ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017

THRUST EFFICIENCY OF DRONES (QUAD COPTER) WITH DIFFERENT PROPELLERS AND THERE PAYLOAD CAPACITY

Shubham Yadav
Punjab technical university
B.tech /aerospace engineering
Shubhamyaduvansi221@gmail.com

Monika Sharma
Punjab technical university
B.tech /aeronautical engineering
Monasharma2014.ms86@gmail.com

Abhishek Borad
Punjab technical university
B.tech /aerospace engineering
Boradabhishek84@gmail.com

ABSTRACT

This paper contains ananalysis of the different size of the propeller on manual and autonomous controlled QUAD – copter + TRI-copter separately. To check which propeller is more efficient to provide more thrust to carrying more Payloads at the same power supply and also find what is the thrust to weight ratio for same configuration models to increase performance.

Keywords

drone configuration, propellers details, power consumption, thrust -weight ratio, thrust efficiency with different propellers.

General Terms

There are some general terms which are used in drone technology mathematical term i.e. ηp = propeller efficiency, T = thrust, u = aircraft speed Shaft.

Propeller efficiency can be measured against advance ratio (J), the ratio of forward to rotational speed of the propeller,

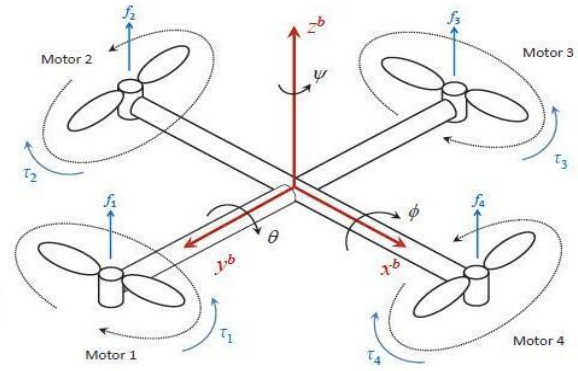
$$J = \frac{V}{nD}$$

Where V is forward speed of aircraft, n is the propeller rotation speed in revs/sec and D is the diameter of the propeller

1. INTRODUCTION

We are going to test different sized propellers on our quad copter‘s which having weight 850grm to 2kg weight without any payload. We Paddled (Changing of propellers) with motors which give us different -2 performance graph of thrust efficiency.Different types of drone have different application purpose. Quad copter Efficiency and also find out there flight time endurance.

We know that bigger propeller gives us more thrust efficiency in compression to smaller one. We will get suggested prop value in the brushless motor specification, so we should go with it but what if the value of props is not given. We will see kind of table with different props, Volts, Amp, Thrust and Efficiency. Here we shall have to try trial and error method. But it doesn’t mean we swing 13×3.8 prop on 1700kV motor. Lower kV motor can deal with a bigger prop. With increasing kV value size of the prop will be decreased. So we shall have to keep this in mind. For quadcopter, we should go with low pitch prop if we need more stability and fewer vibrations. Here e use some basic formulas to calculate the thrust-weight ratio, flight timing, payload, propeller thrust and there distribution on the multirotorquad.



2. MATHEMATICAL FORMULAE USED IN CALCULATION

Quadcopter flight times = (Battery Capacity * Battery Discharge /Average Amp Draw)*60Thrust=2x Total weight of model

propeller efficiency =up= T_{*u} / P_{shaft}

Where: ηp = propeller efficiency, T = thrust, u = aircraft speed Shaft

Propeller efficiency can be measured against advance ratio (J), the ratio of forward to rotational speed of the propeller,

$$J = \frac{V}{nD}$$

Where V is the forward speed of aircraft, n is the propeller rotation speed in revs/sec and D is the diameter of the propeller.

Thrust- weight ratio= total thrust of all motors/ total weight of model

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017

Payload Capacity = (Motor thrust * Number of motors * Hover Throttle %) –The weight of the model itself.

Power consumption = Amps x Volts = Watts AUW (all up weight) = 1/2 thrust (around)

1 amp (Continuous current of 1 amp) = 1000 mah

These above formula used in calculation analysis.

