OBSERVATIONS CONCERNING PROPELLERS FOR OUTDOOR RUBBER POWERED MODELS

An article by Steve Griebling --CFFS published in the November/December 2002 Issue of Flying Aces Club News, Col. Lin Reichel, CinCFAC, Editor

The great search for the perfect prop. continues, but I have made a few observations that might be of some value to fellow ‘gum band stretchers'.

1. The higher the pitch and the greater the width of the prop, the lower the rpm. - but - - -

2. High drag, slow flying models require lower pitched props than fast, low drag models. (Prop pitch can be compared to the gear ratios of a transmission. If you are going slow, you must be in low gear = low pitch.)

3. Most plastic props do not have true helical pitch. (so what??) I don't know about this either, but many modelers feel that props should have helical pitch.

4. Helical pitch means that at any point along the blades the prop will theoretically pull the airplane forward the same distance for each revolution. Stated another way, the prop will have the same pitch in inches at any point along the blade. Sounds good doesn't it??

5. Pitch in inches can be calculated by multiplying the tangent of the blade angle by the circumference (diameter x pi) at the same point on the blade. For example: a 7” diameter prop has a tip circumference of 22”. If its tip angle is 20 degrees; Tan 20 = .364; so .364 x 22”= 8”. So its pitch is 8” at the tip.

6. The diameter on the blade where the blade angle is 45 degrees is always pitch divided by pi. For example: at 8” pitch; 8÷3.1416 = 2.57” = diameter at the 45 degree point.

7. Most bottle formed props never have a blade angle as high as 45 degrees even at the root because it is difficult to twist the blades enough to get a difference in angle of 45° to 22°.

8. Under cambered blades will create a low tip pitch if the trailing edge sweeps forward at the tip. This is often responsible for the lack of helical pitch (by calculation) when measuring tip angle of a finished prop. I usually calculate prop blanks to get helical pitch, then mess it up by slanting the tips forward to eliminate tip stall!

9. Plastic props range in aspect ratio from 2.8 to 4.3, averaging about 3.3. (blade length/ blade width). A very low aspect ratio results in a wide blade, but a wide blade with undercamber results in a very great pitch difference from leading to trailing edge and soaks up a lot of power and makes for an inefficient prop.

10. Props for very light weight indoor models are intentionally made very inefficient to keep the RPMs low, but the rnodels are so light that they fly anyway. (Many indoor models have motor weights equal to the airframe weight!)

Now for some personal experiences, maybe worth passing on:

On several biplanes I used props with too high a pitch, blades too wide and/or too large in diameter. They didn't fly well at all. A lower pitch, narrower prop was substituted on some of these planes and flights were very good indeed!

Conclusion: High drag, slow flying planes need a low pitch prop.
Too soon old and too late smart, huh?

On the other hand fast planes like the Mustang and the Chambermaid fly very well on high pitch props and certainly have longer flight times because of the resulting longer power run due to the slower rpm. of the prop. Any plane will fly well on a low pitched prop, but you will not get max. flight times on a high speed model with a low pitch prop.

What is meant by low vs. high pitch. Well, I don't have a firm answer, but I regard a P/D of 1.3:1 or more to be “high pitch” and 1.0:1 or lower to be “low pitch.” Commercial plastic props are generally fairly low in pitch and do not often have helical pitch, but there are exceptions.

Is there a case for carved vs. props formed on a bottle? (bottle props). Again, I don't know; I've had success with both types, but generally think that bottle props are best on small planes because bottle props are somewhat fragile even though mine are usually made with basswood blades. It's also difficult to get truly helical pitch with bottle props but they seem to work very well anyway. (See above item #7).

