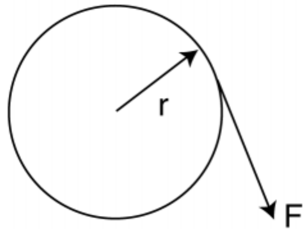
A stepper motor should provide an output torque larger than load torque and be required to start and stop at a proper step rate against load inertia. Also, when operating the motor at a rate higher than the starting pulse rate, the rate needs to be varied within a proper acceleration time.

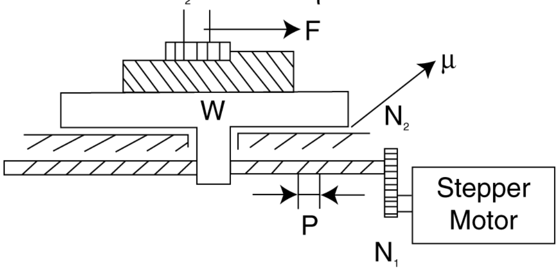
1. OBTAINING LOAD TORQUE

$$T = F \times r$$



where,
T: Load torque (kg • cm)
F: Force to rotate the coupling shaft of a stepper motor (cm)
r: Radius to apply the force F (cm)

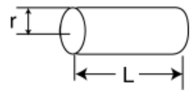
$$T = \frac{N_1}{N_2} \times \frac{(F + \mu W)P}{2\pi\eta}$$



where,
T: Load torque (kg • cm)
N_1: Number of pinion teeth
N_2: Number of gear teeth
W: Weight of table and work (kg)
F: Cutting resistance (kg)
μ: Frictional resistance of rubbing surface
P: Pitch of feed screw (cm)
η: Transfer efficiency of the system including feed screw and gear

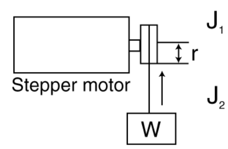
2. OBTAINING LOAD INERTIA

$$J = \frac{Mr^2}{2} = \frac{W}{g} \times \frac{r^2}{2} = \frac{\pi r^2 \bullet L \bullet \rho \bullet r^2}{980 \times 2} = \frac{\pi \bullet \rho \bullet Lr^4}{1960}$$



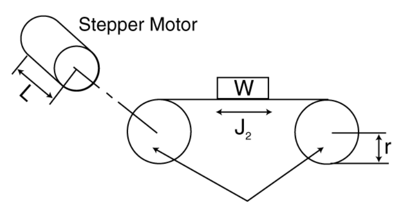
where,
J: Load Inertia (kg•cm•s²)
π: Ratio of the circumference of a circle to its diameter (3.14)
ρ: Specific gravity of cylinder material (kg/cm³)
(Iron: 7.8 x 10^{-3}, Aluminum: 2.7 x 10^{-3})
L: Length of cylinder (cm)
r: Radius (cm)
g: Gravitational acceleration 980 (cm•s²)

$$J = J_1 + J_2 = \frac{\pi\rho \bullet L \bullet r^4}{1960} + \frac{Wr^2}{980}$$



where,
J: Load Inertia (kg•cm•s²)
J_1: Inertia of pulley (kg•cm•s²)
J_2: Inertia of take-up (kg•cm•s²)
W: Weight of material to be wound (kg)
r: Radius of pulley (cm)

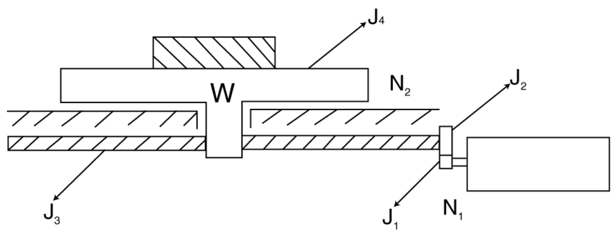
$$J = 2 \times J_1 + J_2 = 2\left(\frac{\pi\rho Lr^4}{1960}\right) + \frac{Wr^2}{980}$$



where,
J: Load Inertia (kg•cm•s²)
J_1: Inertia of pulley (kg•cm•s²)
J_2: Inertia of linear movement (kg•cm•s²)
W: Weight of belt and material (kg)
r: Radius of pulley (cm)
L: Length (cm)

2. OBTAINING LOAD INERTIA (cont'd)

$$J_0 = J_1 + (J_2 + J_3)\left(\frac{N_1}{N_2}\right)^2 + J_4$$



$$J_4 = \frac{W}{980}\left(\frac{\delta}{\frac{\pi}{180} \bullet \alpha}\right)^2$$

$$\text{or } J_4 = \frac{W}{980}\left(\frac{P}{2\pi} \bullet \frac{N_1}{N_2}\right)^2$$

where,

J_0: Load inertia (kg•cm•s^2)
J_1: Inertia of pinion (kg•cm•s^2)
J_2: Inertia of gear (kg•cm•s^2)
J_3: Inertia of feed screw (kg•cm•s^2)
J_4: Inertia of work and table (kg•cm•s^2)
N_1: Number of pinion teeth
N_2: Number of gear teeth
W: Weight of work and table (kg)
π: Ratio of the circumference of a circle to its diameter (3.14)
α: Step angle per pulse (°)
δ: Table movement per pulse (cm)
P: Pitch of feed screw (cm)

3. OBTAINING ACCEL/DECEL TIME

You can obtain criterion for the accel/decel time based on load torque and inertia obtained through calculation by referring to the characteristic curve of the stepper motor.

1. **Step Angle**
   The step angle is the angle by which a stepper motor shaft rotates in response to an input signal pulse.

2. **Starting Pulse Rate (Stepping Rate)**
   The pulse rate at which a stepper motor can synchronize with input signal pulses to start and stop without error between the number of input pulses and angle of rotation.

3. **Slewing Pulse Rate**
   The high pulse rate at which a stepper motor can run in perfect synchronization with signal pulses but without stopping between steps.

4. **Peak Holding Torque**
   The peak torque with which a stepper motor can hold its step position against a torque given externally with the stepper motor excited at the rated current.

5. **Accel/Decel Time**
   The time required for a stepper motor to rotate without losing synchronism with input pulses when the pulse rate is gradually increased from the starting pulse rate and is gradually decreased from the slewing pulse rate.