THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

4813 Heat Transfer and Power Transmission
6790 Mechanical Design and Heat Transfer

November 2000

Time: Three hours

Candidates are also allowed 10 minutes to read the paper before examination begins.

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

The use of notes, textbooks and calculators are permitted.

QUESTION 1

A woven cotton flat belt drive is required to connect a grinding machine to a low starting torque 3000 rpm electric motor. The grinding machine is to run at approximately 25000 rpm. Assume a belt thickness of 0.5mm.

(a) Select suitable steel pulley diameters. [8 marks]

(Hint: start by using $V_{opt} = \sqrt{\frac{\sigma_d}{3\rho}}$)

(b) Select a suitable belt width to satisfy the maximum grinder power requirement of 1 kW. Assume a pulley centre distance of 0.8m. [12 marks]

(c) Calculate the required initial belt tension. [8 marks]

QUESTION 2

A single stage reduction gearbox is to be used to connect a six cylinder engine with a maximum speed of 1600 rpm to a propeller which is to have a corresponding maximum speed of 400 rpm. Assuming that the pinion and gear are both full-depth involute spur gears with a pressure angle of 20°, and the pitch line velocity is not to exceed 7.0 m/s, calculate:

(a) The maximum allowable pinion and gear pitch circle diameters, and the corresponding number of teeth on the gear, assuming 18 teeth on the pinion. [6 marks]

(b) The module, the circular pitch and the diametral pitch (adjust the PCD of the pinion and gear to give a standard module if necessary). [5 marks]

(c) The addendum, dedendum and tooth clearance. [2 marks]

QUESTION 3

A flat steel plate is heated by an electric current. The electric current produces a heat source of $\dot{q} = 88{,}780 kW/m^3$ along the flat steel plate which is 1.25cm thick and 10cm wide. The temperature of one surface of the plate is 80°C and that of the other is 95°C.

a) give the equation for Fourier's Law of Heat Conduction (one-dimension, steady-state with heat generation). Figure 1 (next page) shows the temperature distribution for this equation. Sketch the temperature distribution for Fourier's Law of Heat Conduction (one-dimension, steady-state *without* heat generation). [6 marks]

b) Find the temperature distribution across the plate, and the value and position of the maximum temperature. [9 marks]

c) Calculate the total amount of heat generated per meter length of plate and the flow of heat from each surface of the plate. [6 marks]

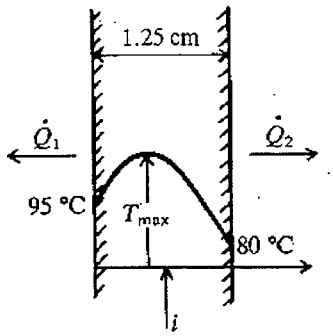

Figure 1

Note: The end effects along the short sides of the plate may be neglected, i.e. it may be assumed that no heat flows across these surfaces. It may also be assumed that the heat source is generated uniformly across the section. The thermal conductivity of the steel is k=54W/mK.

QUESTION 4

a) Explain the Nusselt Number and Prandtl number and the role they play in convection heat transfer. [4 marks]

An irrigation system in the Barossa valley uses pipes of 0.02m diameter to carry water at a temperature of 19°C. In the summer season warm winds of 30 m/s and 45°C blow across these water pipes.

b) how much heat transfer is required to heat the water in the pipe to 35°C ? Assume the Reynolds number for the water flow in the pipe is 15. [5 marks]

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

d) calculate the heat transfer per meter length of the pipe from the warm wind to the water pipe. [6 marks]

QUESTION 5

A company in Adelaide wants to buy a double-pipe heat exchanger for their production plant. The heat available is from warm oil (take values for engine oil unused) at a temperature of 160°C and a mass flow rate of 175 kg/h. This waste heat will be used to heat up water from 25 to 87°C. The mass flow rate of water is 155 kg/h.

a) explain the differences between "mixed" and "unmixed" heat exchangers. Which type would you use in the present case (explain your answer) ? [4 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