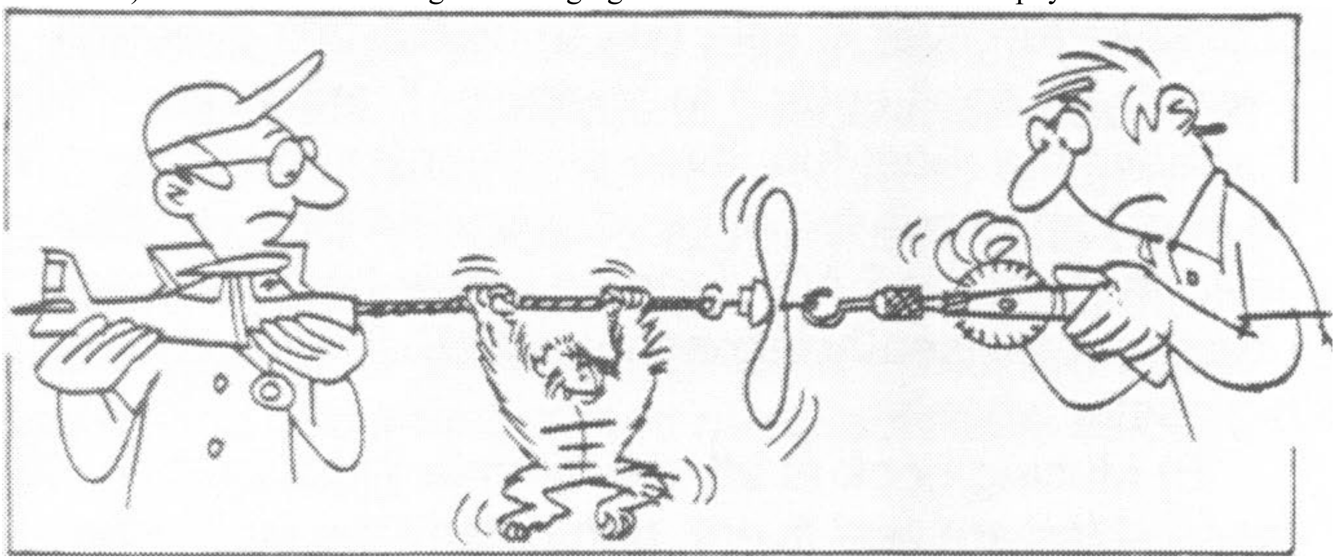
RUBBER FACTS

by Stew Meyers

The energy that we use to power our rubber powered models is stored as tension in the rubber strands. When the motor is wound, it is tensioned by twisting. There is a direct relationship between the torque and the tension in the motor. When tension is relaxed, the torque is reduced and vice versa. This can be easily demonstrated by watching a torque meter while varying the tension on a motor by stretching it to a different length without winding or unwinding. We dump the energy out of a wound motor by letting it tum a prop. The torque goes down as the winds come out and the tension becomes less.