3. EXPERIMENTAL SECTION

Quadcopter Propeller size for reference:

Diameter Inch	Pitch Inch	60 Revolutions(Inch/Sec) 60 * Pitch
7	3.5	210
8	4.5	270
9	5	300
10	3.8	228
10	4.5	270
10	6	360
11	4.7	282
12	3.8	228

Type of prop is important as well, but we will see the effect of diameter and pitch on flight of Quad copter. In general, we see Quad copter Propeller size with the specification of below table

In general,we use maximum propellers size from 4 to 12 inch in RC drones. Here we consider from 7 to 12 inch propeller, but you can calculate propeller configuration from above data or formula.

Now we calculate some thrust with power consumption and motor rpm at different- different RPM with throttle percentage. Here we use thrust and power consumptions formula.

Motor Thrust Data table

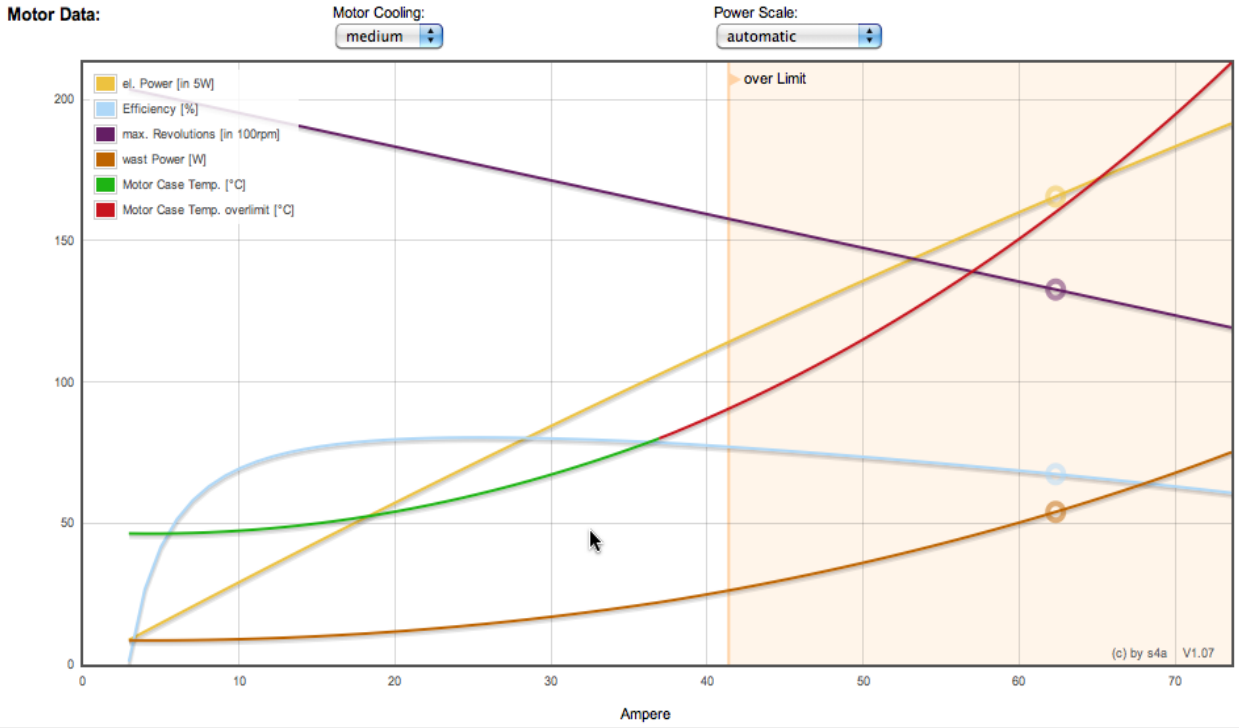
Here I used ecalc.com for complex calculation and graphs for motor characteristics and efficiency thrust limitation as shown below:-

