Fall 2021, ME1029 Mechanical Design 2

Homework 05

Question 01 (35 points)

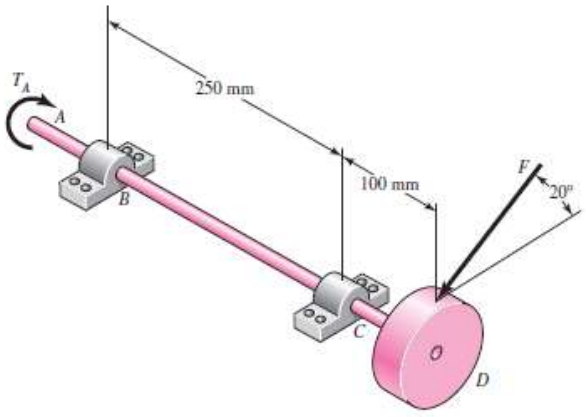
The job is to conduct a first-cut shaft diameter estimation. Designed shaft needs to transmit 1000 N-m torque with superimposed 250 N-m alternating torque due to torsional vibration. Shaft material is a heat-treated alloy steel with S_{ut}=1.2GPa and S_y=1.0GPa. The shaft has a shoulder with designated D/d=1.2 and r/d=0.05. Shaft surface demands a good quality ground finish. Reliability target of the designed shaft is 95 percent.

a. What is the minimal diameter required for infinite life?
b. Identify your assumptions made to get estimated diameter.

Question 02 (40 points)

The rotating solid steel shaft is simply supported by bearings at points B and C and is driven by a gear (not shown) which meshes with the spur gear at D, which has a 150-mm pitch diameter. The force F from the drive gear acts at a pressure angle of 20°. The shaft transmits a torque to point A of T_A = 340 N · m. The shaft is machined from steel with S_y = 420 MPa and S_{ut} = 560 MPa.

Using a factor of safety of 2.5, determine the minimum allowable diameter of the 250-mm section of the shaft based on (a) a static yield analysis using the distortion energy theory and (b) a fatigue-failure analysis. Assume sharp fillet radii at the bearing shoulders for estimating stress-concentration factors.



Question 03 (25 points)

The torque to be transmitted through the key from the gear to the shaft is T = 2819 in-lbf. The nominal shaft diameter supporting the gear is 1.00 in. Specify a square key for torque transmission, using a factor of safety of 1.1. Use 1020 CD steel for the key material and DET theory as the failure criteria for safety factor calculation.