Next Level Helicopter Flying: Using Rubber Density Measurement to Get Really Long Flights!

By Brian Turnbull for NFFS, September 5, 2024

Read the NFFS "Basic Helicopter Flying" before going through this document. See the NFFS Helicopter Student Resources webpage here: https://www.freeflight.org/science-olympiad/science-olympiad-resources/

Watch the NFFS "Helicopter Basics" video here: https://www.youtube.com/watch?v=86ZrFkga40c

General Observations

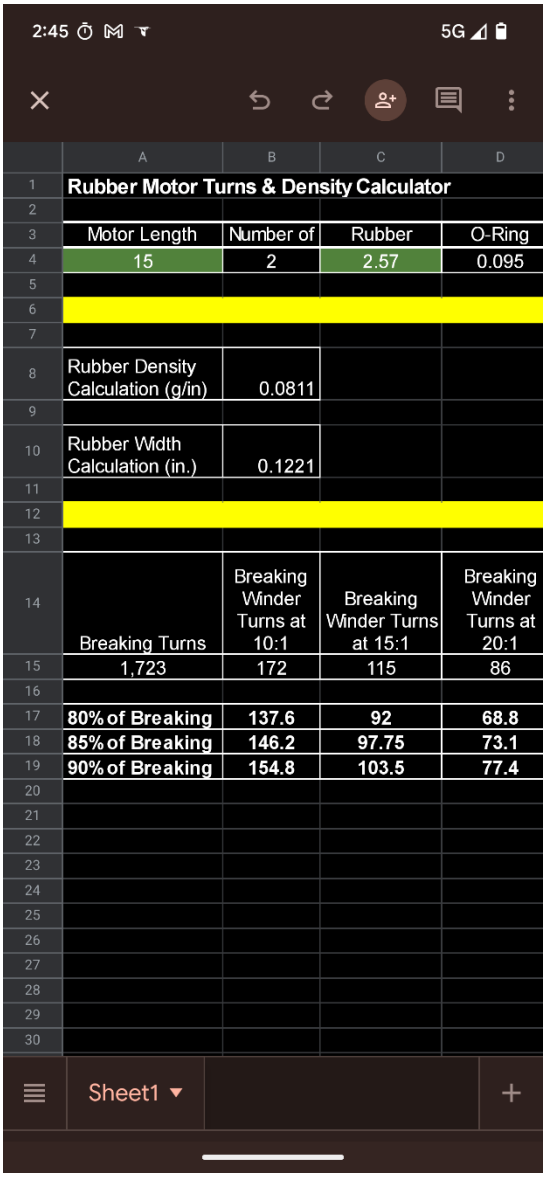
1) Instead of using "rubber width" (ex. 1/8", 3/32", etc.) during testing, a more precise measurement is to use rubber motor average linear density (we'll call this just "density" from now on), which is simple to calculate as it's just rubber motor mass divided by the length of the rubber strip that makes up the motor (which can be measured after the rubber strip is tied into a loop forming the motor).
2) Using density is a more efficient method to determine the best rubber motor for your heli and makes it easier to consistently repeat best flight times.
3) As Tan Super Sport rubber used for airplane and helicopter flying varies about 5% in thickness over its length, density of rubber motors cut from the exact same batch of rubber will also vary 5%.
4) In a batch of 1/8" rubber strip you can see density variation from .078 grams/inch to as much as .085 grams/inch. Rubber motors that vary even as little as .002 g/in will fly totally different. .078 g/in does not fly at all like .080 g/in.
5) To use rubber density for flying and testing your helicopter, simply measure rubber band strip length that makes up the motor and then weigh the motor after it is tied and subtract the weight of the o-rings and record density in your flight log.
6) For example, a 15" long motor loop is 30.5" of rubber strip as it is two 15" strands of rubber and has 0.5" of rubber in the knot. If this 15" motor weighs 2.57 grams and the O-rings weigh 0.1 gram, then the density of the rubber in the motor is (2.57-0.1)/30.5=0.081 g/in.
7) All mentions of "rubber motor" refer to the loop length not the length of the rubber strip in the loop.