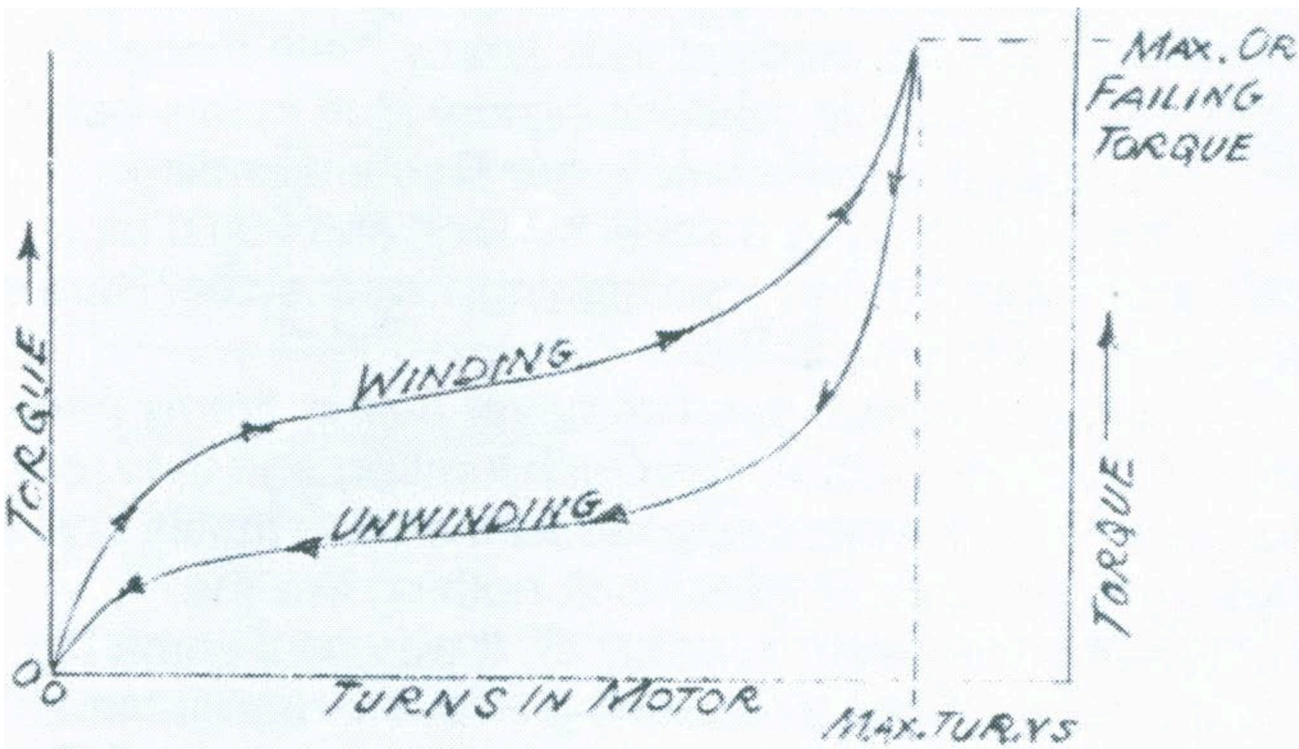
But that's a simplification of what is really going on. As you wind or unwind a rubber motor, it is constantly trying to redistribute the winds and knots into a minimum energy state. There is a continual trade off going on between the basic twist and the knots. (This action also occurs in DNA coiling, solar plasma physics and motions of undersea cables, and has been mathematically investigated for some time now.) You can think of Hungorilla hanging in there to enforce this law of physics.



Tension, since it is how the energy is actually stored, plays a big role in this. When you stretch a motor and wind, you are initially just putting in pure twist. As you relax tension, knots form. That's the reason for stretching the motor as much a possible when winding. The release of energy during the unwind can be rather chaotic as the motor relaxes and tries to maintain a minimum energy condition while twisting the prop. Here Hungorilla is most active and may poke a hole through the side of your model with a knot.

The ratio of the length of the rubber motor to the hook length has a big affect on the behavior of knot formation. The larger this ratio, the more chaotic the action. Braiding mitigates the problem as it maintains some tension in the unwinding motor, and tension favors twist over knots. The tension also tends to reduce standing waves that can form during the run down.

I have developed a recording torque meter system (RTM) that has allowed me to capture this action on an Excel spreadsheet and accurately plot the Torque-Turns graph for some typical FAC type motors. I am able to observe and record the behavior of rubber motors with high resolution. The unwinding of the motor driving a prop is also captured including time. Unfortunately tension is not yet measured. The knot formation is readily discernible as bumps on the curve.



Using the RTM was a real eye opener emphasizing the interplay of torque and tension. The ideal "S" shaped hysteresis loop of the typical rubber motor being wound and unwound like that shown below from McCombs is hard to reproduce in the real world.