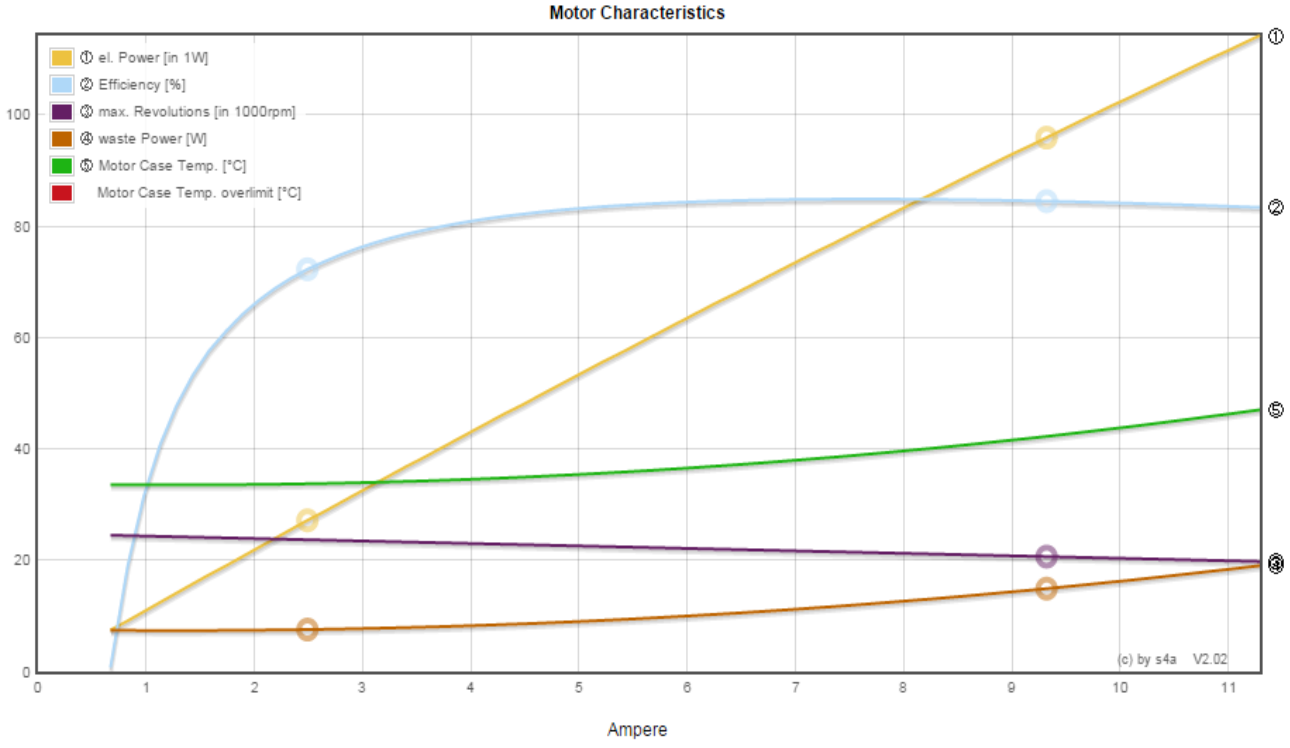
Volts	Props	Throttle	Amps	Watts	RPM	Thrust (g)
11.1	9443	30%	1.8	21.78	4780	187
11.1	9443	45%	3.2	38.72	5811	282
11.1	9443	65%	5.6	67.76	6906	438
11.1	9443	75%	7.6	91.96	7676	542
11.1	9443	100%	11.2	135.52	8498	706
11.1	10*5	30%	1.3	15.73	3821	108
11.1	10*5	45%	3.4	41.14	5385	285
11.1	10*5	65%	10.8	130.68	7985	661
11.1	10*5	75%	12.4	150.04	8313	737
11.1	10*5	100%	12.4	150.04	8325	734