Initial Rubber Selection

8) While SO airplane events usually have a rubber motor limit of 1.5 or 2.0 grams. **Helicopter for 2024-25 has no rubber weight limit.** Once heli design has been decided upon, the objective of testing is to determine the following:
    a. Rubber motor ideal density
    b. Rubber motor length
    c. Rubber motor total weight Testing rubber motor total weight is **a critical parameter that is unique to helicopter vs. airplanes**.
    d. Too much rubber length for a particular density means that the heli is carrying additional weight that it doesn't need and this acts as ballast and reduces flight time.
9) Start with "mid-range" rubber length, density and motor weight per kit recommendations. Calculate this first motor's density (it might be in the .082 g/in for a 30 or 34cm rotor diameter). If there is no rubber motor length or weight recommendation, you can start with what is probably labeled in the kit as 1/8" or .125" width rubber strip and a motor length of one or two inches longer than the hook-to-hook measurement of the helicopter (rear rubber motor hook to front rubber motor hook).

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Rubber Motor Winding



10) Watch this new for 2024-25 SO Heli winding and launching video before you begin testing: https://youtu.be/o4UAXeURcSE

11) Download this "Maximum Turns & Average Density Calculator" from the NFFS website and use it! The calculator is the fourth link on this page ("Max Turns Calculator"). It downloads as soon as you click the link. https://www.freeflight.org/science-olympiad/science-olympiad-resources/

12) **Heli Max Turns Calculator** This calculator only requires data entry of the motor length and weight and the O-rings weight and it gives you the maximum turns that can be wound into the motor and calculates the average linear density and the equivalent "rubber width".

    a. The calculator is an Excel spreadsheet and you may need to install Google Sheets to use it (especially true if you have an Apple device).

13) Fly your initial flights at 65% of breaking turns with one or two backoff winder turns to test the heli for stability and to learn launching technique.

14) Once you have learned launching technique and are confident of your helis stability, wind all flights to at least 80% of maximum turns and use minimal backoff turns (1-3 winder turns or 10-45 motor turns if 15:1 ratio winder).

15) With rubber in the 1/8" width (.078-.085 g/in) range, maximum torque on the fully wound motor will feel very tight and the fully wound motor will be more difficult to handle and load on the heli compared to airplanes.

16) **A torque meter tip**: It's probably best not to wind wire element torque meters one full turn (for most this is 2.0 inch ounces).

17) **A winder tip for you all**: the yellow plastic K&P 10:1 winder might be easier to use for winding to high torque. The 15:1 winder might not be best for helicopter.

18) Another tip: high torque winding (close to 2.0 in oz) may damage expensive indoor rubber winders and torque meters. Get a K&P 10:1 winder!

19) For the longest flight times, only one or two backoff winder turns are needed (10-45 actual motor backoff turns). This will mean loading a motor onto a helicopter with over 1.0 in oz torque. Fairly strong fingers, and clean fingers with minimal lube on them are needed to handle a motor this tight. You could even grip the O-rings with hemostats. Build up to high torque launching and motor loading gradually.

20) Helicopters with close to or more than 1.0 in oz torque motors will fly very fast to the ceiling and hit the ceiling relatively hard. You will need to be sure that your helicopter design is sturdy enough for this.Once you have a number of test flights with a particular density and length rubber motor, the turns remaining data point and flight duration will help you determine whether to try shorter or longer or thicker or thinner (thicker or thinner means higher or lower density) rubber motor.

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21) To decide whether to go thicker or thinner or longer or shorter, count and record on you log remaining motor turns (see the winding/launching video linked above).

22) If max motor turns are in the 1,000 to 1,800 range and turns remaining are a lot (around 400-600 when flying in a 7-10 ft ceiling would be a lot), then the next motor to try would be either the same density and 1”-2” shorter motor length (which would mean overall motor is about 0.2 grams lighter) or the same length but higher density motor (maybe another .002-.003 g/in density), which would mean a heavier motor too.

23) If data from initial flights show very few turns remaining (150 or less), then a slightly longer same density or slightly lower density same length motor would be the next logical test.

24) Of course, also pay attention to flight time. If your change to a new thicker, thinner, longer or shorter motor results in poorer flight times, then it’s likely that you need to select a different parameter to change for the next series of flight tests.

25) When testing different motor density, weight or length, be sure to fly 3-5 flights with each different motor and do your best to wind each flight to the same maximum torque and backoff turns to the same launch torque and try to use count of turns that is close to the same percent of max turns as shown by the calculator.

26) When varying density, changes in the 0.002 gram/inch increments (ex. 0.080 g/in, then 0.082 g/in, etc.) are a good idea.

27) When varying length, changes in 1” increments of rubber motor loop length are a good idea (ex. Compare same density motors 13” long and then 14” long).

28) Continue this iterative cycle of testing to the extremes in order to determine the best possible rubber motor density, length and overall weight for your particular helicopter!