(*a*) For shaft A, find the factor of safety for infinite life using the modified Goodman fatigue failure criterion.

(*b*) Repeat part (*a*) using the Gerber fatigue failure criterion.

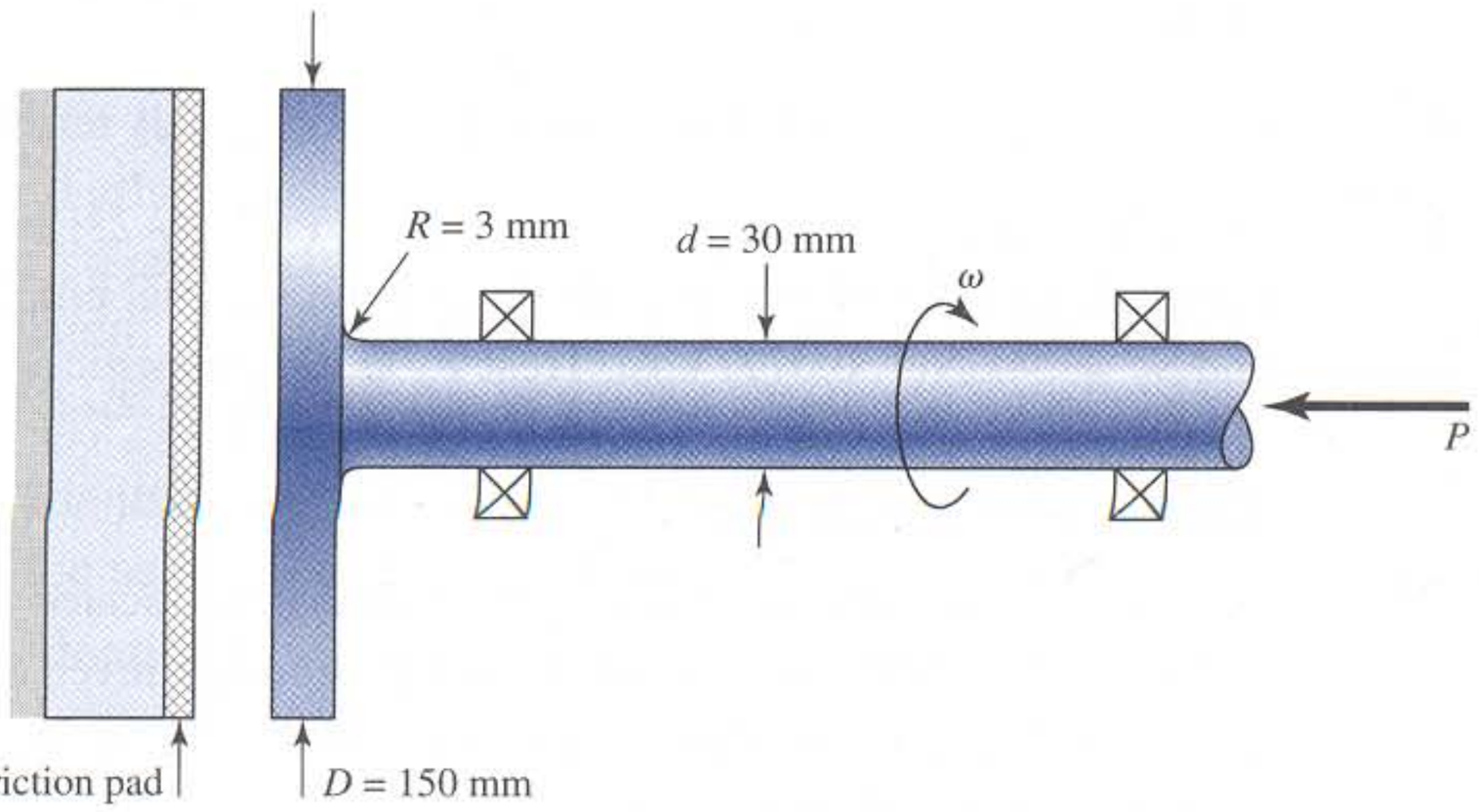
SIS **7–27** A schematic of a clutch-testing machine is shown. The steel shaft rotates at a constant speed ω. An axial load is applied to the shaft and is cycled from zero to P. The torque T induced by the clutch face onto the shaft is given by

$$T = \frac{f P(D + d)}{4}$$

where D and d are defined in the figure and f is the coefficient of friction of the clutch face. The shaft is machined with $S_y = 800$ MPa and $S_{ut} = 1000$ MPa. The theoretical stress concentration factors for the fillet are 3.0 and 1.8 for the axial and torsional loading, respectively.

(*a*) Assume the load variation P is synchronous with shaft rotation. With $f = 0.3$, find the maximum allowable load P such that the shaft will survive a minimum of 10^6 cycles with a factor of safety of 3. Use the modified Goodman criterion. Determine the corresponding factor of safety guarding against yielding.

(*b*) Suppose the shaft is not rotating, but the load P is cycled as shown. With $f = 0.3$, find the maximum allowable load P so that the shaft will survive a minimum of 10^6 cycles with a factor of safety of 3. Use the modified Goodman criterion. Determine the corresponding factor of safety guarding against yielding.



Problem 7–27

IS **7–28** For the clutch of Prob. 7–27, the external load P is cycled between 20 kN and 80 kN. Assuming that the shaft is rotating synchronous with the external load cycle, estimate the number of cycles to failure. Use the modified Goodman fatigue failure criteria.

S **7–29** A flat leaf spring has fluctuating stress of $\sigma_{\max} = 420$ MPa and $\sigma_{\min} = 140$ MPa applied for 5 (10^4) cycles. If the load changes to $\sigma_{\max} = 350$ MPa and $\sigma_{\min} = -200$ MPa, how many cycles should the spring survive? The material is AISI 1040 CD and has a fully corrected endurance strength of $S_e = 200$ MPa. Assume that $f = 0.9$.

(*a*) Use Miner's method.

(*b*) Use Manson's method.

S **7–30** A machine part will be cycled at ±48 kpsi for 4 (10^3) cycles. Then the loading will be changed to ±38 kpsi for 6 (10^4) cycles. Finally, the load will be changed to ±32 kpsi. How many cycles of operation can be expected at this stress level? For the part, $S_{ut} = 76$ kpsi, $f = 0.9$, and has a fully corrected endurance strength of $S_e = 30$ kpsi.

(*a*) Use Miner's method.

(*b*) Use Manson's method.

S **7–31** A rotating-beam specimen with an endurance limit of 50 kpsi and an ultimate strength of 100 kpsi is cycled 20 percent of the time at 70 kpsi, 50 percent at 55 kpsi, and 30 percent at 40 kpsi. Let $f = 0.9$ and estimate the number of cycles to failure.