Carleton University
Department of Mechanical and Aerospace Engineering
Winter 2014

MECH3002 Machine Design and Practice

Assignment #3

(Figure Numbers are from Juvinall and Marshek, Fifth Edition)

1). A stepped shaft, as shown in Figure 4.35, has dimensions of D = 1.2 in, d = 1 in, and r = 0.03 in. It was machined from steel having tensile properties of S_u = 100 ksi and S_y = 80 ksi.
(a). Estimate the torque T required to produce static yielding (Note: For static loading of ductile material, assume the yielding is not significant; hence ignore stress concentration.)
(b). Estimate the value of reversed torque, ±T, required to produce eventual fatigue failure.

2). A cold-drawn rectangular steel bar of 160 Bhn is 8 mm thick, 50 mm wide and has a central hole of 20 mm in diameter (as in Figure 4.40). Estimate maximum tensile force that can be applied to the ends and have infinite fatigue life with 95% reliability and a safety factor of 1.5: (a) if the force is completely reversed and (b) if the force varies between zero and a maximum value.

3). Two parts of a machine are held together by bolts that are initially tightened to provide a total of initial clamping force of 12,000 N. The elasticities are such that $k_c = 4\ k_b$:
(a). What external separating force would cause the clamping force to be reduced to 800 N (assume that the bolt remains within elastic range)?
(b). If this separating force is repeatedly applied and removed, what are the values of the mean and alternating forces acting on the bolts?

4). A grade 5, $1\frac{1}{2}$-in UNF bolt with rolled threads is used in a joint having a soft gasket for which the clamped member stiffness is only 3/4 of the bolt stiffness. The bolt initial tension corresponds to F_i = 20,000d, d in inches. During operation, there is an external separating force that fluctuates between 0 and P. For this application, there is negligible bending of the bolts.
(a). Estimate the maximum value of P that would not cause eventual bolt fatigue failure.
(b). Estimate the maximum value of P that would not cause joint separation.

5). Two aluminum plates, which are part of an aircraft structure, are held together by a grade 7, $\frac{3}{4}$-in UNF bolt. The effective area of the aluminum plates in compression is estimated to be 10 times the cross sectional area of the steel bolt. The bolt is initially tightened to 90% of its proof strength. Gust loads, varying from zero to P, tend to pull the plate apart (this results in negligible bolt bending). With a safety factor of 1.2, what is the maximum value of P that will not cause eventual bolt fatigue failure? What clamping force will remain when this value of P acts?

Note for Question 2):

Brinell hardness test can be used to estimate strength properties of steel. The ultimate tensile strength for steel is:

$$S_u = 0.5H_B \text{ (ksi)}$$

and

$$S_y = (0.525H_B - 30) \text{ (ksi)}$$

where H_B is the Brinell hardness number (Bhn). See section 3.6 (page 97) in the text book for more details.

- Due on Wednesday March 19th, 2014, 1:05 pm before the start of the lecture.