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| Mansoura university | Final Examination |
| Faculty of Engineering | Heat and Mass Transfer |
| Biomedical Engineering | Time allowed 2 hours |

**Attempt all question**

**Tables are allowed**

**Question 1**

Steam at 235°C is flowing inside a steel pipe (k =61 W/m°C) whose inner and outer diameters are 10 cm and 12 cm, respectively, in an environment at 20°C. The heat transfer coefficients inside and outside the pipe are 105 W/m°C and 14 W/$m^2$ °C, respectively. Determine (a) the thickness of the insulation (k = 0.038 W/m°C) needed to reduce the heat loss by 95 percent and (b) the thickness of the insulation needed to reduce the exposed surface temperature of insulated pipe to 40°C for safety reasons.

**Question 2**

A 15-cm by 20-cm hot surface at 85°C is to be cooled by attaching 4-cm-long aluminum (k = 237 W/m °C) fins of 2-mm 2-mm square cross section. The temperature of surrounding medium is 25°C and the heat transfer coefficient on the surfaces can be taken to be 20 W/$m^2$ °C. If it is desired to triple the rate of heat transfer from the bare hot surface, determine the number of fins that needs to be attached.

**Question 3**

A thin-walled double-pipe parallel-flow heat exchanger is used to heat a chemical whose specific heat is 1800 J/kg · °C with hot water (C= 4180 J/kg · °C). The chemical enters at 20°C at a rate of 3 kg/s, while the water enters at 110°C at a rate of 2 kg/s. The heat transfer surface area of the heat exchanger is 7 $m^2$ and the overall heat transfer coefficient is 1200 W/$m^2$ °C. Determine the outlet temperatures of the chemical and the water.

**Question 4**

Using $\pi$ theorem to find a dimensionless relation of heat transfer (h) in case of natural convection if it depends on viscosity $\mu$ , density $\rho$, gravitational acceleration g, coefficient of volumetric thermal expansion $\beta$, conductivity k, temperature difference $\Delta T$, length L, specific heat cp.

Best wishes for you Prof. Ahmed Sultan