ME231: Tutorial – IV

November 03, 2020

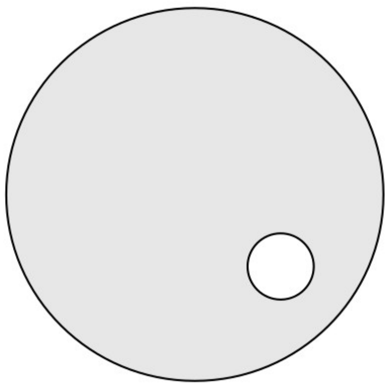
Q.1: Invert stress-strain-temperature relationship to find stresses in term of strains. Write all equation in the matrix form $[\boldsymbol{\sigma}] = [\mathbf{C}]\ [\boldsymbol{\epsilon}]$. $\mathbf{C}$ is called stiffness matrix.

Q.2: For a thin plate loaded in xy-plane (plane stress) we know that $\sigma_{zz} = \tau_{xz} = \tau_{yz} = 0$. Using the generalized Hooke's law, derive the relationship between stress components $\sigma_{xx}, \sigma_{yy}, \sigma_{xy}$ and strain components $\varepsilon_{xx}, \varepsilon_{yy}, \gamma_{xy}$. Also write the expression for ε_{zz} and show that it is function of stresses in xy-plane.

Q.3: For a plane strain case i.e., $\varepsilon_{zz} = \gamma_{xz} = \gamma_{yz} = 0$, derive the relationship between stress components $\sigma_{xx}, \sigma_{yy}, \sigma_{xy}$ and strain components $\varepsilon_{xx}, \varepsilon_{yy}, \gamma_{xy}$. Also write the expression for σ_{zz} and show that it is function of strains in xy-plane.

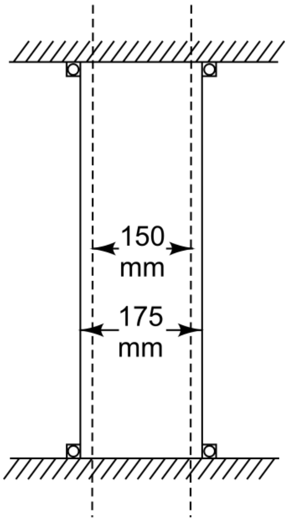
(NOTE: Q.2 and Q.3 shows that plane stress and plane strain cases are purely two-dimensional cases. Even strain and stress in the third direction are function of inplane stresses and strains.)

Q:4: A sheet of metal in the form of a circle has a small circular hole cut out of it, as indicated in the sketch. If the sheet is initially free of stress and is not restrained in any fashion, what general shape will the originally circular boundaries assume if the sheet is heated uniformly to a temperature T above its original temperature?

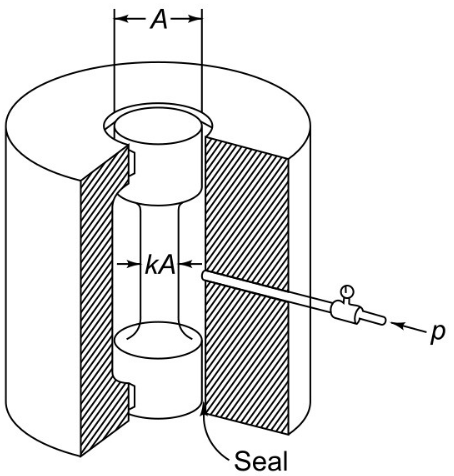


Q.5: It is desired to produce a tight fit of a steel shaft in a steel pulley. The internal diameter of the hole in the pulley is 24.950 mm, while the outside diameter of the shaft is 25.000 mm. The pulley will be assembled on the shaft by either heating the pulley or cooling the shaft and then putting the shaft in the pulley hole and allowing the assembly to reach a uniform temperature. Is it more effective to heat the pulley or to cool the shaft? What temperature change would be required in each case to produce a clearance of 0.025 mm for easy assembly?

Q.6: A steel pipe is held by two fixed supports as shown in the figure. When mounted, the temperature of the pipe was 20°C. In use, however, cold fluid moves through the pipe, causing it to cool considerably. If we assume that the pipe has a uniform temperature of –15°C and if we take the coefficient of linear expansion to be $12\times10^{-6}/°\mathrm{C}$ for this temperature range, determine the state of stress and strain in the central portion of the pipe as a result of this cooling. Neglect local end effects near the supports and neglect body forces and fluid pressure and drag forces.



Q.7: A materials test is performed by pressurizing the chamber shown. The specimen is machined to have cross-sectional area A at the ends and area kA in the test section ($0<k<1$). What is the stress state in the test-section when the pressure (above atmospheric) in the chamber is p? Under atmospheric conditions, the material yields in simple tension at $\sigma_Y = 280\ \mathrm{MN/m^2}$. How large must the pressure p be to produce yielding? For this case, does it make any difference whether you use the Mises or the maximum shear-stress criterion?



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