How to buy the right engine for your experimental/light sport or ultralight aircraft

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- Chapter 1 - How the aircraft engine market operates.
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Chapter 1

How the aircraft engine market operates

I'm going to share with you exactly how to get the right aircraft engine and propeller for your particular application.

Keep in mind that these recommendations are based on years of practical experience in the aviation industry and the most accurate information available at this time. This information may be subject to change in the future and updated additions will be made available.

Most of you will love my straight, to-the-point and easy to understand style. Others may criticize the few engineering terms and complicated formulas. That's okay because we are not designing engines and props in this book.

If you can suspend any preconceived ideas for a short amount of time and absorb the information in this book, you will be way ahead of most folks when you enter the aircraft engine market.

So you have your dream machine picked out, or maybe you already have an aircraft and it has a worn out engine or no engine at the moment.

There are all kinds of potential motors out there and it's really tough to tell what's best because, of course everyone says, "I have the best engine for you!"

When I point out actual results, benefits and what certain engines can do for you, it's from a practical application stand point and not about just selling whatever happens to be the "in thing" or "the most profitable".

Politics

Here's something you may not be aware of and that's the fact that original equipment manufactures (O.E.M.) aircraft kit dealers and distributors typically make a hefty profit by selling an engine with the kit, sometimes half the profit in fact!

So it's no surprise that the dealers will try to push a certain engine and usually they only have engine mounts for those particular models.

What has happened is that certain engine brands have had a very aggressive marketing strategy. One of the main things they did right off the bat was to offer the aircraft kit manufactures huge engine discounts if they would build their aircraft around their engines.

I can tell you that it did not take me too long after getting involved in this part of the aviation spectrum to discover that there are in fact, other excellent engine options available.

Initially when I began promoting them, I came under a great deal of fire. From nasty and threatening e-mails and phone calls to other underhanded harassment. It's becoming less these days as people wake up to the facts.

So you see, a large part of the aircraft engine market is still another one of those "it's all about the money" situations and has very little to do with offering the best value to the public.

Chapter 2

The pros and cons of new vs. used

How about saving a few bucks by purchasing a used unit from an ad? That's okay sometimes, but often you are more likely to wind up with a lemon than when buying a used car.

A way to initially screen a seller is to ask a few pertinent questions about the engine. If it's advertised as "ready to fly" but they cannot honestly and accurately answer all the questions below, they have no business selling an aircraft engine.

Some things to ask

1. Does it run?
2. When was the last time it ran?
3. Is it complete with all the engine accessories?
4. Does it have accurate log book entries for time and maintenance and by who?
5. What are the total running hours and calendar time since new or it's most recent overhaul and by who?
6. What sort of maintenance has been performed?
7. What sort of oil and fuel has been used in it?
8. Has it ever suffered a prop strike?
9. Has it ever exceeded the manufacturers maximum RPM limit? (RPM red-line)

10. Has the cylinder head temperature (CHT) or exhaust gas temperature (EGT) ever exceeded the manufacturers limits?

Then take the answers with a big grain of salt before you commit. Also make sure that the seller knows how to package it properly for shipping and have it insured.

Shipping

UPS ground is a great way to ship engines up to one hundred fifty pounds. Heavy engines should be bolted to a pallet with a crate over the top.

Smaller ones up to one hundred pounds can be shipped in plastic storage containers. Triple up the lower portion, one lid is okay. Pad the engine and parts real well, drill a series of quarter inch holes around the perimeter of the lid and through the container lip and tie wrap shut. Write "Engine Instruments" and "No Stack" on the lid and insure it for more than it's worth.

A Heads up

The sad fact is, that bogus used uncertified engines are rampant in this industry. Because there is no regulation and no log books are required on uncertified engines. People tend to say and do whatever they think will get them the most money out of their used equipment.

Quite often you will discover that your "fresh" engine needs so much work and so many parts before it's air-worthy that it would have been better to buy new instead.

I am one of the few guys who does a real Airframe and Powerplant Technician (A&P) log entry describing all work performed on all my engine and or airframe repairs even though it's not required on non-certified stuff.

This gives you peace of mind and increases the re-sale value of your investment.

Used engines can be found on web sites such as www.barnstormers.com and in aircraft publications and magazine classified ads. Some are from individuals and a few are from engine shops. Only a very few of the shops are reputable, even if they claim to be "authorized repair stations".

The only time you should bolt on and fly an engine from an individual is if you know him like a brother and he has the integrity of Superman.

New engines are always the best way to go if you want safety, reliability and no hassles.

The pre-purchase

If you find a deal from an individual that sounds too good to pass up, have him send it to a reputable shop for a complete inspection which may require a complete tear down, that way everyone knows what it may need to be air-worthy and a realistic and fair value can be assessed.

