國 立 清 華 大 學 命 題 紙

八十四學年度 動力機械研究 所 甲 組碩士班研究生入學考試

科目 熱流力學(I) 科號 1802 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. Consider incompressible two-dimensional channel flows which develop with uniform inlet velocity. The height of the channel and the inlet velocity are H and V, respectively. If the flows with the same average velocity, laminar, turbulent or inviscid by suitable choices of the fluid viscosity, are fully developed, please

   (a) derive the governing momentum equations for these flows, respectively. (3%)

   (b) obtain the velocity profiles based on the respective governing equations for these flows, if possible or indicate any difficulty encountered. (4%)

   (c) plot the representative velocity profiles for these flows across the channel (x axis magnitude, y axis height) on the same graph. (4%)

   (d) plot the representative variations of shear stresses for these flows across the channel (x axis magnitude, y axis height) on the same graph.(4%)

2. For boundary-layer-type flows, please

   (a) define momentum thickness, displacement thickness and shape factor. (3%)

   (b) derive the momentum integral equation to be, (6%)

$$\frac{C_f}{2} = \frac{d\theta}{dx} + (2+H)\frac{\theta}{U}\frac{dU}{dx}$$

   where U, δ, δ^*, θ and H are the free stream velocity, boundary layer thickness, displacement thickness, momentum thickness and shape factor, respectively.

   (c) For laminar flow, Karman assumed that the velocity profiles had an approximately parabolic shape,

$$u(x,y) = U\left(\frac{2y}{\delta} - \frac{y^2}{\delta^2}\right) \quad 0 \le y \le \delta(x)$$

   Use the momentum integral equation and the assumed velocity profiles to determine the coefficients in the following relations of boundary layer flows over a flat plate. (6%)

$$\frac{\delta}{x} = \frac{C_1}{Re_x^{1/2}}, \qquad C_f = \frac{C_2}{Re_x^{1/2}}, \qquad \frac{\delta^*}{x} = \frac{C_3}{Re_x^{1/2}}$$

   where $Re_x = \rho U x/\mu$.

3a Prove that for an ideal gas $\left(\dfrac{\partial u}{\partial p}\right)_T = 0$. (10%)

3b Sketch a phase diagram (p-T) for water, and then sketch on the diagram lines of constant density and constant enthalpy, respectively. (6%)

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4. There are three important air-standard cycles which form the basis of all practical reciprocating engines; they are the Otto, diesel and dual cycles. A dual cycle is a close approximation to the actual performance of a compression ignition engine, and it consists of a two-segment heating process. The first segment is a constant volume process, and the second segment is a constant pressure process. The rest of the processes are identical to those in the ideal diesel and Otto cycles. For the three cycles which starts at the same conditions, please

   (a) plot the P-v diagrams and indicate the nature of each process for the three cycles. (4%)

   (b) derive the ideal cycle efficiencies in terms of compression ratio (r_v), cut-off ratio (r_c) and constant volume heating process pressure ratio (r_p) whichever are appropriate. (6%)

   (c) plot the T-s diagram for the three cycles on the same graph with the same compression ratios and heat inputs and list the order of efficiency supported by derivations. (5%)

   (d) plot the T-s diagram for the three cycles on the same graph with the same work output and peak pressure and list the order of efficiency supported by derivations. (5%)

5. Consider the design of a heat engine for use in outer space. The working substance of the system can reject heat to space only by radiation ($Q=\sigma A T_L^4$), where A and T_L are the area and temperature of the radiator, respectively. Because the radiator is expensive to launch, such a heat engine is usually designed for minimum radiator area.

   (a) What is the maximum thermal efficiency of such a heat engine for a given power output $\dot{W}$ and a given T_H? (14%)

   (b) Show that the corresponding radiator area is $A=\dfrac{256\dot{W}}{27\sigma T_H^4}$. (6%)

6. Is it possible for the availability of a closed system to be negative? Explain your answer, giving reasons or examples. (5%)

7. Explain how it is possible to dehumidifying air by passing it through water sprays. (5%)

8. A hydrocarbon fuel is completely burned in air. How does the dew point of the products vary with the fraction of the hydrogen in the fuel? (4%)