Is there a case for carved props? Sure, because you can control the pitch. If your plane needs nose weight, why not carve a prop from a heavier wood such as bass or pine to get the weight as far forward as possible. On the other hand, if you need a low pitch prop, some plastic props will be fine and are heavier and stronger than balsa. I generally carve props if their diameters are greater than 7". (Exception - - I built a very successful Rearwin Speedster with an 8" 1/32" sheet basswood bottle prop. The plane never crashed so the prop was never put to the test!). The best aspect ratio for props seems to be about 3.1 :1, which means that the blade width should be about 32% of the blade length or 16% of its diameter. The best prop diameter is generally about 1/3 of the wing span, but if the wing is quite wide and/or has a lot of dihedral, the prop can also be larger, up to 50% of the span. According to the book by W.F. McCombs you may also need a large rudder to compensate for a large prop.

Now, for some illustrations for those who wish to carve their own props:

1. You will need a saw for cutting the blanks. A band saw or scroll saw is best, but a simple coping saw will do if you are careful to saw perpendicular to the work so that all the surfaces are nice and square with each other.
2. A drill press or drill guide is necessary to drill the shaft hole absolutely perpendicular to the blank.
3. A 3/32" dia. drill bit, and 3/32".o.d. aluminum tubing for the prop bushing.
4. I recommend a very sharp carving knife with a stiff blade. I like one I bought from AMT some years ago, but I think they are out of business. As an alternative, Wood Carvers Supply has one identified as #610008 hand carving knife with a 1 -7/8" blade that should be fine. It lists for $11.65 in their current catalog . Another is their model 430000 at $10.60 Phone: Orders1 -800-248-6229 or Questions: 1-941-698-0123 - or - If you ever travel to Dover, Ohio you could check out the Warther Museum for their whittling knives.
5. I recommend a steel rule graduated in 1/100" to do accurate measuring.
6. A calculator for calculating the dimensions of the prop blanks.

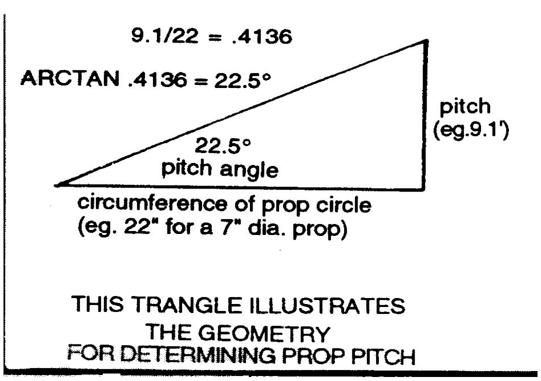
CALCULATING DIMENSIONS FOR THE BLANK:

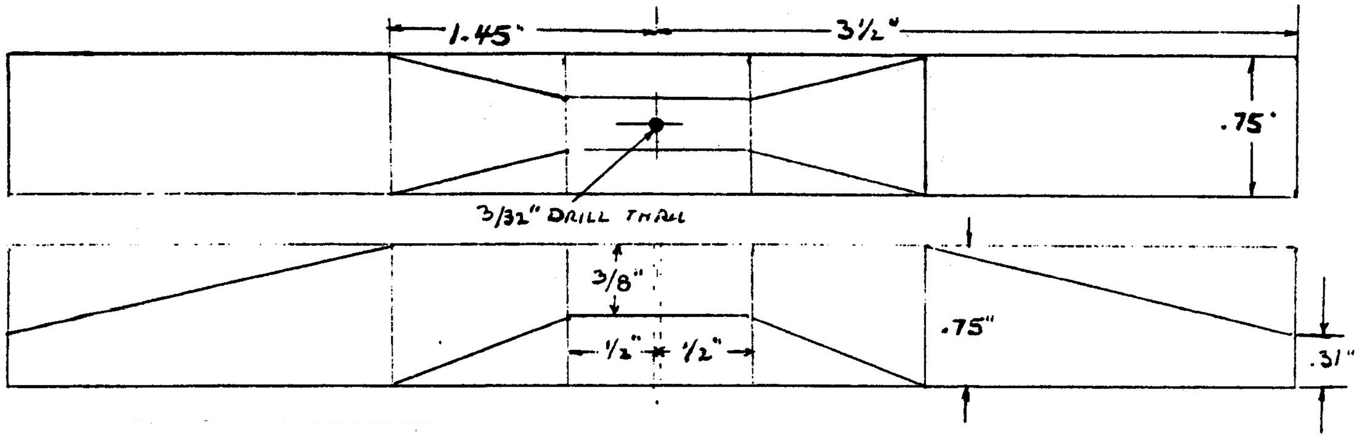
To calculate the maximum blade width of the prop you wish to make, you should decide on the ratio you want. Suppose you decide to make a 7" prop with a blade length to width ratio of 3.3. Well, the blade length is 7"/2 = 3.5" So the ratio 3.5"/3.3 = 1.06" This is the maximum blade width. To find the dimensions of the blank for this width, at the 45° point (which is the place where the blade will be widest) multiply 1.06 by the sine of 45° which is .707. This happens to give you .75" for the width and the thickness of your prop blank. (the only trigonomety number you really need is this .707).

