淡江大學九十一學年度碩士班招生考試試題

系別：化學工程學系

科目：輸送現象與單元操作

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1. Figure 1 shows a concrete tank that is to be filled with water from an adjacent river in order to provide a supply of water for the sprinklers on a golf course. The level of the river is $H = 10ft$ above the base of the tank, and the short connecting pipe, which offers negligible resistance, discharges water at a height $D = 4ft$ above the base of the tank. The inside cross-sectional area of the pipe is $a = 0.1ft^2$, and that of the tank is $A = 1{,}000ft^2$. Derive an algebraic expression for the time t taken to fill the tank, and then evaluate it for the stated conditions. (20%)

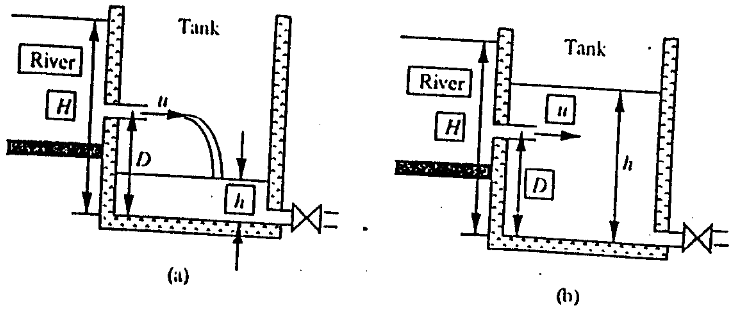

Fig. 1 Tank filling from water: (a) before pipe is submerged; (b) after pipe is submerged.

2. Two different series/parallel arrangements of three identical centrifugal pumps are shown in Fig. 2. The head increase Δh across a single such pump varies with the flow rate Q through it according to:

$$\Delta h = a - bQ^2 .$$

Derive expressions for the head increases $\Delta h_{(a)}$ and $\Delta h_{(b)}$, in terms of a, b and the total flow rate Q, for these two configurations. Sketch your results on a graph, also including the performance curve for the single pump. (20%)

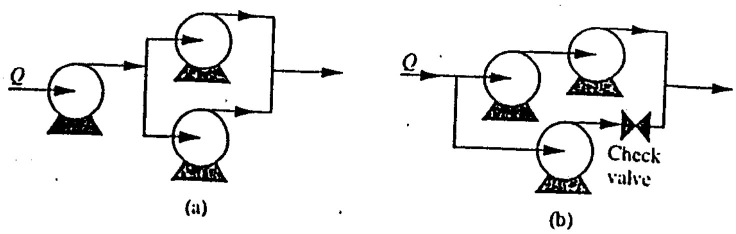

Fig. 2 Series/parallel pump arrangements.

3. Derive the equation for steady-state laminar flow inside the annulus between two concentric horizontal pipes, as shown in Fig. 3. The fluid is incompressible and viscosity μ is a constant. The flow is driven in one direction by a constant-pressure gradient. Does the maximum velocity occur halfway between the inner and outer cylinders, or at some other location? (20%)

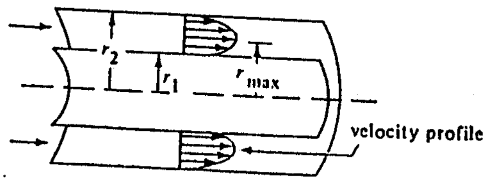

Fig. 3 Flow through a cylindrical annulus.

4. A heavy hydrocarbon oil which has $c_{p,oil} = 2300\, J/kg \cdot K$ is being cooled in a heat exchanger from $371.9K$ to $349.7K$ and flow inside the tube at a rate of 3630 kg/hr. A flow of 1450 kg water/hr enters at 288.6K for cooling and flow outside the tube ($c_{p,water} = 4178\, J/kg \cdot K$).(20%)

(a) Calculate the water outlet temperature and heat-transfer area if the overall $U_i = 340\, W/m^2 \cdot K$ and the streams are countercurrent.
(b) Repeat for parallel flow.

5. Saturated steam at $267^{\circ}F$ is flowing inside a steel pipe having an ID of 0.824 $in.$ and an OD of 1.050 $in.$ The pipe is insulated with 1.5 $in.$ of insulation on the outside. The convective coefficient for the inside steam surface of the pipe is estimated as $h_i = 1000\, btu/hr \cdot ft^2 \cdot {}^{\circ}F$, and the convective coefficient on the outside of the lagging is estimated as $h_o = 2\, btu/hr \cdot ft^2 \cdot {}^{\circ}F$. The mean thermal conductivity of the metal is $26\, btu/hr \cdot ft \cdot {}^{\circ}F$ and $0.037\, btu/hr \cdot ft \cdot {}^{\circ}F$ for the insulation. Calculate the heat loss for 1 ft of pipe if the surrounding air is at $80^{\circ}F$. (20%)