"Wait a minute," you may say, "the engine runs great now, why disassemble it?" If it's a Rotax 2-stroke and it's been more than five years calendar time or three hundred hours of run time, then, at a minimum, the crank end seals need to be replaced before further flight.

At one hundred fifty hours the top end may need de-carbon and the gear box should be inspected and adjusted.

If it's a Hirth there really is no calendar time between overhauls and the running times are either one thousand or twelve hundred hours and the crank seals are virtually immune to leakage. On the fan-cooled versions, fan belts and fan bearings are recommended to be changed every 200 hours.

At five hundred hours a top end de-carbon may be required and the gear box inspected and adjusted.

If it's another brand, then having a pre-purchase inspection is still a highly recommended procedure.

Where to get help

Three shops I have good experience working with and recommend for Rotax work and or to buy a new or used engine from are:

- Oregon Aircraft Design LLC 503-267-1486 New Hirth and some used Hirth and Rotax.
- The Ultralight Place 815-529-3000 New and used Rotax
- Lockwood aviation 863-655-6229 New Rotax

Chapter 3

How to choose the right engine

Performance

First, determine the kind of performance you want. The airframe manufacturer will generally recommend several different horse power ratings for your aircraft.

Keep in mind that HP is not the end all be all and that torque is what moves airplanes. An example would be that the 100 HP Rotax with the 2.43 to 1 reduction produces about 225 ft. lbs. at the prop shaft. A 100 HP Hirth with a 3.65 to 1 reduction produces about 321 ft. lbs. were it counts.

Your choice should depend mainly on your anticipated flying requirements such as location, elevation and intended use.

A lot of guys base their decision solely on lowest initial cost and this is a huge mistake of false economy, as this path invariably winds up being more expensive and can be fatal.

It's best to stay on the upper half or all the way to the maximum rated horse power for your airframe. Mainly for safety reasons, so you can make it over those trees at the end of the runway one day when you may have a fluffy passenger and high density altitude conditions. That means, thin air and or high temperatures.

The other reasons are for resale value and just plain fun! It can be disappointing if your climb rate is poor and a few more horse power and or more torque typically means only a small increase in fuel consumption and weight.

The proper propeller and reduction drive selection are also a huge part of a highly efficient combination, which we will see in chapter five.

Weight and balance

Another critical factor is to be sure that your engine choice will not be overweight or throw your aircraft out of the designers designated center of gravity range.

If your aircraft has accurate weight and balance data now, it's a straight forward matter of calculation using the weight and balance formula. If you are at all unsure, then a re-weigh with certified calibrated scales by an A&P is highly recommended.

Adjustments can be made, by repositioning items such as batteries, in a few cases the engine location may need to be shifted slightly. A slightly nose heavy condition is far preferable to a tail-heavy condition, which can make an aircraft very difficult to control in pitch.

Mounting

Now you may wonder how you will mount your engine of choice. Take heart because it's not rocket science and we are here to help. O A D even offers free engine mount design or existing mount modification design with your purchase of a new engine.

