propShaftModelNotes

Objective

The objective of this is to *see* how varying the different parameters of a propeller *shaft* (not propeller) changes its speed characteristics. The torque to speed dynamics can be modeled as a mechanical shaft with inertia, linear damping, aero damping and stiction.

Model

$$\dot{\omega} = \frac{1}{J} \times (T - b_a\omega^2 - b_l\omega - s)$$

J is shaft inertia (including propeller) $kg.m^2$
b_a is aero damping (as the propeller spins) $Nm.s^2$ (this varies with speed in reality - but kept constant here)
b_l is linear damping $Nm.s$
s is stiction

Stiction details

Theoretically,

- $\omega = 0$
  - $s = min(|T|, s_{max}) \times sign(T)$
- $\omega \neq 0$
  - $s = s_{max} \times sign(\omega)$

For numerical simulation

- $|\omega| < 10^{-6}$ (very small number)
  - $s = min(|T|, s_{max}) \times sign(T)$
- $\omega < J \times \Delta t$
  - $s = (\omega \times s_{max}) \ / \ (J \times \Delta t)$
- $\omega \geq J \times \Delta t$
  - $s = s_{max} \times sign(\omega)$

Simulation with parameter variation

- blue line - baseline
- orange line - only stiction increases
  - lower steady state speed
  - lower acceleration from the start
  - higher deceleration throughout - as soon as external torque is removed
- yellow line - only linear damping increases
  - same lower steady state speed as the orange line
  - lower acceleration as speed gets higher

- lower deceleration as speed reduces - yellow line is almost parallel to the blue line