HW 2 - ME 8613

Read sections 2.4-3.2 in the textbook (pages 48-92).

Problem 1. Book problem 2.34

Problem 2) For the figure shown below (page 2) assume that the "armature" has a moment-speed curve of $M_a(\omega_1) = -315 \cdot \omega_1 + 2000$ when the motor is on and acts as a damper when the motor is off with $M_a(\omega_1) = -14.4 \cdot \omega_1$. In both cases the armature speed is in rad/s and the moment is in lbf*in.

Assume, that all shafts are made of steel (G = 1.15*10^7 psi), and that the diameter of the bevel gears is 2 inches. Model each shaft as a rotational spring ($k = \frac{\pi \cdot r^4 G}{2L}$). Model the resistance felt by each of the paddles (inertias 7 & 8 shown at the bottom of the industrial mixer) with rotational dampers with damping coefficient of B=2880 lbf*in*s. The number of teeth of each gear (20T, 12T, and 36T) is given in the figure. Obtain the following:

a) A detailed Free Body Diagram (FBD) including your choice of reference coordinates.
b) A complete set of differential equations in state variable form. Notice that there are 8 inertias and 4 springs, but not all inertias are independent.
c) Solve the state variable equations using a 4th order Runge-Kutta numerical method for a time period 20 seconds. Assume that all initial all states are initially zero and that the motor armature is on for the first 10 seconds and off another 10 seconds. It is recommended that a very small time step is used. Try $\Delta t = 0.0005 s$
d) Verify using energy conservation and include a discussion on the results with the following points: When the motor is turned on and at steady-state (ω_1 is constant), does it operate at its maximum power? Also, consider the mechanical failure modes that might occur with the plotted speed results.

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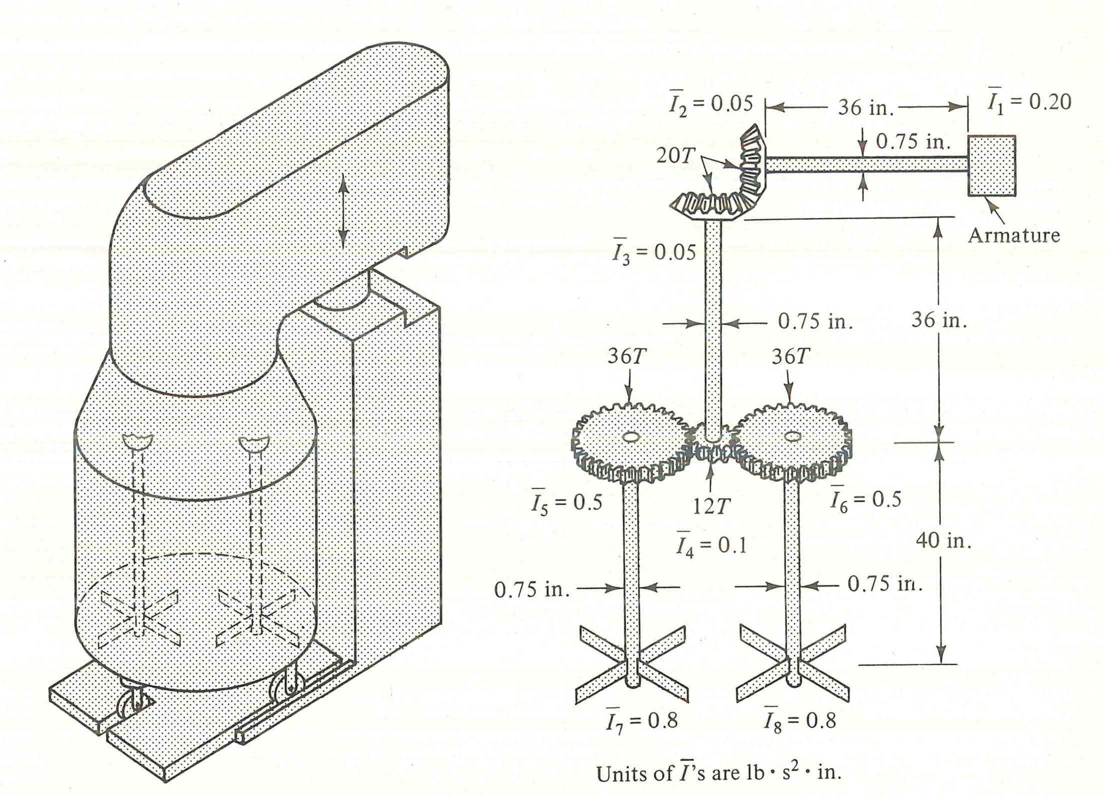

(a) (b)