To determine the pitch of your prop, choose a ratio of P/D (pitch / diameter).

For example: if P/D = 1.3; D x 1.3 = pitch; 7" x 1.3 = 9.1" This means that for every revolution of the prop, the plane will theoretically be pulled forward 9.1. (if there were no slip or inefficiencies). To determine the dimensions of the blank to get this 1.3 P/D ratio we can visualize a triangle illustrating the circumference and the pitch. The base of the triangle represents the circumference of the prop at it tip and the short vertical leg represents the pitch. (see page 5) To get circumference multiply the diameter by pi (7" X 3.1416 = 22"), so our triangle can be drawn with a base of 22" and a short vertical leg of 9.1" representing the pitch. if you want to know the angle of the blade at the tip, divide 9.1 b by 22" and find the arc tangent on your calculator, but you don't really need to know this unless you are curious.

The tips are to be .31" thick, so mark this on the side of the blank at each tip. Mark the 45 degree diameter (2.9"/2 = 1.45" from the center out on each blade). Connect this to the tip mark with a straight line on the side of the blank. This is the basic blade layout. Inboard of this you will need to decide the dimensions of the hub which are really pretty arbitrary only keeping in mind that it should be thick (long) enough to provide good bearing length and wide enough to be strong and light too. I recommend a length of 3/8" and a width of about .30". You will probably want these dimensions to extend about 1/2" from the center before the prop blades flare out, so that is what is shown below.





Steps in carving your prop:

1. After you have cut the blank and drilled the shaft hole start carving the back of the blades first. You will notice that there is a difference in cutting one direction versus the other because of the grain of the wood. Carve in the direction that will not cause splits, because you run the danger of cutting too deep if you allow the wood to split as you carve. Carve without under camber at first. The objective is to connect the front and rear corners with a diagonal cut, but be sure you cut the diagonal in the right direction or you could end up with a left handed prop! After you carve cut the diagonal in both blades, put a wire through the shaft hole and check balance. It should be close, but may not be perfect especially with balsa because of variations in density which is common with balsa. Try to get a good balance if you can, but if it looks like the wood is too variable, wait till you have carved the front sides before attempting to perfect the balance. If you sight down the diagonal cut you have made you should see a nice spiral now, indicating a helical pitch has been formed.

2.. Carve the front in the same manner, except you will want to create a convex airfoil shape here. The tips should be quite thin and the trailing edge should come almost to a knife edge.

3. Check for balance and start sanding or doing light carving to correct the balance. If one blade is a lot softer that the other you can stiffen it and make it heavier with sanding sealer or Hot Stuff. If you want to add some under camber in the rear surface, you can sand this in with coarse sandpaper, but finish up with 120 grit and 400 grit to get a really smooth surface. Go easy on underamber. The best reason for undercamber is really to stiffen the prop without making it too heavy. Excessive undercamber will result in a variable pitch from leading to trailing edge, and you will undo a lot of the helical pitch if you round off the trailing edges very much.

4. If you want to shape the blades to remove the ugly angular corners and round off the tips, use your knife and sandpaper, but follow up with sanding so the trailing edges will be thin.

Try carving props. It is not that difficult and the more you make the easier it becomes!

Steve Griebling - - CFFS