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PROJECT: Precision Underwater Positioner

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Title: Motor Sizing calculations

UNITS:

$kip \equiv 1000 \cdot lbf \quad ksi \equiv \frac{kip}{in^2} \quad psi \equiv \frac{lbf}{in^2}$

$ozf := \frac{1}{16} \cdot lbf$

PROPERTIES & ASSUMTIONS:

Weight of probe head $F_1 \equiv 15 \cdot kg$

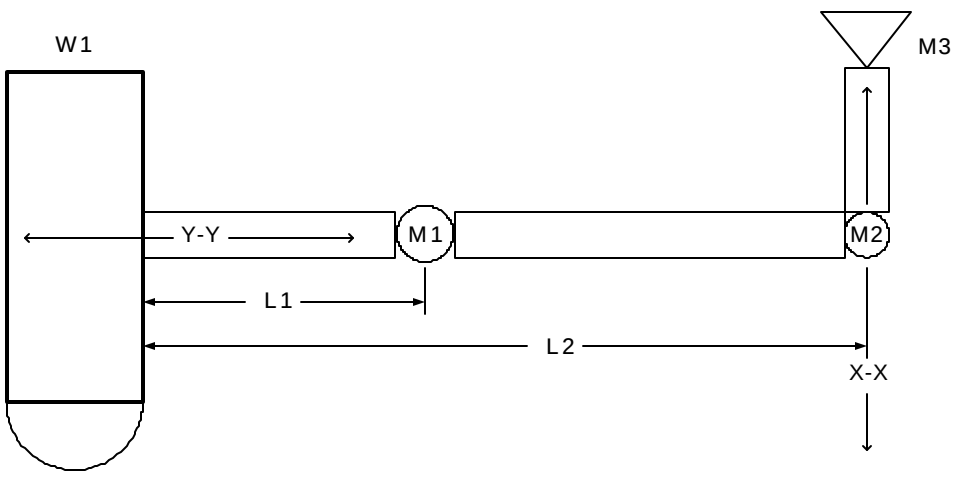
Probe head length = y_{ph} $y_{ph} := 18.5 \cdot in$

Radius of probe head $a_{ph} := 2.5 \cdot in$

Probe Head mass $m_{ph} := F_1 \quad m_{ph} = 33.069\,lb \quad m_{ph} = 15\,kg$

Length 1= length of first joint: $L_1 := 6 \cdot in$

Length 2 = total length: $L_2 := 16 \cdot in$



CALCULATION:

Mass moment about x-x
Probe head

$I_x := \left(\frac{1}{2} \cdot m \cdot a^2\right) + m \cdot y^2$

$I_x := \left(\frac{1}{2} \cdot m_{ph} \cdot a_{ph}^2\right) + m_{ph} \cdot y_{ph}^2$

$I_x = 79.315\,lb\,ft^2$

$I_x = 3.342\,kg \cdot m^2$

Mass moment about x-x
Square bar linkage 2x2

$m_L := 7 \cdot lb$

$I_{x2} := \frac{1}{3} \cdot m_L \cdot \left(L_2^2\right)$

$I_{x2} = 0.175\,kg \cdot m^2$

Torque required at Rotary joints:

Inertia total x-x $I_{xx} := I_x + I_{x2}$

Load inertia $I_{xx} = 3.517\,kg \cdot m^2$ $J_1 := I_{xx}$

Total inertia for motor $J_m := J_1$

Load accel from zero $\omega_1 := 0 \cdot \frac{rad}{sec}$

Time to accelerate $t := .5 \cdot sec$

Final velocity $\omega_2 := .013 \cdot \frac{rad}{sec}$

(Move 45 deg in 60 sec)

Angular acceleration (rad/ sec^2) $a := \frac{\omega_2 - \omega_1}{t}$

$a = 0.026 \frac{rad}{sec^2}$

Torque required for given load $T_{total} := J_m \cdot a$

$T_{total} = 0.091\,newton \cdot m$

$T_{total} = 0.067\,ft \cdot lbf$

$T_{total} = 12.95\,ozf \cdot in$

Alternate check

Titanium density $\rho := .072 \cdot \frac{kg}{m^3}$

Radius of can $r := .06 \cdot m$

Length from axis of measure to center of mass. $L_x := .45 \cdot m$

Mass of can $M := 15 \cdot kg$

Polar moment of inertia $\frac{1}{2}$ ^{2}

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Polar moment of inertia for a mass $J_x := \frac{2}{2} \cdot M \cdot r^2$

Angular displacement $D_1 := 45 \cdot deg$

Time to travel $t_1 := 1 \cdot sec$

Velocity deg/sec $v_1 := \frac{D_1}{t_1}$

Acceleration rad/sec^2 $a_x := \frac{v_1}{t_1}$

$v_1 = 45 \frac{deg}{sec}$

$v_1 = 0.785 \frac{rad}{sec}$

Transfer axis equations $J_{m1} := J_x + L_x^2 \cdot M$

$J_{m1} = 3.064\, kg \cdot m^2$

Torque required for rotation $T_2 := J_{m1} \cdot a_x$

$T_2 = 2.407\, newton \cdot m$

$T_2 = 340.84\, ozf \cdot in$

$k \equiv kip \qquad ksf \equiv \frac{kip}{ft^2} \qquad psf \equiv \frac{lbf}{ft^2} \qquad pcf \equiv \frac{lbf}{ft^3} \qquad plf \equiv \frac{lbf}{ft}$