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017

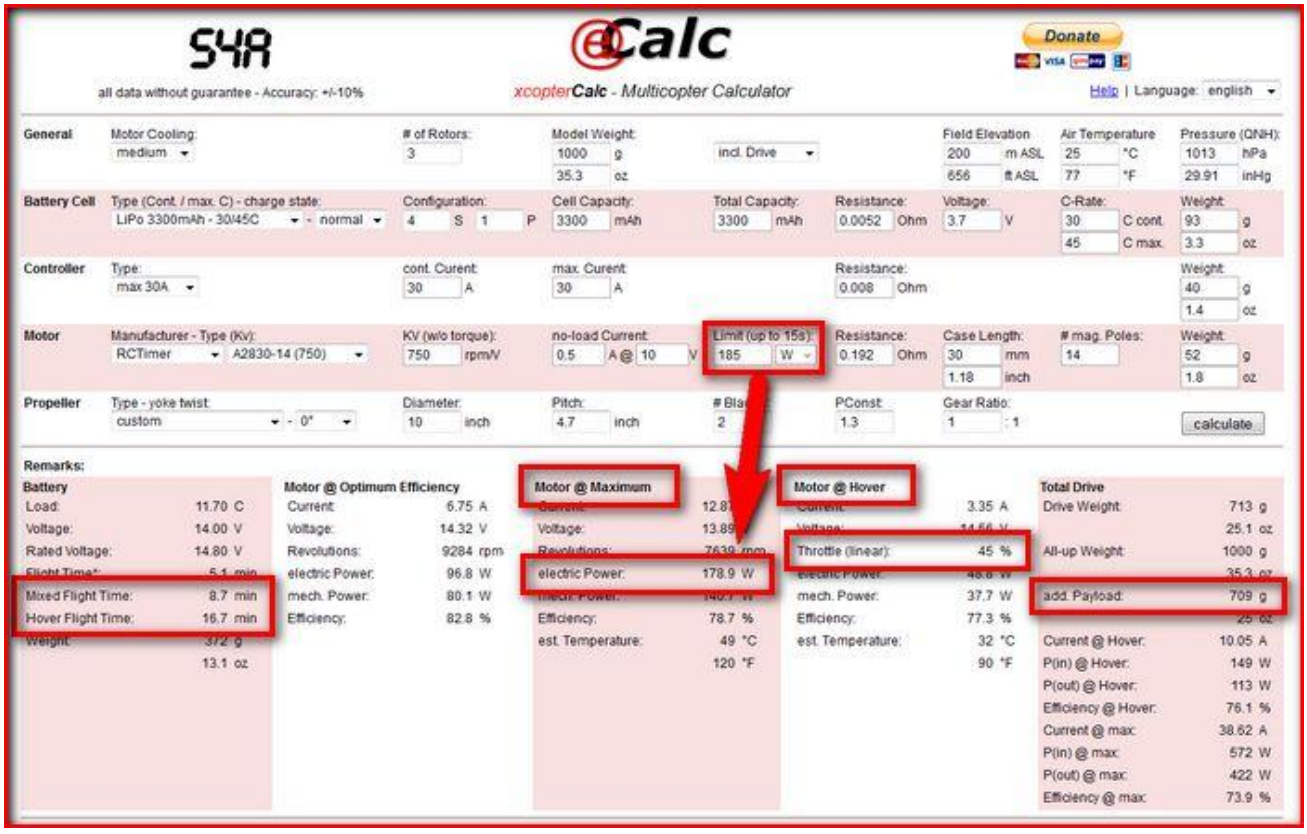




ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017



General	Motor Cooling: poor	# of Rotors: 4 flat	Model Weight: 1692 g / 59.7 oz	incl. Drive		Field Elevation: 0 m ASL / 0 ft ASL	Air Temperature: 20 °C / 68 °F	Pressure (QNH): 1013 hPa / 29.91 inHg		
Battery Cell	Type (Cont. / max. C) - charge state: custom - normal	Configuration: 3 S 1 P	Cell Capacity: 3600 mAh	Total Capacity: 3600 mAh	Resistance: 0.0068 Ohm	Voltage: 3.7 V	C-Rate: 20 C cont. / 30 C max	Weight: 86 g / 3 oz		
Controller	Type: max 20A	cont. Current: 20 A	max. Current: 20 A		Resistance: 0.01 Ohm			Weight: 25 g / 0.9 oz		
Motor	Manufacturer - Type (Kv): RCTimer - A2830-12 (850) search...	KV (w/o torque): 850 rpm/V	no-load Current: 0.5 A @ 10 V	Limit (up to 15s): 200 W	Resistance: 0.136 Ohm	Case Length: 30 mm / 1.18 inch	# mag. Poles: 14	Weight: 52 g / 1.8 oz		
Propeller	Type - yoke twist: APC SlowFly SF - 0°	Diameter: 10 inch	Pitch: 4.7 inch	# Blades: 2	PConst: 1.11	Gear Ratio: 1 : 1		calculate		

