AN ERROR TO AVOID IN MOTOR SIZING

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Motors often drive loads through speed-reducing gears. To determine the torque required to accelerate a load in such systems, the inertia of the load, referred to the motor shaft, is commonly thought to be inversely proportional to the square of the speed-reduction ratio. Thus, the equation generally used to calculate required motor torque is

$$T_s = \frac{T_{Lf}}{Nn} + J_M a_M + \frac{J_L a_M}{N^2} \quad (1)$$

where T_S = torque required at motor shaft, T_{Lf} = friction load, J_M = motor inertia, J_L = load inertia, a_M = motor shaft acceleration N = gear ratio (motor speed/load speed), and n = gearbox efficiency

Results obtained with the equation are accurate enough when $n \cong 1$ or when the third term is small with respect to the other two. However, where n is appreciably less than 1 and the third term is large, as in many motion control applications, the required motor torque can be much larger than that calculated with Equation 1.

The error arises because torque required at the motor shaft to accelerate the load is affected by the efficiency of the gear train. Thus, the equation should properly read,

$$T_s = \frac{T_{Lf}}{Nn} + J_M a_M + \frac{J_L a_M}{N^2 n} \quad (2)$$

The effect of gear-train efficiency is demonstrated by an example where a stepping motor with 0.5-unit inertia drives a load having a 50-unit inertia. The gear ratio is 10:1, friction is negligible, and $a_M = 1$. (The relationship between motor inertia, load inertia, and gear reduction is a common one for stepping-motor systems.)

The accompanying chart shows that with low-efficiency gears the torque required to accelerate the motor and load is appreciably higher than that calculated with Equation 1. And motor losses, which vary as the square of the torque, can be excessive even with relatively high-efficiency gears. ■