THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

3007 Heat Transfer and Power Transmission

November 2002

Time: Three hours and 10 min.

Candidates are encouraged to read the complete exam before answering any questions.

Candidates are required to answer **ALL SEVEN** questions in this paper.

The use of notes, textbooks and calculators are permitted.

Question 1

You are to design a multi-disk clutch with a design torque of 200 Nm. Due to various physical restraints, the inside and outside disk diameters must be 60 mm and 100 mm respectively. The clutch housing you are supplied with can accommodate a maximum of seven disks. Additionally, the maximum axial clamping force that can be applied to the disks is 12.0 kN. Assume uniform wear condition.

Determine p_{max} and f, and hence select an appropriate friction material for this application.

[5 marks]

Question 2

A 7500W normal torque electric motor running at 1750 rpm is to be used to drive a small rotary pump which operates 24 hours a day. The pump should run at approximately 1175 rpm. The centre distance should not exceed 1.10m. Space restrictions limit the diameter of the driven sheave to 280mm. You are required to design a V-belt drive for this system. Determine the diameter of the smaller sheave (assuming it must be a "first choice" preferred size), the belt section and length, and the number of belts required.

[20 marks]

Question 3

A cast iron spur pinion has a module of 1.25mm, 18 teeth cut on the 25° full-depth system, and a face width of 12mm. You may assume that the mountings are not completely rigid, but contact occurs across the full face. At a speed of 1800 rpm, this pinion is expected to carry a steady load of 0.5 kW. Determine the resulting stress at the base of the pinion teeth.

[10 marks]

Question 4

A single-strand No. 60 ISO Type A roller chain is used to transmit power between a 13-tooth driving sprocket rotating at 300 rpm and a 52 tooth driven sprocket. Determine the centre distance between the sprockets if the chain length is 82 pitches.

[5 marks]

Question 5

In an industrial plant in Adelaide a combustion furnace causes concerns due to its heat transfer with the surroundings. Various options for insulation are discussed.

a) describe the difference in heat transfer through the furnace wall with and without an insulation layer; **[5 marks]**

The metal furnace wall has an external temperature of 990°C. The decision was made to insulate the furnace wall with two layers, the first layer being mineral wool and the second layer fiberglass boards. The outside of the insulation is exposed to an environment with h=14 W/m^2·°C and a T_∞ = 37°C. *(Assume that the outside temperature of the metal wall does not change in this process)*

b) calculate the thickness of the two insulating layers so that the interface between the two layers is 400°C. and the outside temperature of the fiberglass boards is 55°C; **[9 marks]**

c) calculate the heat loss from the insulated wall in W/m^2. **[6 marks]**

Question 6

a) Explain the mechanism of forced convection and the role the Reynolds number plays in this mechanism; **[3 marks]**

Unused engine oil at 25°C flows in a large pipe with a diameter of 50 cm. The pipe is subjected to strong, icy winds of 15m/s with temperatures of -15°C.

b) calculate the heat loss per meter of pipe length; **[7 marks]**

c) how much heat transfer is required to reduce the temperature of the oil by 8°C; *(assume a Reynolds number for the oil flowing in the pipeline of 16)* **[6 marks]**

c) calculate the convection heat transfer coefficient h for the oil flow in the pipeline. **[4 marks]**

Question 7

In the paper production industry, double-pipe heat exchangers are commonly used for heat recovery. In the present case a mass flow of water of 0.05 kg/s needs to be heated up from 29 to 91°C. The heating fluid is warm oil *(take values for "engine oil unused")* at a temperature of 165°C and a mass flow rate of 205 kg/h.

a) explain the differences between "mixed" and "unmixed" heat exchangers. Which type would you use in the present case (explain your answer) ? **[5 marks]**

b) calculate the exit temperature of the oil leaving the heat exchanger; **[5 marks]**

c) what heat exchanger area *A* is needed to fulfil the requirements ? **[7 marks]**

d) describe the difference in temperature profiles for a parallel flow and counter flow double-pipe heat exchanger. Which one would you use in the present case (explain your answer)? **[3 marks]**

END OF EXAMINATION PAPER