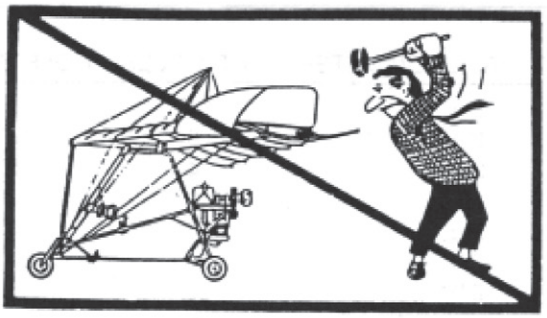

The Proper Care and Feeding of the Rotax Motor — Part 5

Delivering the Power — How to Order a Prop

REPRINTED FROM SEPTEMBER 1987 ULTRALIGHT FLYING! MAGAZINE

by Mike Stratman

It is only after great deliberation I have decided to tackle the subject of the of the all-important prop. This is an item that invokes more arguments on theory and design than any other part of the aircraft. My experience with prop manufacturers can be compared to debating fine oil paintings with their artists. Each will usually never give credit to the other or agree on just about anything dealing with whose prop will push more air than the next. With these things in mind, I will attempt to give you some pointers on how to order a prop. Next issue we'll get into what's available.

First, no matter who you buy from or what you buy, there is important information you must have to get the right prop the first time. The accuracy of this information is imperative. Any supplier who does not positively ask for certain information is just selling you a prop. Custom-made props that don't do the job are a waste of money and a source of heartburn for both you (the guy who ordered the wrong thing), and the supplier who probably couldn't sell it to anyone else for the next 10 years. Props are often infinitely unique and are of little value to someone else. The following is what you need to know to order a prop, plus some things you may want to contemplate before ordering.

DIAMETER: It is generally recognized that a big prop turning slowly is likely to push more air than a small prop turning fast. It is also recognized that a big diameter prop turning slowly is quieter than a small prop turning fast. If you are old enough to remember the direct drive days of 36-inch props turning at over 6,000 rpms, you'll recall the ear piercing sound of the prop tips going sonic as well as the impressive increase in power and quiet when a reduction drive was installed on the same powerplant. With this in mind, determining the proper diameter is a function of the actual area or propwell that you have to work with. Ground and frame clearance is, of course, of major importance. The load area of a prop is best described in area or square inches. Recall your high school mathematics.

$$\pi \times R^2 = \text{AREA}$$

$3.1416 \times 18^2 = 1018$ sq. in. — area of a 36" prop
$3.1416 \times 26^2 = 2124$ sq. in. — area of a 52" prop
$3.1416 \times 30^2 = 2827$ sq. in. — area of a 60" prop
$3.1416 \times 34^2 = 3632$ sq. in — area of a 68" prop

FIGURE 1. How to figure the load area of a prop.

Obviously a change in diameter means a dramatic change in area and, therefore, load on the powerplant.

Another figure to consider is tip speed. I am sure you've all heard a general aviation pilot with an in-flight adjustable pitch prop reduce the blade angle and increase the rpm until the tips go sonic. The noise can be deafening. You can calculate the tip speed of your prop by using this formula:

Tip Speed = (Diameter of prop x π) x (Engine rpm ÷ ratio) x (60 minutes per hour ÷ 5,280 feet per mile) = Miles per hour

For Quick Reference:

1. Engine with 6,250 rpm using 2.000-to-1 gear box

$$\text{Tip Speed} = (\text{Dia. of prop} \times \pi) \times \left(\frac{6250}{2}\right) \times \left(\frac{60}{5280}\right)$$

2. Engine with 6,250 rpm using 2.238-to-1 gear box

$$\text{Tip Speed} = (\text{Dia. of prop} \times \pi) \times \left(\frac{6250}{2.238}\right) \times \left(\frac{60}{5280}\right)$$

3. Engine with 6,250 rpm using 2.580-to-1 gear box

$$\text{Tip Speed} = (\text{Dia. of prop} \times \pi) \times \left(\frac{5250}{2.580}\right) \times \left(\frac{60}{5280}\right)$$

FIGURE 2. How to figure the tip speed of a prop.

6250 RPM	TIP SPEEDS IN MILES PER HOUR					
GEAR BOX RATIO	52"	56"	60"	64"	68"	72"
2.580	374	404	431	461	491	518
2.238	431	466	497	532	566	598
2.000	496	521	556	595	633	669

FIGURE 3. Example of tip speeds common on Rotax Powerplants.

As you can see by the formulas, tip speed can easily approach the speed of sound (approximately 740 mph at sea level). Calculating tip speed is important in figuring which prop will operate more quietly than the next. Study the charts and you can see the higher ratios (2.580) make for slower tip speeds and quieter operation if you can use the larger diameter props.

PITCH: The pitch or "bite" a prop takes is obviously important to the load a prop will have on an engine. Pitch is usually given in inches of forward travel per one revolution. For the sake of clarity, let's compare the pitch of a prop to the threads of a bolt. A 1/4 x 28 bolt means there are 28 threads per inch, or it will take 28 turns of the wrench for the bolt to cover one inch. If it's a 1/4 x 20 bolt, it will take 20 turns of the wrench. Now here's where you have to do some thinking. It obviously takes fewer turns for a high pitch prop to cover the same distance as a lesser pitch prop. But it also requires less force on the wrench to work a fine thread bolt than a coarse thread bolt. That's why they make both kinds. Therefore it is generally agreed that a lesser pitch prop turning faster will climb better than a higher pitch prop turning slower. It is also obvious that it takes fewer turns of the engine for a high pitch prop to keep the aircraft airborne after you reach cruise altitude, thus you could throttle back more than with a climb prop. General aviation aircraft are usually equipped with in-flight adjustable pitch props which can take advantage of both situations. They also cost more than you are probably willing to pay, even if they were available for your powerplant. As you can see, the pitch and diameter versus load equation is a typical aircraft trade-off. You don't get something for nothing. Government tests in the 1940s have shown that a 40-percent pitch over diameter is theoretically the most efficient prop overall.

$$40\% = \frac{\text{PITCH}}{\text{DIAMETER}}$$

People have argued this formula as much as the creation of the universe, but regardless, it is still a good place to start.

