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 2001

Time: Three hours and 10 min.

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

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

The use of notes, textbooks and calculators are permitted.

Question 1

A V-belt is to be used to transmit 30 kW between two shafts. A service factor of 1.3 can be assumed. The driving shaft has a sheave diameter of 200 mm and rotates at 1200 rpm. The driven shaft is required to rotate at 600 rpm.

a) Select a suitable belt section, based on the design power and the speed of the faster shaft.

b) Calculate the diameter of the larger sheave.

c) Calculate the belt speed. Is it acceptable?

d) A standard V-belt in the required section with a pitch length of 1800 mm is available. Calculate the distance between the centres of the sheaves. Check that is it acceptable.

e) Determine K_1, K_2 and K_3.
Note: you may round (D-d)/C off to one decimal point when determining K_3. Interpolation is not necessary.

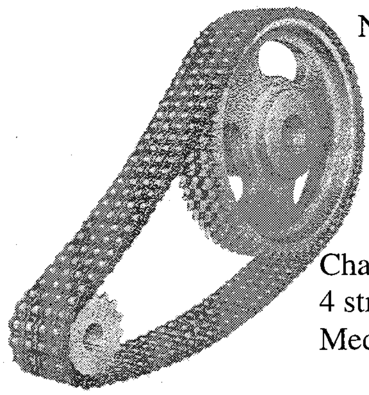
f) Calculate the rated power per belt.

g) How many belts are required?

[23 marks]

Question 2

A 9 kW electric motor drives the smaller sprocket in the chain system shown below at 1400 rpm. It experiences heavy shock conditions.



a) Select suitable values for K_1, K_2, and K_S.

b) Calculate the design power, H_D.

c) Select a suitable medium-pitch ISO Type A chain.

d) Find the chain pitch, and hence calculate the average chain velocity.

[8 marks]

Question 3

A multiple-disk clutch with a *design torque* of 650 Nm uses dry rigid moulded asbestos as its friction material. Due to various physical restraints, the inside disk diameter must be 100 mm, and the maximum axial clamping force that can be applied to the disks is 10.0 kN. Assume uniform wear condition.

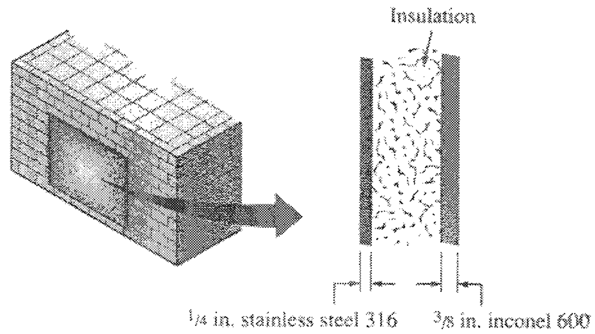
a) Determine the minimum outside disk diameter.

b) Using the value for outside diameter determined in (a), calculate the number of disks required.

[9 marks]

Question 4

The door for an industrial gas furnace is 2m x 4m in surface area and is to be insulated to reduce heat loss to no more than 1200 W/m^2. The door is shown in the Figure below. The interior surface is 3/8 inch thick Inconel 600 sheet, and the outer surface is ¼ inch thick sheet of stainless steel 316. Between these metal sheets a suitable thickness of insulation material is to be placed. The effective gas temperature inside the furnace is 1150°C, and the overall heat transfer coefficient between the gas and the door is $h=20W/m^2K$. The heat transfer coefficient between the outer surface of the door and the surroundings at 20°C is $h=5W/m^2K$. Neglect the influence of radiation.



Furnace Door Cross Section

a) Explain briefly the two modes of heat transfer involved and draw the electrical analog for the present system; **[5 marks]**

b) Assuming k= 25 W/mK for both sheets of metal, select a suitable insulation material and its thermal conductivity k to calculate the required thickness of the insulation. **[10marks]**

Question 5

For high altitude research a horizontal, cylindrical vessel with a diameter of 1.25m and a length of 2.15m is to be designed. The vessel can be used at altitudes where the ambient pressure is 1.2kPa and the ambient temperature is -52°C. The outside surface temperature of the horizontal cylinder is at approximately 2.5°C.

a) Explain the difference between free and forced convection. What role does the density of the air play in convection heat transfer in the case described above.
[5 marks]

b) Calculate the free-convection heat loss from the outside of the vessel.
[8 marks]

c) How does this compare with the forced-convection heat loss from such a cylinder with a free-stream velocity of approximately 76cm/s ? **[7 marks]**

Question 6

Water at the flow rate of 3.3 kg/s is heated from 36°C to 55°C in a shell and tube heat exchanger. On the shell side, one pass is used with water as the heating fluid (1.75kg/s), entering the exchanger at 93°C. The overall heat transfer coefficient is 1420 $W/m^2 \cdot °C$, the average water velocity in the d=1.8-cm-diameter tubes is 0.35 m/s. The area per meter length of one tube can be calculated as $\pi \cdot d$.

a) Describe the basic principle and the temperature distribution inside a shell-and-tube heat exchanger. Explain briefly the terms "shell" and the "tube";
[6 marks]

b) Calculate the area of the heat exchanger using one tube pass and determine the length of the tubes; **[9 marks]**

c) Calculate the required number of tube passes, the number of tubes and the length of the tubes, if the length of the tubes is restricted to less than 2.15m (you may need to iterate to obtain the final solution)? **[10 marks]**

END OF EXAMINATION PAPER