Some Thoughts on Trimming Rubber Models

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Over years of flying rubber models and crashing them in every conceivable way, I have developed a feeling for some of the basic things that are involved in making a rubber model fly well. I have studied the physics of model flight and I have experimented with my models to try to get a better understanding of what's going on. If you are interested in hearing what I think experience has taught me, I'll explain it in the following paragraphs. I believe my approach is fully supported by classical aerodynamics, but I will not use graphs or equations in telling you how to use it.

Setting the CG Location

When I had just about completed my Lockton Park stick model, I looked at ways to strap the wire wing mount to the fuselage. Then I reminded myself that the fore-and-aft location of the wing mount doesn't have to be adjustable. Sliding the wing fore or aft to adjust the flight pattern is for kids with dime store gliders. (What's a dime store, Pop?) The wing mount should be placed so the CG is in the desired location, then fastened permanently. The question is, where should you put the CG?

. . . and the answer is, at a point where the model has positive pitch stability, but not too much. You can get part way to determining the CG location by using a simple equation to calculate the Neutral Point. That's the CG location which will give neutral stability. You then put the CG some arbitrary amount forward of the Neutral Point. That arbitrary amount is a guess based on experience. The more forward the CG, the greater the stability. A little later in this article, I'm going to offer some guidelines that will lead you directly to a good neighborhood for the CG — not a precise dimension, but a neighborhood. Keep in mind that we are trying to specify the CG to be some percentage aft of the leading edge of the mean aerodynamic chord. For a wing with no sweepback, the m.a.c. is just the average wing chord. Calculate this by dividing the wing area by the span. Put marks representing its leading and trailing edges on the root rib of the wing. Make the quarter-chord points of the m.a.c. and the root rib coincide.

I said before that we don't want too much stability. A model flies fast under power and slow in the glide. We'd like a setup where there is not a strong nose-up tendency as the speed increases. You start configuring the model by choosing and setting the CG location. (Why not start with the wing and stab angles? Because you can measure CG location much more precisely than you can measure angles.) Here are the guidelines I use to locate the CG of the complete model with rubber motor installed:
—If the designer is known to be trustworthy, and he specifies a CG location, use it.
—Scale models with small stabs and short tail moments: 30 to 40% m.a.c. —Duration models with stab area about 30% of wing area: 50 to 60%
—Models like Mulvihills, with long tail moments: 60 to 70%

These are rather small neighborhoods. You'll have to work carefully to hit them. Some designs allow you to move the wing to put the CG in the desired place. On others, you are stuck with a particular wing location and will have to use nose or tail ballast.

Setting the Decalage

To be stable, the model has to have an angular difference between the wing and stab. That is, the wing must have more incidence than the stab. The amount of angular difference, called decalage, needed to trim the model for a good glide depends on the CG location. A very forward CG, say 25% m.a.c., calls for a large decalage. The result will be a model with strong positive stability, but with a strong looping tendency in powered flight. Such a setup will require gobs of downthrust and sidethrust and adjustment for a tight spiral climb. At the other extreme, a CG so far aft that it approaches the Neutral Point can be trimmed with a small amount of decalage. Handlaunch gliders are often trimmed this way, and their stability is marginal. Recovery from a stall at the top of the launch takes more altitude than the thrower achieved. People who adjust models this way are living on the edge of a cliff.

Now, how much decalage should be built in before we start test gliding? Scale models, about 5 degrees; duration models, about 3 degrees; Mulvihills about 2 degrees. These are “geometric” angles—they are referenced to the bottoms of the airfoils. Minor adjustments to the wing or stab angle will no doubt be needed as test flying proceeds.

At this point, I want to make a few comments about lifting tails. Most of them don't. In powered flight, the wing operates at a low angle of attack; because of the decalage, the stab has an even lower angle of attack and is definitely not lifting. In the glide, a download on the stab is needed to balance the nose-down pitching moment of the wing. (All “ordinary" wing airfoils have this characteristic.) If we shoot for just-adequate stability, the download will be small and its performance penalty will be minor. So, why should we bother to build stabs with lifting airfoils? Because they're convenient to build on a flat workboard! Read my lips: putting a lifting airfoil on a stab does not automatically make it lift. Here's a test: if tail tilt changes the glide turn like a lifting stab would be expected to, you have a lifting tail. This may happen on power models with huge stabs, but is not likely on rubber models.

Test Flying

Let's limit the discussion to models without autosurfaces. Most of these models are intended to circle right under power and left in the glide. Crank in enough rudder tab to give a noticeable left turn on a hand glide. Adjust the decalage to get a glide near stalling speed, by changing the wing angle or the stab angle or both. Then put in enough right thrust to overcome the left rudder under power and achieve a right climb. (Guideline: start with about 3 degrees.) We also need some downthrust to counteract the nose-up tendency in powered flight. Start with 3 degrees of that, also. Thrust offsets are most effective right after launch. Their effects diminish as the model speeds up and also as the motor winds down. Near the end of the power run, the right thrust will gradually lose its fight against the rudder offset and the model will smoothly transition to its left glide.

There is some danger that a gust may increase the left glide turn and cause a spiral dive. The increase in turn causes an increase in speed, making the left rudder more effective, causing a further increase in speed, etc., etc. (Some people call this the self-eating watermelon effect.) A little left wing washin (warp leading edge up) will keep this from happening. As the speed increases, the washin will try to roll the model to the right and will put a limit on the turn rate.

If you have located the CG and set the decalage according to the guidelines, the first powered flight should not be a knee~knocker. Put in about 20% of estimated max turns, light the fuse, and launch. Watch carefully, and decide on the one adjustment you're going to make. If the power pattern is at least “safe”, work on the glide. Make rudder and decalage adjustments one at a time, a little at a time. Now, let's start trimming the power pattern, using thrust adjustments. Increase the turns (or torque) as you go along. The thrust angles will need minor changes as the power level goes up. You may even need to reconsider the CG location. A model that very slowly recovers from stalls probably needs to have the CG moved forward slightly. Move the CG back a little if the model consistently tries to power stall. A CG change will necessitate a decalage change. Reduce the decalage if you move the CG aft, and vice versa. When you have reached a good adjustment at the maximum torque you're willing to put into the motor, make all your contest flights at that level. The power pattern will not be in adjustment at more or less than that torque value.

At this point, some of you are probably saying, 'I knew all this.' If so, I'm glad we agree. For others, I will be pleased if you try this approach and find it helpful.