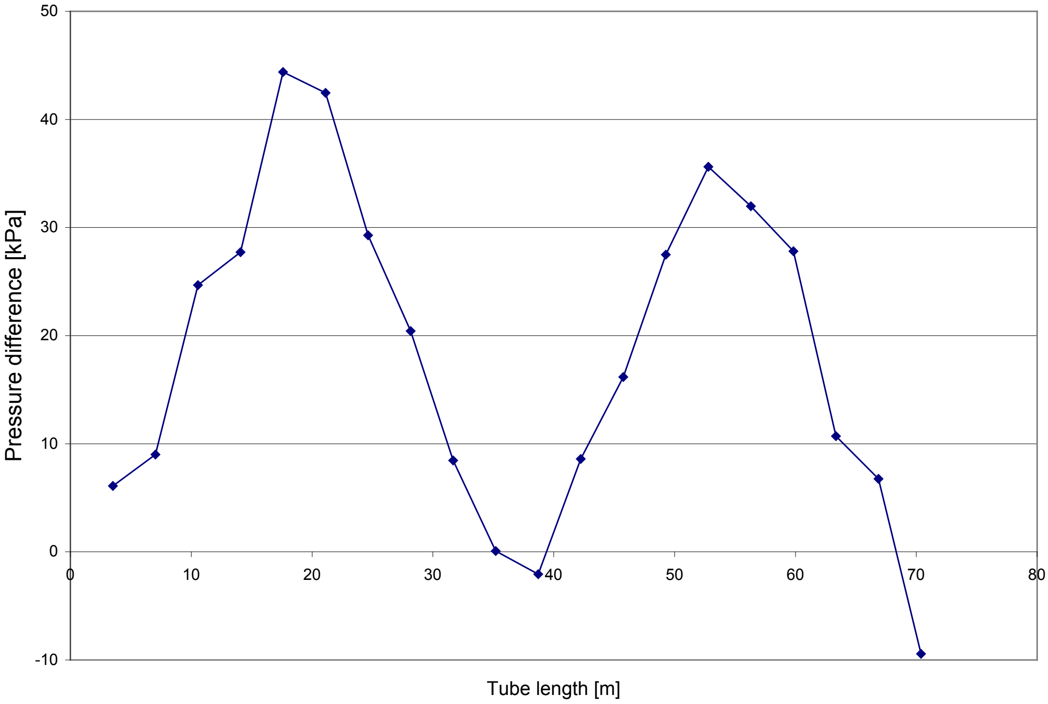


Figure 5: **Pressure difference across tube wall along the tube length.**

The temperature distribution of the air on the shell side, the tube wall and the air on the tube side (along the flow length of one of the parallel tubes) is presented in Figure 4. It can be seen that from about tube length 30 m onwards no effective heat transfer occurs and that the heat exchanger seems too big for the heat duty specified in the simulation. The pressure difference across the tube wall, along the length of the tube, is shown in Figure 5. These typical results will determine whether the tube material and/or thickness are sufficient to handle the pressure and temperature constraints.

Conclusion

The thermal fluid steady-state simulation of a shell and tube heat exchanger was discussed. The results provided for the incremented heat exchanger network can be used to do material selection or assess the design of a heat exchanger under certain conditions.

Flownex® International,
Global Headquarters
+27 (0) 18 297 0326/7
www.flownex.com

Australia	+61 3 8790 1087	Poland	+27 11 782 3895
China	2 164 821 011	Singapore	+65 67 32 9818
Greece	+30 231 0 251 731	South Africa	+27 12 809 9500
India	+91 08 042 151 310	Turkey	+90 312 432 37 85
Israel	+972 3 920 6303	United Kingdom & Europe	+44 08 450 772 810
Japan	+81 44 230 5121	United States & Canada	+11 (781) 993-9003
Korea	+82 22 051 2305		