GRAPHICAL METHOD FOR DETERMINING MAXIMUM RUBBER TURNS FOR INDOOR MODEL AIRCRAFT

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Maximizing flight time is the ultimate goal in any indoor free flight duration event. The propellers on indoor models are continuously spinning during the flight. So knowing how many turns are present in the motor and the rate of consumption of those turns is beneficial when attempting to maximize duration potential. This can be crucial during a contest when the difference between first and third place may be only a few seconds and every turn needs to be put into a motor to win a contest or set a new national record.

By collecting some data when flying, the average turn consumption can be calculated after a flight.

$$Average\ RPM: \frac{(winder\ turns\ -\ backoff\ turns\ -\ turns\ left\ at\ landing)}{flight\ time\ in\ minutes}$$

A motor wound to 2150 turns, with 150 back-off turns, that lands with 200 turns, and gives a flight time of 20 minutes would have an average RPM of 90. With this information if you wanted to fly 22 minutes you would need approximately 90×2=180 more turns at launch. Sounds easy enough but will the motor take the extra 180 more turns or will the motor break?

In my beginning days of indoor modeling the method I used for determining how many turns a motor could take was to make small loops of various width rubber and wind them until they broke and record the data. This was helpful but not really an ideal solution and was time consuming. One day at a local club contest a fellow club member showed us some data tables and graphs he made on his computer using a method for predicting allowable rubber turns. He called it the “K” method. This “K” method used a simple formula to calculate the turns per inch that could be put into a loop of rubber. The formula he used was:

$N = \frac{K}{W^{1/2}}$

N = turns per inch of loop

W = rubber weight (ounces/inch of loop)

K = rubber factor

The “K” factor was a constant that had to be experimentally determined by test winding a few loops of rubber. Since the weight of the loop, length of the loop, and the turns the loop took at break point were all known, the K factor could then be calculated.

$$K = \left(\frac{Break\ turns}{Loop\ length}\right)\left(\frac{Loop\ weight}{Loop\ length}\right)^{1/2}$$

So a 14" test loop weighing .0494 ounces (1.4 grams) and taking 2000 turns at break point would have a resulting K factor of approximately 8.5. Using a K value slightly less, around 8.0 would be a good reference point during a contest when winding. For this sample motor, a K factor of 8 yields 1885 turns. Putting more turns above the 1885 would mean the possibility of breaking the motor as you would be nearing the danger zone for motor failure.

My father and I have used this method for rubber turns determination ever since. As new batches of rubber would come out the K factor would be adjusted and new data charts and tables printed. The only limitation of this method was its implementation during a contest. Calculating the break turns means making the motor, weighing it, calculating the weight per inch, and then using the K charts to find the number of turns per inch then multiplying the turns per inch by the motor length. This process could become tedious and mistakes could be made especially when time was running out near the end of a contest. Sometimes calculators would accidentally be left at home or the batteries would run dead when you least expected it.

As time went on we shifted from weighing motors in ounces and started weighing in grams. This was mainly due to the technological advances resulting in the cost reduction of small battery powered digital scales. With digital gram scales having a resolution down to .01 or .001 gram accuracy, the rubber charts were converted to incorporate the new measuring unit. However, the actual method for calculation was still unchanged as it still relied on a manually calculation or data entry into a spreadsheet on a laptop to give the maximum allowable turns. Laptops and cell phones can make it easy to perform the calculations but they also typically have short battery lives and external power may not always be available at a flying site so you may find yourself with a dead battery and no way to perform the calculations.

The need for a simpler method to determine maximum rubber turns had to be found. This new method should only require the length and weight of the rubber loop in grams to be measured and not rely on the use of formulas or calculation while at the contest to get the desired answer. With these ideas in mind the graphical method shown here was devised.

The graphical method developed is still based on the same K factor concept. However the main difference is that all the calculations required have already been performed and are represented in the forms of the curved plots on the graph. A K value of 8.5 was used to general these curves and that K value is a good representation of the batches of rubber currently used today for indoor competition. I use this chart for the 10/97, 5/99, and 3/02 batches of Tan II rubber and the results on this chart are very close to reality.

Each plotted curve on the graph represents a rubber motor of a consistent weight. There are multiple plots on the graphs and they range from 0.20 to 3.3 grams, which will cover just about any indoor duration model currently flown today. The loop lengths used for plotting ranges from 5" to 24" length, which will also cover most indoor models flown today. Maximum turns for motor lengths beyond 24" can also be determined by using this chart and the method for doing that will be shown later.

How to Use the Chart

To use this chart you only need to know two things about your motor, the length and weight. Once you have tied your motor measure the finished loop length of your motor in inches. Next weigh the unlubricated motor in grams. Find the loop length on the horizontal axis of the chart and then go vertically up the chart until you hit the curve that is labeled with the weight of your rubber loop. Once you find that point, now move horizontally to the left to see how many turns the motor will take. For the example shown on the graph, a loop of rubber 14", weighing 1.4 grams will take 2000 turns.

