SIZING RUBBER MOTORS

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Sizing rubber motors is about balancing conflicting requirements. A rubber motor must meet all of several requirements:

Weight. Rubber is the source of the energy that lifts the plane. Duration is directly related to the amount of energy carried. So you would want the maximum weight of rubber you can get. But more weight also makes the plane come down faster. The duration trade off on weight occurs when the motor weighs twice the weight of the airplane. You will almost never get there, because one of the other requirements will restrict you to a smaller motor. In competition, rules will limit the weight of the motor to much less than this.

Length. A longer motor will take more turns for more duration. The motor must fit in the fuselage, it must fit between the propeller hook and the motor hook or peg. This may be the tightest limit on motor weight. You can make the motor longer than that distance, but only up to a point. You will find that when you get up around twice that distance, you will have troubles managing the motor. When you wind a very long motor and bring it in to fit between the hooks, it will ball up into a tangle. It will not unwind properly. It will jam on the stick or inside the fuselage. It will tangle allover the prop hook and jam it. Once it unwinds a little, it will hang down, no longer aligned with the prop shaft so it will not turn the prop. Braiding the motor will tighten it up a little and will allow you to get a little more rubber into the available space.

Cross Section. Cross section determines turns per inch capacity. Thinner motors can take more turns per inch, giving more propeller revolutions. Cross section determines torque. Greater cross section will produce higher torque values. A certain amount of torque is required to fly the plane. Torque required depends on the aircraft and propeller aerodynamics. Cruise torque, the torque to fly level, is a good indicator. In still air, cruise torque should occur at somewhat over half of maximum turns, maybe in the vicinity of 60% to 70%. (If you set maximum turns below breaking turns, cruise torque point should be reset.) The exact location depends on the shape of the torque curve for the particular batch of rubber used. (Or on the shape of the remaining curve if you set a maximum lower than breaking.) Cruise torque depends on the total weight, including the weight of the motor. Cross section is related to the other quantities because cross section times length times density equals weight. High torque also may produce undesirable rolling, which must be compensated with aerodynamic adjustments; dihedral, rudder, thrustline, aileron.

Center of Gravity. The plane must balance at a trim CG in order to fly properly. Motor weight and length affect CG. Motor CG will be at its midpoint. On a plane with a movable wing, the wing can be adjusted to accommodate different weights and lengths of motor. With a fixed wing, you may have no choice. Weight of motor will determine length or length will determine weight. It may be necessary to add ballast weight to accommodate the motor chosen. Ballast weight will increase the sinking speed. At some point, the added energy from a heavier motor will not overcome the added sink speed.

Structural Strength. The torque and tension in the rubber motor at full winds must be supported by the fuselage and appurtenant structures. A too strong motor will require strengthening the structures with corresponding weight increases. A weak structure will limit the size of the motor. Most of our model structures are pretty strong. This becomes an issue with ultralight indoor models.

Additional Considerations *Stew Meyers*

Rubber Clearance. On some short nosed WW I models the braided motor becomes several times the hook length. I have found there may not be enough room to fully wind the motor. The rows of knots may climb the hook, touch the structure and jam, stopping the prop. (Rather embarrassing during a mass launch.) If the model is picked up and the nose block extracted and reinserted in the model with fewer winds you get a normal flight. I could never wind my 18" Camel to more than 1200 turns despite the fact that 1600 turns were safe. It has a 5" hook length and used 24" of 1/8 x 4 rubber or a 15% rubber load. Ballasting considerations prevented using a higher percentage of rubber weight. Essentially the ballast weight was equal to the rubber weight. The solution might be to use a larger cross section and a larger prop. In any case, since then I have made a mock up of the fuselage for my WWI jobs to make sure the rubber will unwind properly and deliver the energy wound into the motor. You can check the unwinding motor for standing waves which can destroy structure as well as sap energy from the system. This also allows you to arrive at the correct number of

braiding turns by experimentation. Offset "S" hooks and bent prop shafts that contribute to vibrations are also easily exposed with this set up.

Basic Starting Point. Weigh the model with everything but rubber to get the empty weight. Divide this value by 3 to get the weight of rubber for a 25% weight ratio. Divide the all up weight (empty weight. + rubber weight) expressed in grams by 90 to get a suggested cross section width in inches. Now figure out the number of strands of various width rubber that will approximate this total width. (Draggy ships require larger widths than sleek jobs.) A 1.0 inch wide motor will weigh 8 grams per foot. So you can figure out how long the motor should be to match the desired weight .. Flight testing is required to really pin down the rubber - prop combination for your model. A good rule of thumb for max safe winding is 50 turns per inch of length for a 1" width of TAN (or Super Sport) rubber.