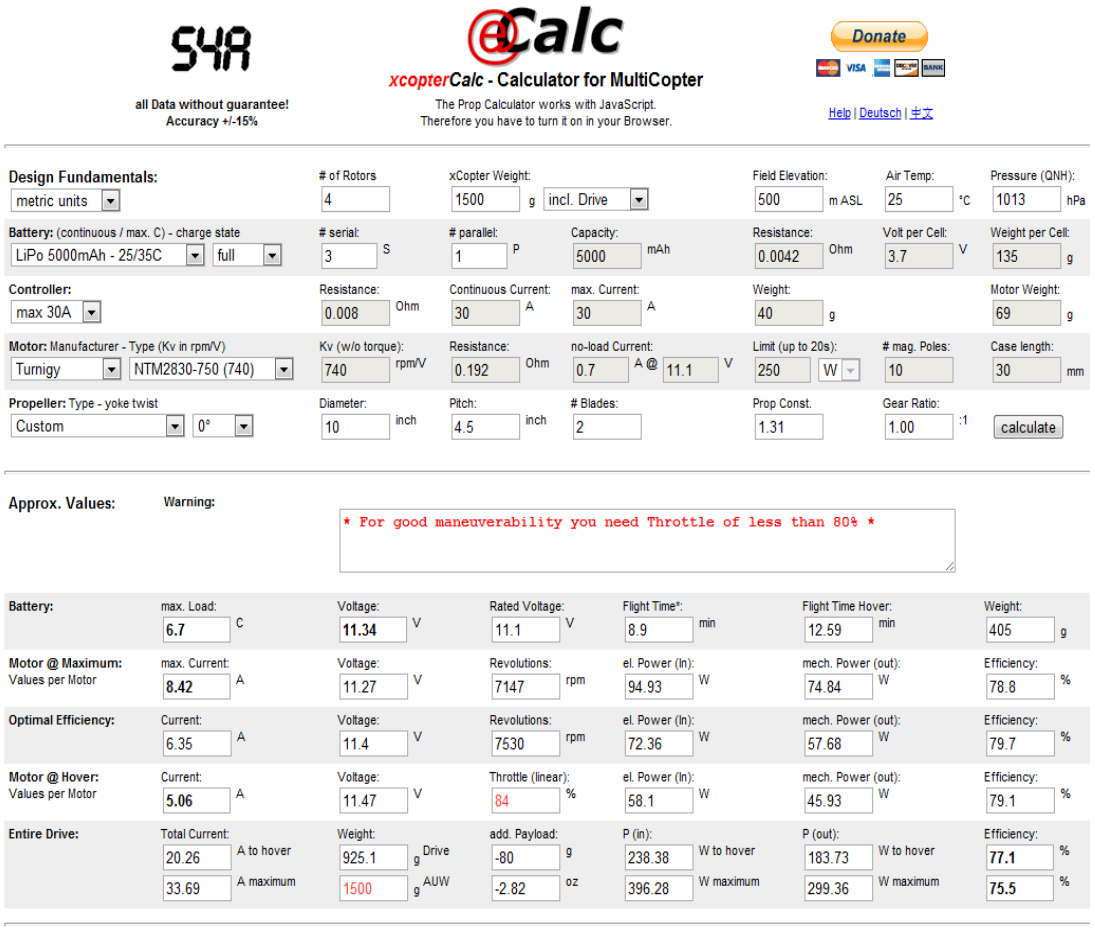
Remarks:

