Thermal Design
Louisiana Tech University
Mechanical Engineering Program
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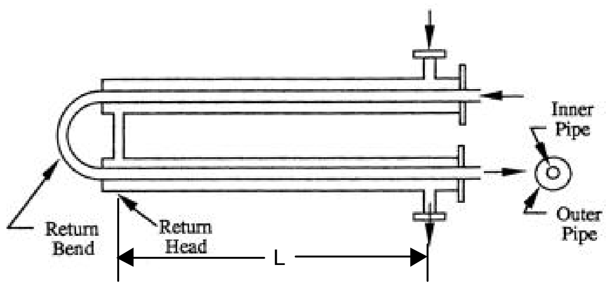
Design Project #3

MEEN 451 Design of a Double-Pipe Heat Exchanger Fall 99

The double-pipe heat exchanger is simple in concept, yet is used quite frequently in the process industries due to its versatility. The principle parts of the double-pipe heat exchanger, as shown below, are two sets of concentric pipes, two connecting tees, a return head, and a return bend.



The inner pipe is supported within the outer pipe by packing glands, and the fluid enters the inner pipe through a threaded or flanged connection located outside the heat exchanger section proper. The two pairs of concentric pipes are connected by the return bend and return head to form the complete heat exchanger, often called a hairpin. This arrangement is used because of the convenience it affords for manifolding the streams. This is particularly advantageous when multiple units are used, since all inlets and outlets are at the same end of the unit. In addition, the hairpins of a group of double-pipe heat exchangers do not have to have the same length. The loop construction also provides for thermal expansion between the inner and outer pipe.

Some standard sizes for double-pipe heat exchangers are given in the following table.

Inner Pipe Nominal	Outer Pipe Nominal	Inner Pipe i.d.(in)	Inner Pipe o.d.(in)	Outer Pipe i.d. (in)	Outer Pipe o.d.(in)
1¼	2	1.380	1.660	2.067	2.375
2	3	2.067	2.375	3.068	3.500
2½	4	2.469	2.875	4.026	4.500
3	4	3.068	3.500	4.026	4.500
3½	6	3.548	4.000	6.025	6.625
4	6	4.026	4.500	6.065	6.625

Problem Statement

A double-pipe heat exchanger is being considered for service to preheat light oil used for a process in a chemical plant. The plant uses cogeneration to provide electricity for the plant as well as a source of process heat so there is an ample supply of steam/hot water to use for such applications. When steam is used as the heating fluid in such an application, it may enter the heat exchanger as a superheated or saturated vapor. It is desirable to design the heat exchanger such that the steam exits after fully condensing (i.e., a saturated or subcooled liquid). Therefore, it is possible for the steam to undergo three heat transfer zones (desuperheating, condensing, and subcooling), two zones (desuperheating and condensing or condensing and subcooling), or only one zone (codensing only) depending on its inlet and exit conditions.

Design a double-pipe heat exchanger (or set of exchangers connected in series) to heat the oil from 100^{o}F to 150^{o}F for a mass flow rate of 8 lbm/s. Steam in a saturated state at 300^{o}F is the fluid in the annular region. Assume that the mass flow rate of the steam is such that it exits the heat exchanger as a saturated liquid. This results in a single heat transfer zone for the heat exchanger (condensing only). The pressure drop across the inner pipe (oil side) should be less than 8 psig. There is no pressure drop restriction on the steam side. The heat exchanger is to be constructed using steel pipe (k = 25 Btu/hr-ft-^{o}F). The hairpins are assumed to be available in 10, 12, and 15-foot lengths, where this dimension represents the heat exchange length for a single one-way pass (L in the figure). The exchangers are to be mounted horizontally in series and only one hairpin length may be used for all of the heat exchangers in the entire series.

For the final DESIGN specify the following: standard sizes for the double pipes, the number of legs, the total heat transfer rate (assuming that the outer shell is insulated), the required steam mass flow rate, pump power requirements for the oil side and a complete drawing of the heat exchanger. The floor space occupied by the heat exchanger should be minimized. As always, state all assumptions in the design calculations.

Additional Information

The equivalent length for a single hairpin (180^{o} turn) is equal to 60D_i, where D_i is the inside diameter of the inner pipe.