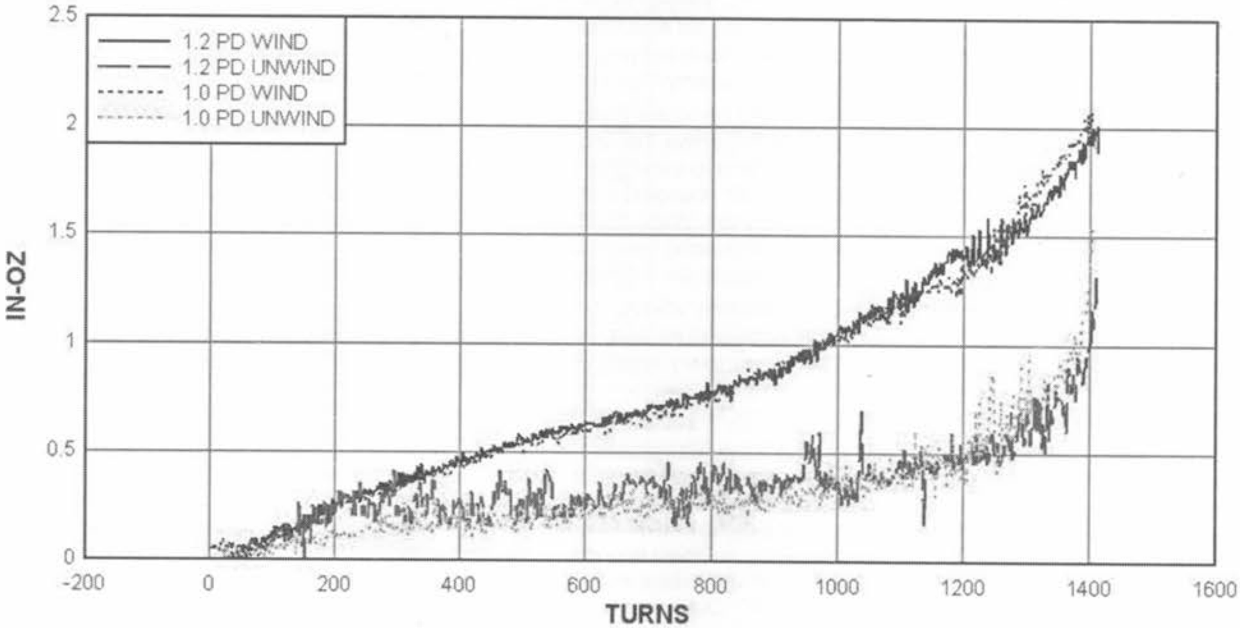
On the opposite page we see plots from the RTM. Two runs are compared using Peck props with different PDs. While the torque comparisons don't show major differences, the power comparison does. The winding curves are near identical as one would expect. I was trying to wind to 1400 turns or about 80%. I did the 1.0 PD run first. 1406 turns resulted in a little over 2.0 in-oz of torque maximum. However by the time I removed the rubber from the winder placed it on the prop hook and inserted the nose block in the test stand the torque dropped to 1.5 in-oz of torque. This of course is due to relaxation of tension in this process; and accounts for the major difference between the ideal and real case. On the second run with the 1.2 PD prop, I again went for 1400 turns. I noted the torque was a little low and added a few more turns. This time the installed torque was only 1.3 in-oz. Maybe the rubber was a little tired. I don't know, probably the knotting was a little different. The unwind curves show the 1.0 torque to be a little higher for the first 400 turns, then a little less. I don't know why.

The Power Comparison curves where derived RPM and Power are plotted over time shows the real effect of PD. The lower pitch prop is spinning much faster and therefore eating up the energy much faster. Not surprising since the power required is a function of the cube of the RPM. The twenty second difference in the motor run time is significant, but not the only discriminator between the performance of the model with these props. The lower pitch prop drives the model faster which results in more drag and in the case of the the dimer I am using it on a slightly erratic swoop before the steady climb. The slower longer climb of the higher pitch prop may not take it higher, but certainly the total time in the air is longer.

