**22.312 ENGINEERING OF NUCLEAR REACTORS**

# PROBLEM 9-8N

## PUMP SEIZURE IN A SINGLE-PHASE LOOP

A water flow loop is used to generate heat transfer and pressure drop data in single-phase flow. The loop, shown in Figure 1, operates at atmospheric pressure and consists of four identical round tubes of 3 cm ID and 4 m length. The fluid is heated to 60°C at the bottom of the right vertical tube and cooled down to 20°C at the top of the left vertical tube. The relative elevation of the thermal centers of the heated and cooled sections is 3.5 m. The properties of water in the temperature range of interest are reported in Table 2.

At normal operating conditions, the fluid is circulated by a pump with a characteristic curve described by the following equation:

$$\Delta P_{pump} = a(1 - \frac{\dot{m}}{b})$$

where $\Delta P_{pump}$ is the pump head, $\dot{m}$ is the mass flow rate, a=1 kPa and b=1.3 kg/s.

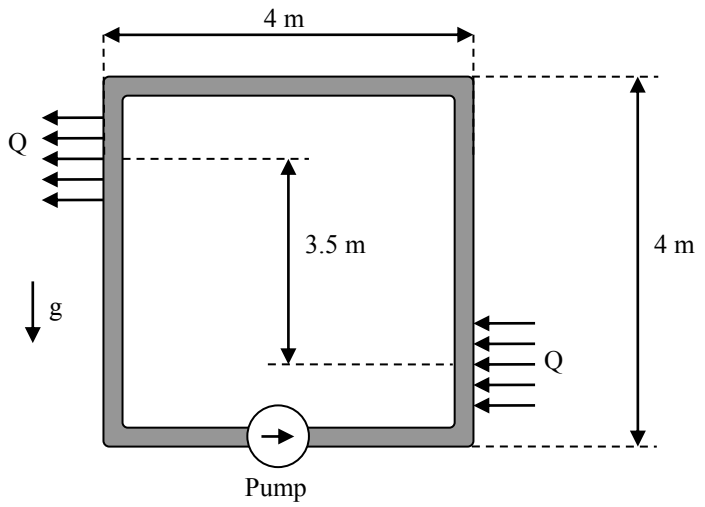


**Figure 1. Schematic of the flow loop.**

i) Calculate the mass flow rate in the loop at steady-state.
ii) Now suppose that at t=0 a pump seizure occurs, so that the pump head vanishes instantaneously. Calculate the mass flow rate in the loop for t>0. (*Hint:* assume

that during the transient the control system maintains the same temperatures of the steady-state situation)

*Assumptions:*

- Neglect the acceleration terms and form terms in the momentum equation.
- To calculate the friction pressure drop, use $f = 0.316/Re^{0.25}$.
- To calculate the gravity term, use the Boussinesq assumption.

**Table 1. Water properties in the temperature range of interest.**

| **Parameter** | **Value** |
|---|---|
| $\rho_\ell$ | 992.2 kg/m$^3$ |
| $C_{p\ell}$ | 4.2 kJ/(kg·K) |
| $k_\ell$ | 0.63 W/(m·K) |
| $\mu_\ell$ | $6.5\times10^{-4}$ Pa·s |
| $\beta$ | $3.74\times10^{-4}$ 1/K |

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