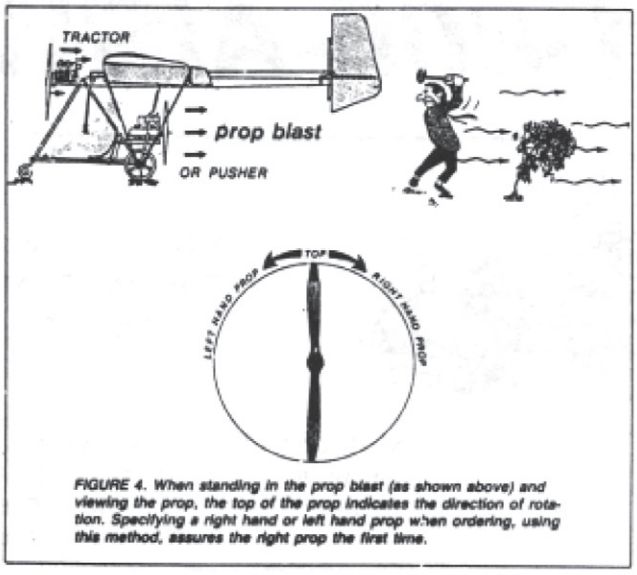

FIGURE 4. When standing in the prop blast (as shown above) and viewing the prop, the top of the prop indicates the direction of rotation. Specifying a right hand or left hand prop when ordering, using this method, assures the right prop the first time.

DIRECTION OF ROTATION: This is real easy. Props come in two directions — right hand and left hand. Stand behind the aircraft where the wind is going to blow and view the prop. With the prop in the vertical position, the top of the prop will go to either your right or to your left. Hence you need a right-hand prop or a left-hand prop. An incredible number of people manage to blow it on this one. A right-hand prop on a left-hand powerplant will make your aircraft fly backwards (or at least try to). A Rotax gear box turns the prop opposite engine direction. A belt drive turns the prop the same as engine direction. Tractor installations will use the opposite of pusher installations. It is your responsibility to be accurate. [*See Figure 4 for the only way to call out the direction of rotation, and get it right the first time.*]

To my complete horror, I have heard of customers ordering the wrong direction prop and then installing it backwards, curved side to the rear. Those who have managed to get their aircraft airborne don't stay there long. *Don't laugh!* This is a serious situation, the kind you read about on the front page. When you receive a prop, always check the direction. Hold it in front of you with the curved surface away from you and the flat side facing you. Looking at the top blade, it should be obvious which way it must turn to take advantage of the cut.

THICKNESS OR PLY RATING: Props come in two major thicknesses: 12-ply or 16-ply. Twelve-ply props are 1.5 inches thick and are okay for powerplants 35 hp or less in diameters more than 56 inches. On powerplants more than 35 hp or 58 inches, or larger, a 16-ply or 2-inch to 2⅜-inch thick hub is best. Some manufacturers use 12- or 16-ply construction while others use a thicker 2- or 3-ply construction. Both seem to be of equal strength, as does either the maple or birch wood commonly used. What is important is getting the proper length prop bolts, which are determined by the thickness of the prop. Prop bolts need to be safety wired through the heads, or secured by some similar fail-safe method. This is not a request. If you have ever seen a prop depart from its mounting at full throttle and survived, you will realize the importance of securing these bolts as well as inspecting them for cracks and shearing on a regular basis.

MOUNTING BOLT PATTERN: Nearly all ultralight/2-place aircraft use a 1-inch diameter prop shaft. This is one of those things that most prop makers have agreed to and they design, cut, and balance their product around it. The mounting of the prop is made around this 1-inch centering hole. The prop-mounting bolt patterns can be at least 18 different configurations. The following is a list of patterns that are the most common:

BOLT CIRCLE DIAMETER	# OF HOLES	HOLE SIZE
2¼"	4	¼"
2¼"	6	¼"
2½"	4	¼"
2½"	6	3/16"
2½"	6	¼"
2¾"	4	3/16"
2¾"	6	¼"
3"	6	¼"
3"	6	5/16"
3"	6	3/16"
75mm	6	¼"
75mm	6	5/16"
3⅛"	4	5/16"
3⅛"	6	5/16"
3¼"	6	¼"
4"	6	¼"
4 1/16"	6	¼"
4⅜"	6	⅜"

FIGURE 5. Common prop bolt mounting patterns.

As you can see, "I have a 6-bolt pattern" doesn't make it. Be prepared to give center to center bolt circle diameter, number of holes, and diameter of bolts. Most prop makers are happy to bore a custom pattern if you are clear on your needs. They will also tell you that "once you buy a prop, it's yours to keep," especially once this hole pattern is cut. Be certain and save yourself a lot of grief.

Now you have an outline of what is required to order a prop. Next time I'll get into what's available. In no way do I plan on making this proprietary, only a comprehensive look at what's out here and how it can be applied to your aircraft and powerplant. I take this opportunity to extend a personal invite to every manufacturer of ultralight props to contact me and/or send literature, charts, graphs, recommendations — anything that you can provide to help let the consumer know what you have available. It is my feeling that an informed customer is a safe and satisfied one as well as an ambassador of your product.