

Electric Motors For Model Aircraft

Flightline Hobby, Feb 10, 2017

Brushed vs Brushless Motors: physics

Brushed:

Magnetic fields switched mechanically. Timing is fixed.

Outrunners with stationary windings (surrounded by magnets) impractical.

Geared brush motors provide better RPM for model aircraft.

Brushless:

Rotor position is sensed via voltage pulse, timing is variable.

Outrunners - more poles - lower RPM higher torque enable direct drive.

Brushless Motor advantages

No brushes to wear, power remains constant with use.**

**Power will drop if magnets get hot.

**Magnetic resistance to temperature = \$\$

Ideal torque / RPM ranges for model aircraft w/o gearbox.

Higher efficiency.

Electric Motors in a Nutshell

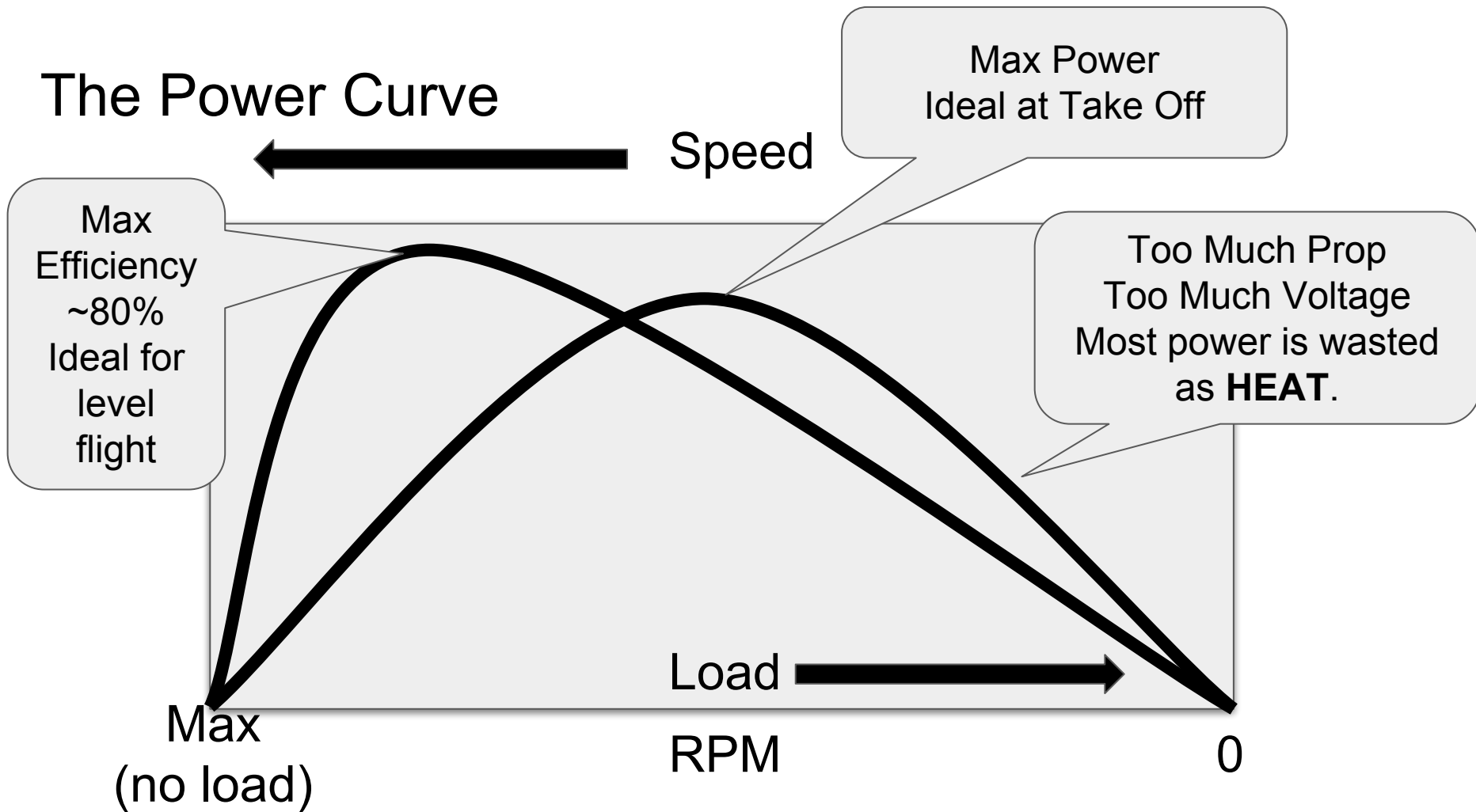
Voltage ~ RPM

Amperage ~ Load

Larger diameter and/or greater pitch = more load!