I am at a loss to explain why the 1.2 PD run has a higher specific energy although it has a few less turns and slightly lower initial torque. It may be that initial 15 second power burst is dissipating more energy out of the system with those torque spikes which indicate knots unwinding and transforming into turns.

TORQUE COMPARISON 7 IN PECK 1.0 & 1.2 PD

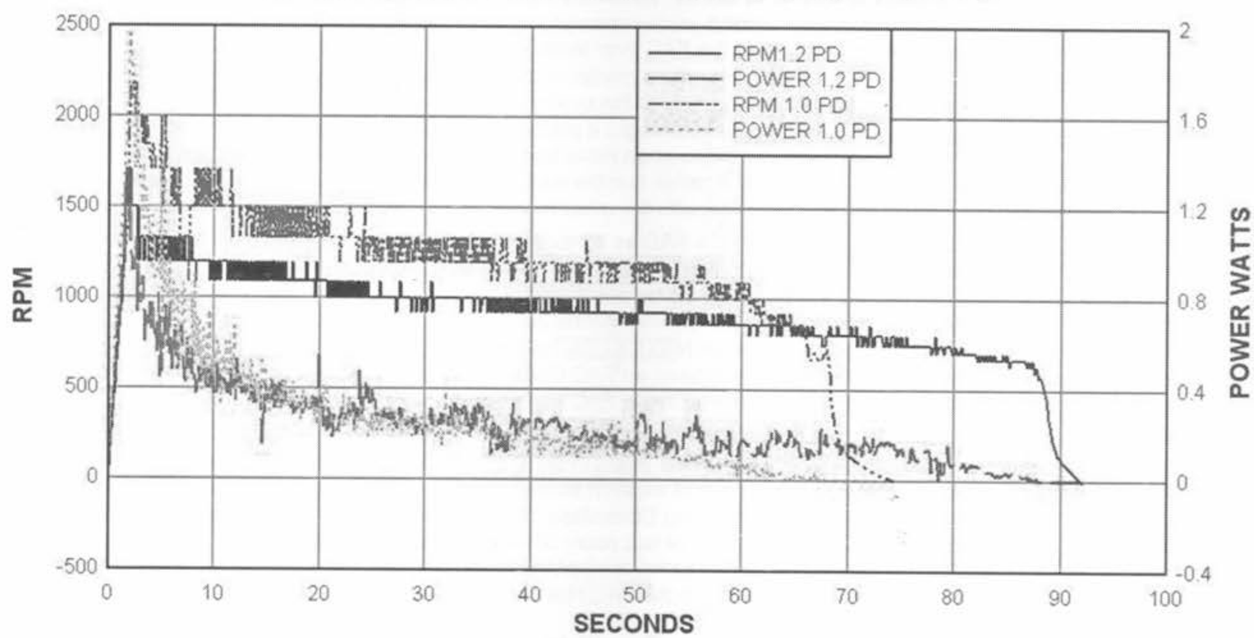
RUBBER : 22 in 0.0925 X 4 11/29/2012 - 7 in HOOK LENGTH - 400 BRAIDS
1.0 PD 74.24 sec. RUN TIME - WOUND TO 79% 1210 FT SPECIFIC ENERGY
1.2 PD 92.03 sec. RUN TIME - WOUND TO 79% 1366 FT SPECIFIC ENERGY



7 IN TORQUE COMPARISON.grf

7 IN 1.0-1.2 PD RPM-POWER COMPARISON

RUBBER : 22 in 0.0925 X 4 11/29/2012 - 400 BRAIDS
PD 1.0 WOUND TO 1406 TURNS - 1.538 in-oz 79% 1210 FT SE
PD 1.2 WOUND TO 1413 TURNS - 1.322 in-oz 79% 1366 FT SE



7 IN POWER COMPARISON .grf1