For loops longer than 24", the easiest method to determine the max turns is to divide the motor length and weight in half, find the maximum turns on the graph for the "half motor", then double the result. For example if you have a 26" long loop that weighs 2.50 grams, cutting that in half would give a 13" loop weighing 1.25 grams. Using the graph, the 13" loop intersects the 1.25 gram weight curve at 1900 turns. Since the full loop is 26" (twice as long), just double the 1900 and the result for the 26" loop will be 3800 turns.

Comments on the Use of this Method

The term "loop length" is the length of the loop when the motor is first made. Motors that have been broken in will be longer than when first made so if you use the stretched length on this graph you will most likely break motors before the predicted value. As a fresh

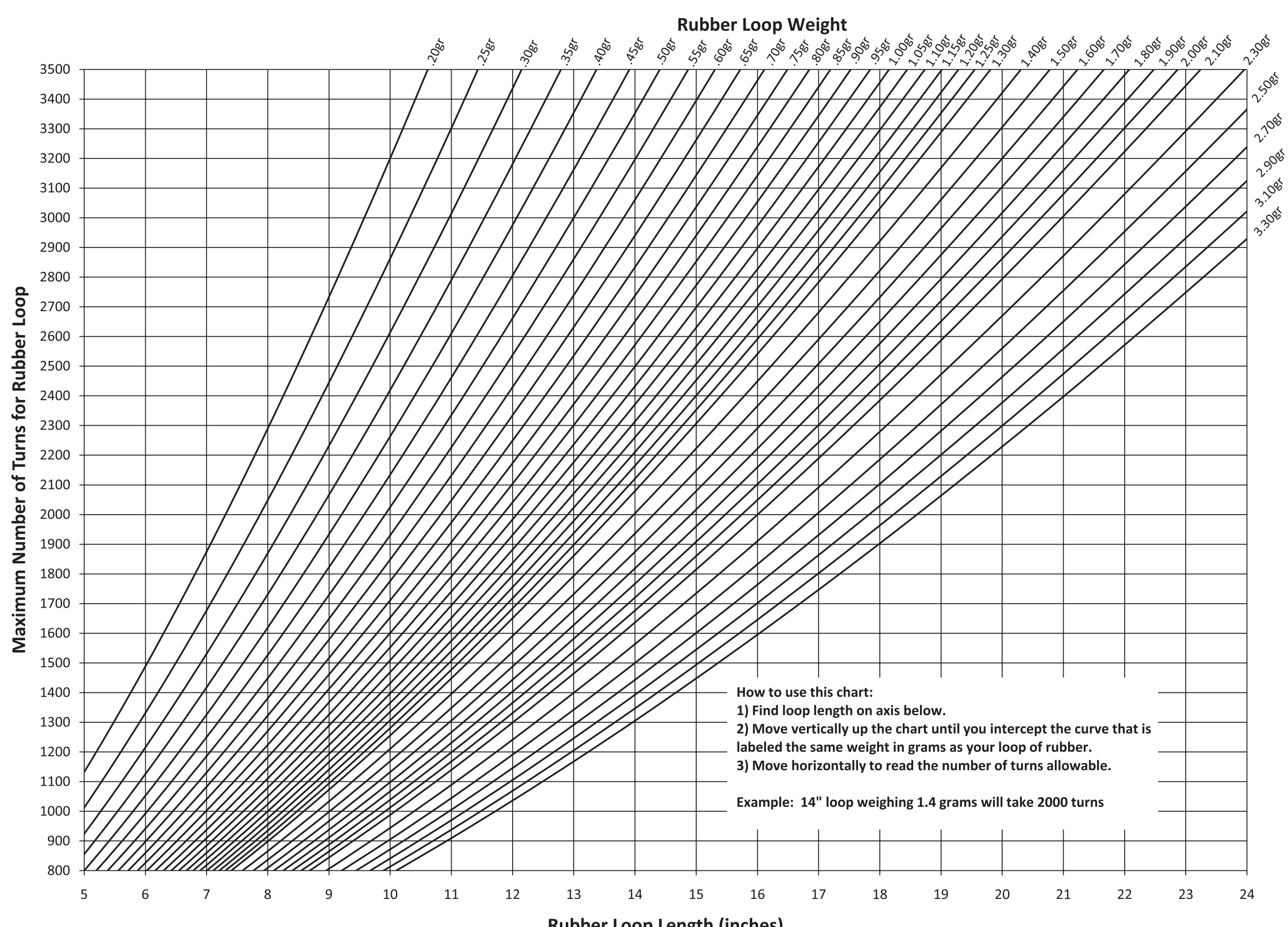

Figure 1: The Chart.

motor is broken in you may get slightly above the predicted value as the loops stretches out. Also there will be variation from rubber batch to rubber batch as well as winding technique and lubrication. However, the predicted values should be pretty close to what the graph shows. What I typically do is make up the motor and weigh it, look up the max turns on the graph then wind the motor to about 80% of those winds on the first wind up. The motor is then generously lubricated, then rewound again to 90-95% of the predicted turns value. The motor is unwound then lubricated again. The third wind is when I will use the motor to fly on and the motor has been broken in and will typically be able to now take close to 100% of the predicted turns.

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