Quick Calculation Reference

Basics

Force = mass x acceleration

Torque = force x distance

For Linear Axes

Sum of Moments = 0

Sum of Forces = 0, except direction of travel F = m x a
(mass times acceleration)

For Rotary Axes

Sum of Forces = 0

Sum of Moments = 0, except axis of rotation T = J x α
(rotary inertia times angular acceleration)

Typical Analysis

(θ = 0 degrees – horizontal)

(θ = 90 degrees – vertical)

(g = acceleration of gravity)

(m = mass)

Normal Force = m x g x cos θ

(μ = coefficient of friction)

Axial Force = (m x g x sin θ) + (μ x m x g x cos θ) + (m x a) + externally applied force

Stiffness

Stiffness = force/deflection = K

Compliance = deflection/moment

Linear Deflection = force/stiffness

Angular Deflection = compliance x moment

$1/K\ (total) = (1/K_1) + (1/K_2) + (1/K_3) + (1/K_4) + \ldots$

Move Profile

V = 1.5 x (D/T) – trapezoidal move profile only

A = 4.5 x (D/T^2) – trapezoidal move profile only

(D = distance, T = Time)

Duty Cycle

Duty Cycle = move time/total time

Typical Motor Sizing Calculations for Linear Axes

Rotary to Linear Motion Conversion

Torque(1) = (Force x lead) / (2 x π x efficiency)

(Force = total axial force)

ω (angular velocity) = V (velocity)/L (lead)

α (angular acceleration) = a (linear acceleration)/L (lead)

Constant Speed For Motor Sizing

Torque(2) = (torque(1) + running torque (due to inherent friction)) / (gear reduction ratio)*

*(if there is no gear reduction, the ratio = 1)

Acceleration For Motor Sizing

J = rotary inertia

Torque(3) = Torque(2) + J(total) x α

J(total) = J(gear reduction) + [J(precision table)/(gear reduction ratio)^2]

J(precision table) = J(coupling) + J(drive screw) + (m(moving) x (lead/2 x π)^2)

m(moving) = total moving mass including carriage

$\alpha < \alpha$ (max) of the motor

RMS Torque

$T(rms) = \sqrt{T(a)^2 \times t(a) + T(b)^2 \times t(b) \times T(c)^2 \times t(c)}\ /\ (t(a) + t(b) + t(c))$

T = torque

t = time

Typical Safety Margins For Motor Sizing

Servo 20%

Stepper 50%

Inertia Ratio for Motor Sizing

(Load Inertia / Motor Inertia) < 5 (ideally)

Please refer to the Engineering Section for further details.

Industrial Devices Corporation
707-789-1000 • 800-747-0064 • E-mail: info@idcmotion.com