TRITON ROBOTICS

Alternate Pitch Configuration Calculations

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By Roger Nguyen

Introduction

These calculations are used to determine the amount of torque needed to change the pitch in its current configuration and its alternate configuration. Subsequently, its power usage is calculated through torque. Additionally, the length of the chain needed, the increase in mass due to the new configuration, the mechanical advantage gained through a chain drive, and the change in torque and power needed by the yaw changing motor is calculated.

Constants

Weight of Top Plate and Objects Supported by Top Plate (M_P)	1264.62 g
Length of Top Plate and Objects Supported by Top Plate (l_t)	140 mm
Width of Top Plate and Objects Supported by Top Plate (w_t)	360.81 mm
Length of Turret (l)	204.30 mm
Height of Turret not including Yaw Motor (h)	228.36 mm
Weight of Old Turret not including Yaw Motor (M_{rest})	1874.78 g
Rated Torque of Motor	1.2 Nm
Angular Speed Range at Rated Torque	0-132 RPM

Motor Weight (M_M)	468 g
Motor Outer Radius (R_o)	33.35 mm
Motor Inner Radius (R_i)	9 mm
Long Shaft Mass (M_{LS})	78.87 g
Long Shaft Radius (R_{LS})	4 mm
Short Shaft Mass (M_{SS})	19.68 g
Short Shaft Radius (R_{SS})	4 mm
Motor Connecter Mass (M_{MC})	82.71

<u>Torque Needed to Change Pitch of Current Configuration Turret</u>

A lot of **assumptions** were made in order for the calculation to be simple. The angular displacement is 45 degrees, the motor constantly rotates at the root mean square of the maximum angular speed at rated torque and is a uniform density hollow cylinder, and the top plate and the objects supported by it are assumed to be a uniform rectangular prism.

$\omega_{rms} = 93.34\,RPM;\ \Delta\theta = 45^o;\ \omega_0 = 0$

Using the equation, $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$, $\alpha = 60.8\,rad/s^2$. The moment of the plate and the motor combined is

$I_{Plate} + I_{Motor} = (\frac{1}{12}M_P(l_t^2 + w_t^2)) + (\frac{1}{2}M_M(R_o^2 + R_i^2))$.

Using the equation, $\tau = I_{total}\alpha$, the torque needed to change the pitch by 45 degrees at the root mean square of the maximum angular speed at rated torque is **0.977 Nm**. This gives us a current of 1.32 A and a **power consumption of 9.23 W**.

<u>Mechanical Advantage of Chain Drive</u>

Since the sprockets have the same number of teeth, **the mechanical advantage is 1**.

<u>Torque Needed to Change Pitch of Current Configuration Turret</u>

The same assumptions were made as above, but another is that the torque transfer from the motor to the shaft is 100% and the motor connector and motor are assumed to be a combined uniform density hollow cylinder. The key difference from the earlier calculation is that given the same input, how much is the pitch rotated; using this value, the torque is calculated with a 1:1 relationship with angular displacement.

$\omega_{rms} = 93.34\, RPM;\ \omega_0 = 0;\ \alpha = 60.8\, rad/s^2$

The input torque of the chain drive is

$\tau_{input} = (I_{long\ shaft} + I_{motor\ and\ plate})\alpha = (\frac{1}{2}M_{LS}R_{RS}^2 + \frac{1}{2}(M_M + M_{MC})(R_o^2 + R_i^2)\alpha$

. This gives us an input torque of 0.017 Nm.

Since the mechanical advantage is 1, the input torque is equal to the output torque. The output angular acceleration of the chain drive is

$\tau_{output} = (I_{short\ shaft} + I_{Plate})\alpha_{output} = (\frac{1}{2}M_{SS}R_{SS}^2 + \frac{1}{12}M_P(l_t^2 + w_t^2))\alpha$. This gives us an output angular acceleration of $1.079\, rad/s^2$. Using the equation, $\omega^2 = \omega_0^2 + 2\alpha_{output}\Delta\theta$, this gives us an angular displacement of 44.31 degrees. This gives us **98.49% efficiency** compared to the direct drive of 45 degrees. The resulting torque needed is **0.992 Nm (a loss of 1.51% torque efficiency)**, giving us a current of 1.34 A, and **power consumption of 9.27 W**.

Total Mass Increase

The new mass is 2767.66 grams, giving us a **18.14% increase in mass** relative to the current configuration.

Length of Chain

The chainstay is 65.42 mm or 2.576 inches; the sprockets each have 10 teeth. Using the equation

$Length = 2(Chainstay\ Length\ in\ in) + (\frac{\#\ of\ Teeth\ on\ Driving\ Sprocket}{4} + \frac{\#\ of\ Teeth\ on\ Driven\ Sprocket}{4} + 1)$

, gives us a **length of 12 in.**

Torque and Power Consumption Increase of Yaw Motor

Similar assumptions are given to this calculation, but the entire turret is assumed to be an uniform density rectangular prism.

$\alpha = 60.8\, rad/s^2$

$\tau_{initial} = (\frac{1}{12}M_{rest}(l^2 + h^2) + \frac{1}{2}M_M(R_o^2 + R_i^2))\alpha$. This gives us an initial torque of 0.908 Nm. Since $\tau \sim M$, **the final torque is 1.11 Nm, which is a 22.25% increase in torque needed. The power consumption is a 22.14% increase from 8.58 W to 10.48 W.**