



## MDP 454: Mechatronics(2)

### Sheet 2: Actuator Sizing

1. The specifications of a machine that utilizes a lead screw mechanism are:
  - a. Ball screw: Diameter: 14 mm, length: 500 mm, pitch: 0.5 rev/mm, efficiency: 45%
  - b. Mechanical data: Friction coefficient ( $\mu$ ): 0.1, load: 6 kg, orientation: inclined by  $10^\circ$  relative to horizontal. Taking into consideration that inertia ratio between the machine and the motor is 4:1
  - c. Move profile: Type: 1/6- 2/3- 1/6 Trapezoid, distance: 8 mm, move time: 0.2 s, dwell time: 0.1 s.

Determine the peak and root mean square torques of a suitable motor to drive this machine.

2. A new machine requires the use of a linear motor for high acceleration and speed. The following specifications summarize the system.
  - a. Machine details: Bearings: linear roller, load: 60 kg, orientation:  $20^\circ$  relative to horizontal, air cooling: 2 bar.
  - b. Move profile: Type: 1/3- 1/3- 1/3 Trapezoid, distance: 600 mm, move time: 300 ms, dwell time: 330 ms.

Determine the peak and root mean square force of the linear motor.

3. Consider a rotary motion axis driven by an electric servo motor. The rotary load is directly connected to the motor shaft without any gear reducer (Figure 1). The rotary load is a solid cylindrical shape made of steel material,  $d=60$  mm,  $l= 60$  mm,  $\rho= 7800$  kg/m<sup>3</sup>. The desired motion of the load is a periodic motion (Figure 2). The total distance to be traveled is 1/4 of a revolution. The period of motion is  $t_{cyc}= 400$  ms. and dwell portion of is  $t_{dw}= 100$  ms. and the remaining part of the cycle time is equally divided between acceleration, constant speed and deceleration periods. Determine the required motor size for this application when the working temperature is  $50^\circ\text{C}$ .

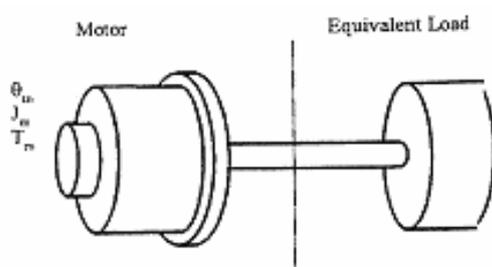


Figure 1

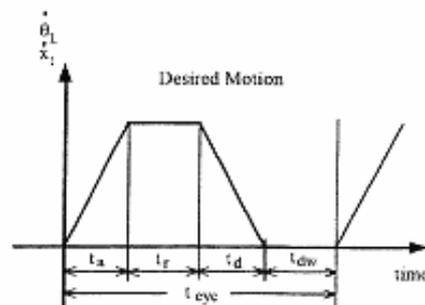


Figure 2

4. Fig. 3 shows a rotary motion axis driven by an electric servo motor directly. The rotary load is a solid cylindrical shape made of steel material,  $d= 50 \text{ mm}$ ,  $l= 60 \text{ mm}$ ,  $\rho= 7800 \text{ kg/m}^3$ . The desired motion of the load is a periodic motion. The total distance to be traveled is  $1/4$  of a revolution. The period of motion is  $t_{\text{cyc}}= 250 \text{ ms}$ . and dwell portion of it is  $t_{\text{dw}}= 100\text{ms}$ . And the remaining part of the cycle time is equally divided between acceleration with an exponential form; according to the following equation:  $k (e^{10t} - 1)$ , constant speed and deceleration with a linear form. Determine the peak and root mean square torques of a suitable motor for this application.
5. Consider a machine with a rotary motion axis driven by an electric servo motor; see Figure 3. The machine is connected to the motor shaft through timing belt. The following specifications summarize the system: The timing belt reduction ratio: 2:1, the rotary load is a solid cylindrical shape made of steel material,  $d= 100 \text{ mm}$ ,  $l= 60\text{mm}$ ,  $\rho= 7800 \text{ kg/m}^3$ , the equivalent viscous damping coefficient of the bearings on machine shaft is  $1.5\text{N.m.s/rad}$ . The desired speed motion profile of the load is a periodic sinusoidal motion with dwell portion. The total distance to be traveled is  $3/4$  of a revolution. The period of motion is  $t_{\text{cyc}}= 120 \text{ ms}$ . and dwell portion of it is  $t_{\text{dw}}= 20\text{ms}$ . Determine a suitable motor size to drive this machine. Taking into consideration that inertia ratio between the machine and the motor is 5:1.

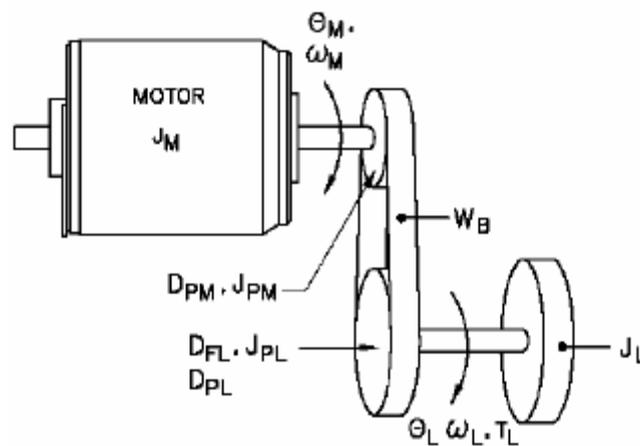


Figure 3

6. A conveyor; shown in Figure 4; is used to transfer bags 15 kg in a production line. The conveyor main roller is connected to main servomotor through a gear box with the following specifications: Roller diameter=300mm, Roller length=1000mm, gear box reduction ratio=50:1, orientation= $20^\circ$  to the horizontal plane, conveyor belt weight=10 kg, working temperature= $35^\circ\text{C}$ , maximum number of bags on conveyor at the same time=10 bags. The motion profile: Type:  $1/10 - 4/5 - 1/10$  –Trapezoid, distance =500mm, move time=30s, dwell time=3s. Determine the peak and root mean square torque of the servo motor.

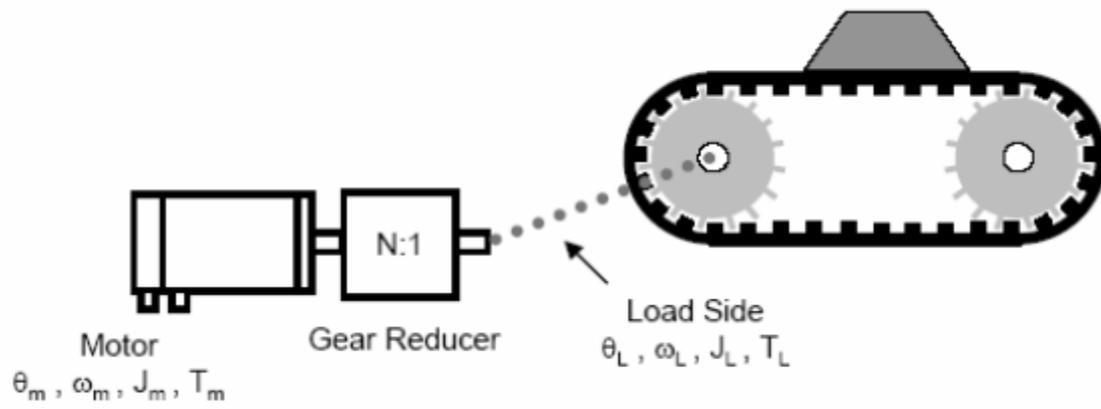


Figure 4