Fundamentals of Heat Transfer

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Figure taken from: http://heatexchanger-design.com/2011/10/06/heat-exchangers-6/ Dated: 17-Jan-2012

Problem-8

Steam at 250 ^oF flows in an insulated pipe. The pipe is mild steel and has an inside radius of 2.0 in and an outside radius of 2.25 in. The pipe is covered with a 1.0 in layer of 85% magnesia. The inside heat transfer coefficient, h_i is 15 Btu/h.ft^2.^oF, and the outside heat transfer coefficient, h_o is 2.2 Btu/h.ft^2.^oF. Determine the overall heat transfer coefficient, U_o, and the heat transfer rate from the steam per foot of pipe length, if the surrounding air temperature is 65 ^oF. Use thermal conductivity of mild steel and 85% magnesia as 24.8 and 0.041 Btu/h.ft.^oF respectively.

Problem-9 [p. 250, 1]

Saturated steam at 35.42 psia is flowing inside a ¾ in steel pipe having an ID of 0.824 in and OD of 1.050 in. The pipe is insulated with 1.5 in of insulation on outside. The convective coefficient for the inside steam surface of the pipe is estimated as h_i = 1000 Btu/h.ft^2.^{o}F, and the convective coefficient on the outside of the lagging is estimated as h_o = 2.0 Btu/h.ft^2.^{o}F. The mean thermal conductivity of the metal is 26.0 Btu/h.ft.^{o}F and 0.037 Btu/h.ft.^{o}F for the insulation.

a) Calculate the heat loss for 1.0 ft of pipe using resistances if the surrounding air is at 80 ^{o}F.

b) Calculate inside and overall heat trasfer coeffcient. What are the values of heat rates per foot of pipe using U_i and U_o.

A part of saturated steam table [859, 1]

Temperature (°F)	Vapor Pressure (psia)	Specific Volume (ft^3/lb_m)		Enthalpy (btu/lb_m)		Entropy ($btu/lb_m \cdot °F$)	
		Liquid	Sat'd Vapor	Liquid	Sat'd Vapor	Liquid	Sat'd Vapo
60	0.2563	0.016035	1206.9	28.08	1087.7	0.05555	2.0943
65	0.3057	0.016042	1021.5	33.09	1089.9	0.06514	2.0791
70	0.3622	0.016051	867.7	38.09	1092.0	0.07463	2.0642
75	0.4300	0.016061	739.7	43.09	1094.2	0.08402	2.0497
80	0.5073	0.016073	632.8	48.09	1096.4	0.09332	2.0356
85	0.5964	0.016085	543.1	53.08	1098.6	0.10252	2.0218
90	0.6988	0.016099	467.7	58.07	1100.7	0.11165	2.0083
95	0.8162	0.016114	404.0	63.06	1102.9	0.12068	1.9951
100	0.9503	0.016130	350.0	68.05	1105.0	0.12963	1.9822
110	1.2763	0.016166	265.1	78.02	1109.3	0.14730	1.9574
120	1.6945	0.016205	203.0	88.00	1113.5	0.16465	1.9336
130	2.225	0.016247	157.17	97.98	1117.8	0.18172	1.9109
140	2.892	0.016293	122.88	107.96	1121.9	0.19851	1.8892
150	3.722	0.016343	96.99	117.96	1126.1	0.21503	1.8684
160	4.745	0.016395	77.23	127.96	1130.1	0.23130	1.8484
170	5.996	0.016450	62.02	137.97	1134.2	0.24732	1.8293
180	7.515	0.016509	50.20	147.99	1138.2	0.26311	1.8109
190	9.343	0.016570	40.95	158.03	1142.1	0.27866	1.7932
200	11.529	0.016634	33.63	168.07	1145.9	0.29400	1.7762
210	14.125	0.016702	27.82	178.14	1149.7	0.30913	1.7599
212	14.698	0.016716	26.80	180.16	1150.5	0.31213	1.7567
220	17.188	0.016772	23.15	188.22	1153.5	0.32406	1.7441
230	20.78	0.016845	19.386	198.32	1157.1	0.33880	1.7289
240	24.97	0.016922	16.327	208.44	1160.7	0.35335	1.7143
250	29.82	0.017001	13.826	218.59	1164.2	0.36772	1.7001
260	35.42	0.017084	11.768	228.76	1167.6	0.38193	1.6864
270	41.85	0.017170	10.066	238.95	1170.9	0.39597	1.6731
280	49.18	0.017259	8.650	249.18	1174.1	0.40986	1.6602

Problem-10 [?]

Study the effect of inside film coefficient on the overall heat transfer coefficient when heat is transferred from a plane wall of Cu with a thickness of 0.1 in. The inside fluid and outside fluid temperatures are 200 ^{o}C and 100 ^{o}C respectively. The outside heat coefficient is reported to be 200 Btu/h.ft^{2}.^{o}F.

Problem-11 [p. 28, 8]

The inside temperature of a furnace is 2400 ^oF and outside wall temperature is 100 ^oF. the furnace wall is made up of 9 in chrome brick, 4.5 in fire brick and 4.5 in of masonry brick. The convective heat transfer coefficient at the inside and outside furnace walls are 10 Btu/h.ft^2.^oF and 1.0 Btu/h.ft^2.^oF respectively. Compute the following:

1. Overall heat transfer coefficient
2. Rate of heat transfer per unit area
3. The surface temperature at each layer of brick
4. Ascertain, if, the temperature of the fire brick is within the allowable limit 2000 ^oF.

Use k_{chrome} = 0.96 Btu/h.ft.^oF, k_{fire} = 0.183 Btu/h.ft.^oF, and $k_{masonary}$ = 0.96 Btu/h.ft.^oF.

Homework problems

Problems 4.3-6, 4.3-7, 4.3-8, 4.3-9, 4.3-10 [p. 346, 1]

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