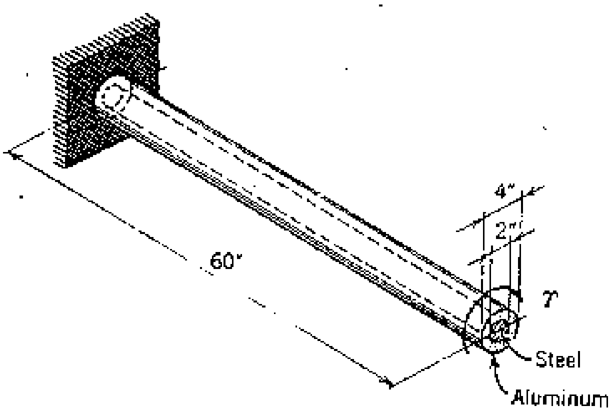
國立中央大學九十學年度碩士班研究生入學試題卷

所別：機械工程學系　甲組　科目：材料力學　共 3 頁　第 1 頁

(1) A hollow circular aluminum alloy (G_a = 4000 ksi) cylinder has a steel (G_s = 11600 ksi) core as shown in the figure. The steel and aluminum parts are securely connected at the ends. If the allowable stress in the steel must be limited to 14 ksi and the allowable stress in the aluminum must be limited to 10 ksi, determine

a) The maximum torque T that can be applied to the right end of the composite shaft. (13%)

b) The rotation of the right end of the composite shaft when the torque of part (a) is applied. (12%)



(2) A beam is loaded and supported as shown in Fig. 2a. The beam has the cross section shown in Fig. 2b. Determine

a) The magnitude and location of the maximum tensile and compressive flexural stresses in the beam. (15%)

b) The magnitude and location of the maximum vertical shearing stress in the beam. (10%)

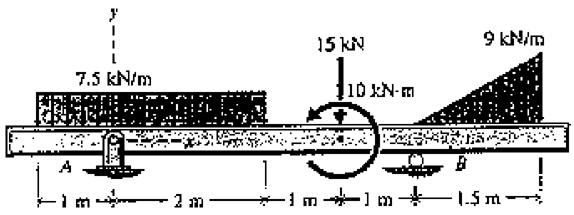


Fig 2a

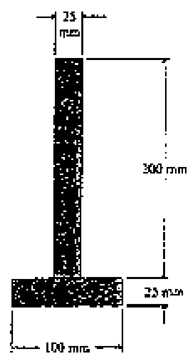
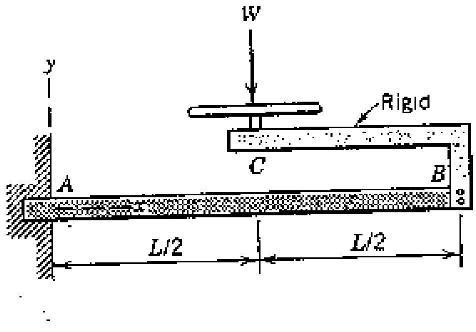


Fig. 2b

(3) The beam AB shown in the figure is the flexural member of a scale that is used to obtain the weight W of food in a microwave oven. Determine

a) The equation of the elastic curve for beam AB in terms of W, L, x, E, and I. (15%)

b) The deflection at point C when W=20 lb, L=2 in., and EI=100 lb · in^2. (10%)



注意：背面有試題

(4) Fig. 4a shows a heavily loaded belt conveyor whereby two head pulleys are arranged in tandem at the drive station. Three identical driving motors are used: the first pulley is driven from both ends, the second one from one end only. The power is transmitted from the motor (8) through a fluid coupling (7), a gear reducer (6) and a shaft coupling (not shown here) to the pulley. The section drawing in Fig. 4b illustrates the welding design of *first head pulley*, which is constructed with one drum (1) and two ribs (2). The pulley connects the driving shaft (4) by means of two shrink disks (3) as shown in Fig. 4b. The shaft of the head pulley is supported on two rolling bearings in the type of plummer block (5). The operating data are:

- Transmitted power to the shaft end from each motor: 300 kW,
- Shaft rotating speed: 57.3 rpm,
- Radial load caused by belt drive (in the positive z-direction in Fig. 4b): $F_R = 100$ kN.

Considering the shaft of the first pulley that is driven by *two motors* from each end, please answer the following questions.

A) Assume that the forces acting through the ribs on the shaft are the same, pleas draw the diagrams for the shaft within the two bearings (5%)
- Shear Force F_q,
- Bending moment M_b,
- Torque T.

