Unit Operation Final Exam (6/23/2021) – Exam A

Please scan or take a photo of your hand-written answer sheet and upload the electronic file on time.

Q1. Explain what von Karman vortex is and suggest one of its applications. (10%)

Q2. In a house, water flows through a copper tube with a 0.75-in.ID, at a flow rate of 2 gallons per minute (gpm). Determine the Reynolds number for: (15%)
a. hot water (T = 120 ^{o}F)
b. cold water (T = 45 ^{o}F)

Q3. A problem showed up in a chemical process, and one of your colleagues guesses that this problem may come from a broken orifice meter. This orifice meter (d = 38 mm) is installed in a pipe (d = 50 mm) to handle a flow of glycerol, which has a density of 1260 kg/m^3 and a viscosity of 50 mN-s/m^2. The orifice meter is now showing a pressure reading of 1852 Pa. To check this guess, you inserted a pitot tube at the center of the pipe, and you found that the pressure reading of the pitot tube is 980 Pa. Is the opinion from your colleague correct? Prove whether the orifice meter is broken (25%).

Q4. A centrifugal pump is to be used to extract benzene (865 kg/m^3) from a low-pressure reservoir in which the pressure is 35500 Pa. The required flow rate of benzene is 10 m^3/h. The vapor pressure of benzene is 26200 Pa, and the viscosity of benzene is 0.68 mN-s/m^2. A cast iron pipe (d = 2 inches) was placed vertically all the way down from the reservoir to the pump along with two standard 90^{o} elbows at both ends. The friction factor of each elbow is 0.7. If the NPSHR of the pump is 3 m, what should be the minimum pipe length, namely, the height of the reservoir above the pump (25%)?

Q5. Oil of viscosity 10 mN-s/m^2 and density 950 kg/m^3 is pumped 8 km from an oil refinery to the storage tanks at the distribution depot through a 75 mm diameter pipeline and is then despatched to customers at a rate of 500 tonne/day. Allowance must be made for periods of maintenance which may interrupt the supply from the refinery for up to 72 hours. If the maximum permissible pressure drop over the pipeline is 3450 kN/m^2, what is the shortest time in which the storage tanks can be completely recharged after a 72 hour shutdown? The roughness of the pipe surface is 0.05 mm (25%).