國 立 清 華 大 學 命 題 紙

99 學年度 動力機械工程學系甲組(熱流組) 碩士班入學考試

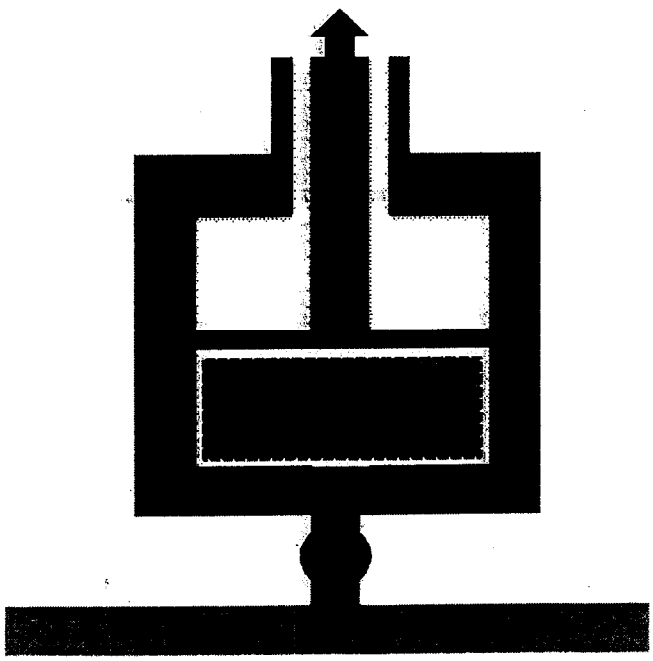
科目 熱流學(一) 科目代碼 0802 共 3 頁，第 1 頁 *請在【答案卷卡】作答

1.

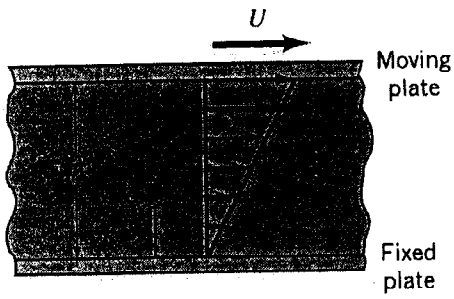
There is an air compressor located at the 1st floor of Engineering Building which supplies the compressed air used in the clean room at the 3rd floor. The air enters the compressor at 20°C, 100kPa with a mass flow rate of 0.02kg/s through a pipe area of $0.01m^2$. An air jet connected from the compressor exits at 3rd floor clean room at 25°C, 100kPa with the velocity of 50m/s. The clean room at 3rd floor is 6 meter higher than the 1st floor. At steady state, assume the heat transfer rate from the compressor to the surrounding is 15% of the power input, the air is incompressible and for air Cp=1.003kJ/(kg.K), Cv=0.717kJ/(kg.K), ρ= $1.204kg/m^3$, $g=9.81m/s^2$. Determine the power input to the compressor in kW. (10%)

2.

Compressed air is proposed as an alternative energy source to provide work output with minimum pollution. To prove this concept, a piston-cylinder device is designed to provide work with compressed air supply, details as following: an insulated $1m^3$ cylinder is used to provide a load through a piston, as shown in the diagram. The piston was initially at the bottom and with neglected volume. A valve which is connected to a compressed air line (500kPa and 27°C) is opened to push the piston to the top of the cylinder. The total work from this process is 300kJ. What is the final pressure in the cylinder if the final mass is 0.5kg? If the piston-cylinder device is not insulated perfectly and extract 100kJ heat from an 800 °C reservoir, calculate the entropy change due to the heat transfer. For Air, Cp=1.003kJ/(kg.K), Cv=0.717kJ/(kg.K), R=287 kJ/(kg.K). (20%)



3.



An incompressible viscous fluid is placed between two large parallel plates as shown in the figure. The bottom plate is fixed and the upper plate moves with a constant velocity, U. For these conditions the velocity distribution between the plates is linear and can be expressed as

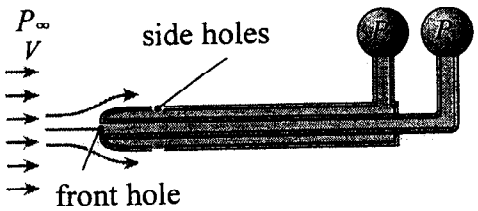
$$u = U\frac{y}{b}$$

(a) Determine: (i) the volumetric dilatation rate, (ii) the vorticity, and (iii) the rate of angular deformation.

(b) Can a velocity potential be defined in this flow? Why?

(c) Write the mathematic expression and calculate for the shear stress at the plate surface.

(d) Roughly sketch the variation of the distribution of $u(y)$ with time after the upper plate is suddenly stopped until a steady state. Set the zero time at the stopping of the plate. (25%)



4.

A pitot probe is composed of a tube within a tube, as shown in the figure. The pressure measured through the front hole of the inner tube is denoted P_1, and that measured through the side holes of the outer tube is P_2. (a) Which of P_1 and P_2 measures the ambient pressure P_∞? Why? (b) What kind of pressure does P_1 and P_2 respectively measure, the static pressure, dynamic pressure, or stagnation pressure? (c) How do you determine the flow velocity V based on the measurements of P_1 and P_2? (15%)

5.

An ideal Brayton cycle with regeneration has a pressure ratio of 4. Air enters the compressor at 300 K and the turbine at 1200 K. If the effectiveness of the regenerator is 80%, using constant specific heat values at room temperature, determine the net work output and thermal efficiency of the cycle. Also show the cycle on a T-s diagram. (15%)

(C_p =1.005 kJ/kg•K, C_v =0.718 kJ/kg•K, k=1.4, R=0.287 kPa•m^3/kg•K)

6.

The compression ratio of an air-standard Otto cycle is 10. Prior to the isentropic compression process, the air is at 100 kPa, 17°C, and 600 cm^3. The temperature at the end of the isentropic expansion process is 800 K. Using constant specific heat values at room temperature, determine the following:

(a) the highest temperature and pressure in the cycle?

(b) the amount of heat transferred, in kJ?

(c) the thermal efficiency.

(d) the mean effective pressure.

(e) show the cycle on a P-v diagram. (15%)

(C_p =1.005 kJ/kg•K, C_v =0.718 kJ/kg•K, k=1.4, R=0.287 kPa•m^3/kg•K)