More voltage = more RPM = more load!

The Power Curve



First Priority: Power

70 to 100 watts / lb: Scale Flying

100 to 130 watts / lb: Sport Flying

> 180 watts / lb: 3D Flying

Tradeoffs for a given power

Tiny prop spinning very fast

- Limited by the speed of sound
- Not much area

Big prop spinning slow

- Limited by ground clearance

Speed

- At 10,500 RPM:
 - Pitch Speed (mph) = Pitch (inches) * 10
 - For example: 10 x 7 prop - 70 mph
- No load Motor RPM = voltage * kV
 - For Example 12 volts * 980 kV = 11,760 RPM
 - Approx. 80% or 9,400 RPM with prop drag.

Common Design Solutions

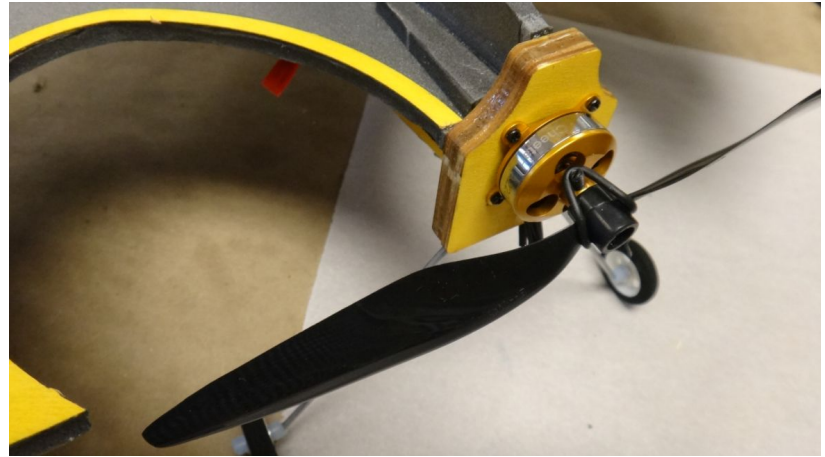
- UMX Stearman (2S 240 mah)
- 3.5 oz, ~17 watts*
- ~80 watts/lb
- 5.75" x 2.5" prop
- $3000 \text{ kV} * 8 \text{ volts} = 24,000 \text{ RPM}$
- Tip speed ~ 67% SS
- Pitch Speed ~ 45 mph



*Watts estimated, no specifications found.

Common Design Solutions

- Foamie (2S 450 mah)
- 7 oz, ~46 watts
- ~105 watts/lb
- 8" x 4.3" prop
- $1400 \text{ kV} * 8 \text{ volts} = 11,200 \text{ RPM}$
- Tip speed ~ 44% SS (slow flyer)
- Pitch Speed ~ 37 mph



Common Design Solutions

- UMX Waco (3S 2200 mah)
- 51 oz, ~450 watts*
- ~141 watts/lb
- 11" x 7" prop
- $880 \text{ kV} * 12 \text{ volts} = 10,560 \text{ RPM}$
- Tip speed ~ 57% SS
- Pitch Speed ~ 56 mph



*Watts estimated, no specifications found.

Common Design Solutions



- 25e Super Cub (4S 3200 mAh)
- 6 lbs, 600 watts
- 100 watts/lb
- 14" x 7" prop
- $870 \text{ kV} * 12 \text{ volts} = 10,440 \text{ RPM}$
- Tip speed = 72% SS
- Pitch Speed ~ 56 mph



What is Consistent in a Balanced System

- ~ 100 watts / lb
- Tip speed ~ 2/3 the speed of sound
- Pitch speed of 35 to 55 mph
- RPM similar to glow engines
 - .049 turned > 20,000 RPM
 - Larger glow - 8,000 to 9,000 RPM on bench, ~10,000 to 11,000 RPM in the air.

Common Battery Sizes and Motor / Prop Combos

- Battery	Watts	KV	Prop
- 2S 240 mAh	17	3000	5.75" x 2.5"
- 2S 450 mAh	50	1400	8" x 4.3"
- 3S 2200 mAh	450	900	11" x 7"
- 4S 3200 mAh	600	870	14" x 7"

Selecting a Motor/Battery/Prop Combo

- Power - typically 100 watts / lb
- Motor manufacturers data
- Online calculators (ecalc.ch)
- Match pitch speed to your model
- Electric props vs glow props
- Check Installation with a Power Meter