Battery		Motor @ Optimum Efficiency		Motor @ Maximum		Motor @ Hover		Total Drive		Multicopter	
Load:	11.29 C	Current:	6.16 A	Current:	10.16 A	Current:	5.60 A	Drive Weight:	623 g / 22 oz	All-up Weight:	1692 g / 59.7 oz
Voltage:	10.27 V	Voltage:	10.54 V	Voltage:	10.17 V	Voltage:	10.59 V			add. Payload:	98 g / 3.5 oz
Rated Voltage:	11.10 V	Revolutions*:	7996 rpm	Revolutions*:	7245 rpm	Throttle (linear):	75 %	Current @ Hover:	22.39 A		
Flight Time:	5.3 min	electric Power:	64.9 W	electric Power:	103.3 W	electric Power:	59.3 W	P(in) @ Hover:	248.6 W	max Tilt:	19 °
Mixed Flight Time:	6.9 min	mech. Power:	55.0 W	mech. Power:	85.2 W	mech. Power:	50.1 W	P(out) @ Hover:	200.5 W	max. Speed:	17 km/h
Hover Flight Time:	8.2 min	Efficiency:	84.7 %	Efficiency:	82.4 %	Efficiency:	84.6 %	Efficiency @ Hover:	80.6 %		10.6 mph
Weight:	258 g / 9.1 oz			est. Temperature:	36 °C / 97 °F	est. Temperature:	28 °C / 82 °F	Current @ max:	40.65 A		
						specific Thrust:	7.14 g/W / 0.25 oz/W	P(in) @ max:	451.2 W		
								P(out) @ max:	340.8 W		
								Efficiency @ max:	75.5 %		

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017



548

all Data without guarantee!
Accuracy +/-15%

eCalc

xcopterCalc - Calculator for MultiCopter

The Prop Calculator works with JavaScript.
Therefore you have to turn it on in your Browser.

Donate

Help | Deutsch | 中文

Design Fundamentals: metric units | # of Rotors: 4 | xCopter Weight: 1500 g, incl. Drive | Field Elevation: 500 m ASL | Air Temp: 25 °C | Pressure (QNH): 1013 hPa

Battery: (continuous / max. C) - charge state: LiPo 5000mAh - 25/35C, full | # serial: 3 S | # parallel: 1 P | Capacity: 5000 mAh | Resistance: 0.0042 Ohm | Volt per Cell: 3.7 V | Weight per Cell: 135 g

Controller: max 30A | Resistance: 0.008 Ohm | Continuous Current: 30 A | max. Current: 30 A | Weight: 40 g | Motor Weight: 69 g

Motor: Manufacturer - Type (Kv in rpm/V): Turnigy, NTM2830-750 (740) | Kv (w/o torque): 740 rpm/V | Resistance: 0.192 Ohm | no-load Current: 0.7 A @ 11.1 V | Limit (up to 20s): 250 W | # mag. Poles: 10 | Case length: 30 mm

Propeller: Type - yoke twist: Custom, 0° | Diameter: 10 inch | Pitch: 4.5 inch | # Blades: 2 | Prop Const.: 1.31 | Gear Ratio: 1.00 :1 | calculate

Approx. Values: Warning: * For good maneuverability you need Throttle of less than 80% *

Battery:	max. Load: 6.7 C	Voltage: 11.34 V	Rated Voltage: 11.1 V	Flight Time*: 8.9 min	Flight Time Hover: 12.59 min	Weight: 405 g
Motor @ Maximum: Values per Motor	max. Current: 8.42 A	Voltage: 11.27 V	Revolutions: 7147 rpm	el. Power (In): 94.93 W	mech. Power (out): 74.84 W	Efficiency: 78.8 %
Optimal Efficiency:	Current: 6.35 A	Voltage: 11.4 V	Revolutions: 7530 rpm	el. Power (In): 72.36 W	mech. Power (out): 57.68 W	Efficiency: 79.7 %
Motor @ Hover: Values per Motor	Current: 5.06 A	Voltage: 11.47 V	Throttle (linear): 84 %	el. Power (In): 58.1 W	mech. Power (out): 45.93 W	Efficiency: 79.1 %
Entire Drive:	Total Current: 20.26 A to hover, 33.69 A maximum	Weight: 925.1 g Drive, 1500 g AUW	add. Payload: -80 g, -2.82 oz	P (in): 238.38 W to hover, 396.28 W maximum	P (out): 183.73 W to hover, 299.36 W maximum	Efficiency: 77.1 %, 75.5 %