B) The maximum stress will occur on the surface of the shaft in the z-direction, such as **element K** in Fig. 4b with maximum tensile bending stress. Please calculate the *maximum shear stress* τ_T and the *maximum bending stress* σ_b of this element K in unit N/mm^2. Note: The shear stress caused by shear force is too small compared with that caused by transmitted torque and can be neglected here. We neglect also the normal pressure between shrink disk and shaft for torque transmission. (5%)

C) This case is a two-dimensional stress condition. For analysis of combined stress please express
- the maximum and minimum principal stress σ_1, σ_2,
- the maximum shear stress τ_{max},
- the angle of inclination of the principal plane φ_σ

in terms of σ_b and τ_T by using the *Mohr's Circle*. (10%)

D) In the practice the designer uses the "*von Mises stress* σ_V" (Distortion Energy Theory) to predicate the failure of the shaft with ductile material:

$$\sigma_V = \sqrt{\sigma_1^2 + \sigma_1^2 - \sigma_1\sigma_2} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}\,.$$

However, it will be convenient for the design work if we calculate this "*von Mises stress*" with the so-called "*equivalent bending moment* M_V":

$$\sigma_V = \frac{M_V}{W},$$

where W is section modulus of the shaft.

Please based on this case derivate the representation of "equivalent bending moment M_V" in terms of known bending moment M_b and torque T. Hint: your answer should be like

$$M_V = \sqrt{M_b^2 + a \cdot T^2}\,,$$

in which the factor a has to be solved by yourself. (5%)

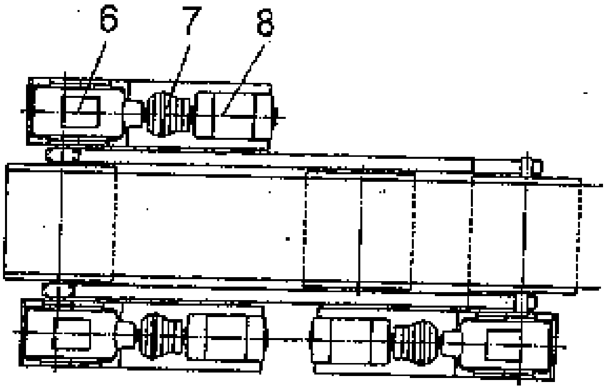


Fig. 4a

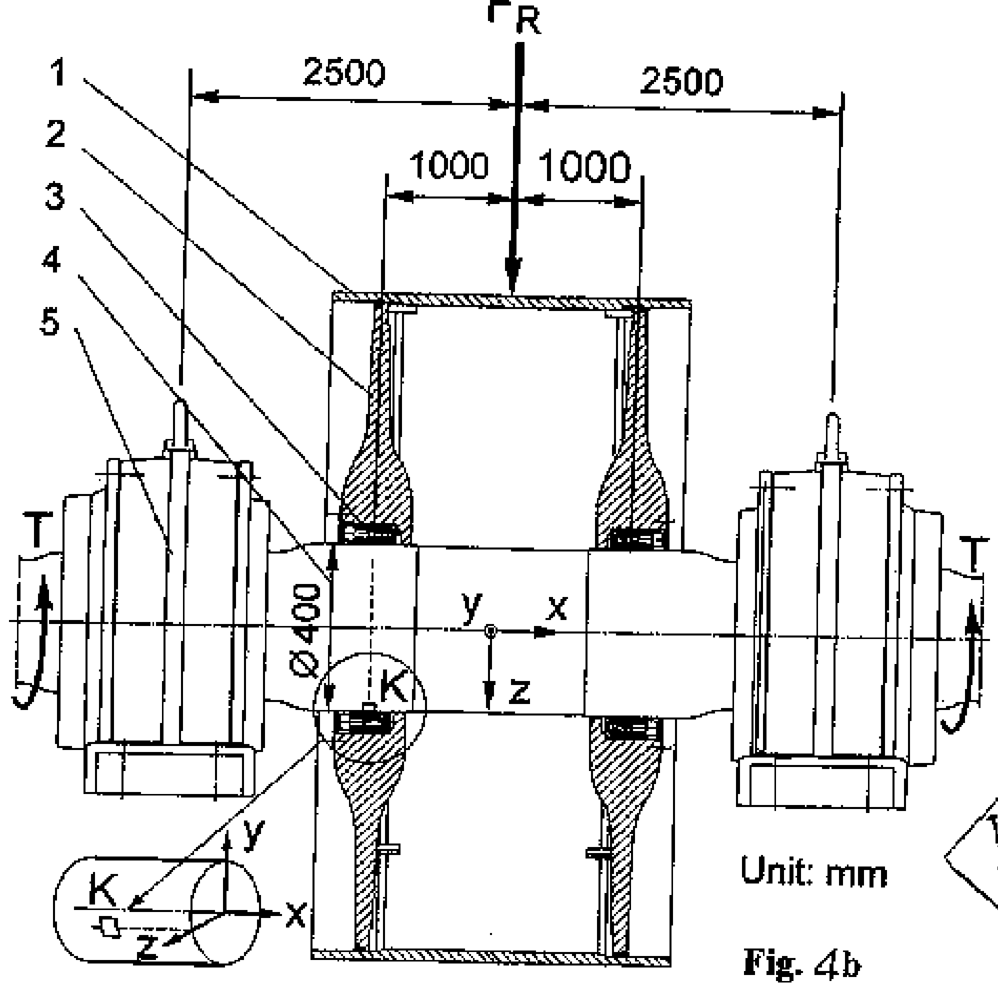


Fig. 4b