4. RESULT

After doing all calculation, we can see that with different propellers motors give different amount of thrust at varying throttle we calculate thrust of propeller 9443 which gives 706 gram thrust on 100% throttle the other hand 1045 gives 737grm thrust at full throttle 1045 gives 31grm more thrust with same motor configuration. It defines that if we want to improve our thrust efficiency to carry more payload .so we need large propeller instead of smaller one. And also need to more power source to increase flight timing of quad.

5. CONCLUSION

Before DIY Quad copter, you should clearly know what you want? How to looking the right components and put them

Together on one frame and make sure everything is set up correctly. The point is to choose the right motor and propeller

And match each other in the process of making quad or any drone. You can use above formula for your one. And take my calculation as a reference.

Some other example of drone thrust requirement with power consumption Shown below-

Quad copter suggestions – related to Lipo	
Quad copter Type	Lipo Batteries
Mini quad	Lipo 80-800mAh 1s/2s
180	Lipo 1000mah/1300mAh 3S/4S
210	Lipo 1000mah/1300mAh 3S/4S
250	Lipo 1300-1800mAh 3s/4s
280/290	Lipo 1500-3300mAh 3s
330/360	Lipo 2200-3200mah 4s
400	Lipo 3200-3300mah 4S
450	Lipo 3300mAh 4S
500	Lipo 3300-5000mAh 4s
540	Lipo 5000-5200mAh 4s
550/650/750mm	Lipo 5000-8000mAh 4s/5s/6s
800mm or big	Lipo 8000mah-30000mah 6s

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 4 – No.2, April 2017

Quad copter frame and Lipo battery and motor and propeller size matching table

Frame Size	Prop Size	Motor Size	Motor KV	Lipo battery
120mm or smaller	3 inch	1104 – 1105	4000KV+	80-800mAh 1s/2s
150mm – 160mm	3-4 inch	1306 – 1407	3000KV+	600-900mAh 2s/3s
180mm	4 inch	1806 – 2204	2600KV+	1000-1300mAh 3s/4s
210mm	5 inch	2204 – 2206	2300KV-2700KV	1000-1300mAh 3s/4s
250mm	6 inch	2204 – 2208	2000KV-2300KV	1300-1800mAh 3s/4s
330mm – 350mm	7, 8 inch	2208 – 2212	1500KV-1600KV	2200-3200mah 3s/4s
450mm – 500mm	9,10,11 inch	2212 – 2216	800KV-1000KV	3300mAh 4s or +

Famous comparison chart for Quadcopter power consumption

Drone	Power consumption	Flight Time	Take-off Weight
Phantom 2	5.6W	25 mins	1.3kg MAX
Typhoon Q500	10W	25 mins	1.7kg
Typhoon H	16W	22 mins	1.8kg
MG-1	6400 W	10 mins	22.5 kg

6. FUTURE SCOPE:

For good combination of propeller and motor above calculation clarify all doubt.

For any electric motor thrust, you can use above formulas. When you use fuel as a power, then some extra terms will be used like fuel consumption rate, etc.

7. REFERENCES

[1] John Anderson aerodynamics -2 book
[2] Quad Articles of hobbyking.com
[3] http://www.rcdronegood.com/quadcopter-battery-calculator-flight-times/
[4] http://a.moirier.free.fr/A%E9rodynamique/Bouquins/Anders
[5] On/Anderson%20~%20Fundamentals%20of%20Aerodynamics%20.pdf
[6] ECalc - propCalc - the most reliable Propeller Calculator on the Web
[7] RC hobbies.com.