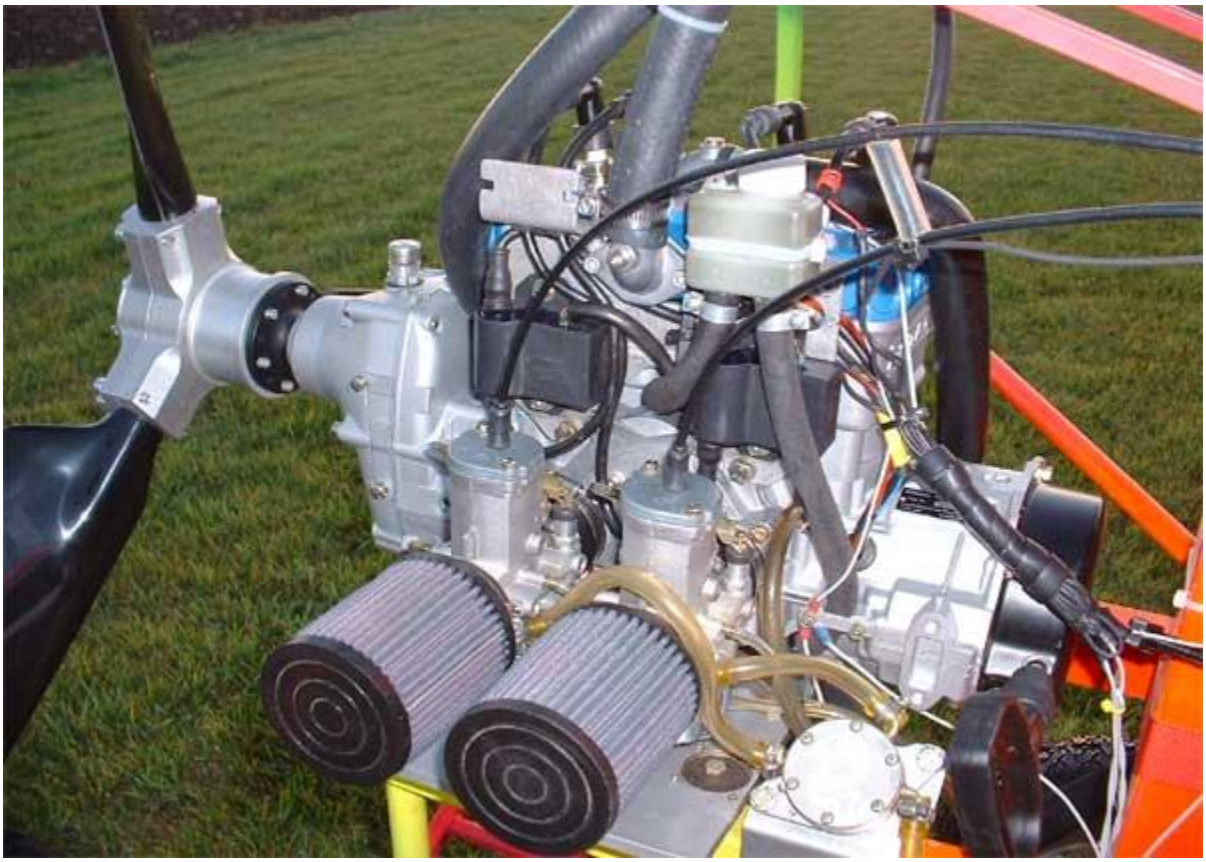
If, for example, your kit comes with a mount for a Rotax 2-stroke and you want to convert to a more efficient unit, we can most likely just modify the mount slightly depending on your engine of choice.

If the installation requires a totally different mount we are also happy to help with that design as well. So the point being, that you are not limited to the only engine brands that your kit manufacturer sells.

If you need help or don't have the time, O A D is also capable of handling most any mount work and or engine installation, break-in and even initial test flights.

Chapter 4

Why some engines tend to fail and how to prevent it



2-strokes

2-stroke aircraft engines are a great choice for aircraft because they are always less weight per horse power than 4-strokes and generally less expensive.

There are many brands out there and the two I will focus on are the Hirth and Rotax because they have the best performance records, are the most numerous and have the best parts availability.

Contrary to what some people believe or will try to convince you of, certain 2-stroke motors can be more reliable than a 4-stroke. Because they have fewer than half the moving parts, only half the things can potentially go wrong.

Wait you may say, "A lot of people have had 2-stroke failures"! That's absolutely true and a lot of people have had 4-stroke engine failures.

The most frequent reasons for 2-stroke problems I see are caused by:

1. Exceeding the manufacturers T.B.O., hours or calendar time.
2. Incorrect operating procedures.
3. Built in obsolescence.

It's all about quality preventive maintenance and even dated designs can be very reliable.

Fuels

One thing some people seem to be concerned about with 2-stroke applications is that sometimes alcohol is mixed with auto fuel and it does not mix with oil.

All 2-strokes either use an oil injection pump or a pre-mix procedure. As long as you don't try to burn E85 fuel which is 85% ethanol, you are fine.

Note that 100LL aviation fuel is not recommended to burn on a regular basis as it will shorten the life of piston rings and spark plugs with excess carbon deposits. The deposits an even glow and cause pre-ignition.

During the winter months, auto fuel is usually E10 fuel which is only 10% ethanol to reduce emissions and it's not a problem for 2-strokes in this small amount.

Something every aircraft fuel system needs are fuel tank drains and a gascolator, which is a filter and drain point located at the lowest point in the fuel system.

It's especially important if there is alcohol in the fuel, as alcohol can absorb water and phase separation can occur resulting in water migrating to the lowest points.

Which one?

There are people who hate Hirth and love Rotax so don't be too surprised if you read or hear some negativity, most of it is simply Rotax propaganda parroted by uneducated people.

I can tell you about the reasons for Hirth problems in the past and I will also tell you about the current Rotax problems.

Now you may be thinking "he is just promoting Hirth because he is a Hirth dealer", untrue. I deal Hirth because it is hands down the absolute best value in this type of aircraft engine.

Years ago Hirth imports and distribution were handled by a Canadian company, that did not provide good customer support. Now it's handled by a U.S. company and we provide excellent customer support.

At one time approximately one hundred un-balanced fly-wheels from one of Hirth's subcontractors were unknowingly factory installed. After thirty or so hours of run time, those engines infected would break the crankshaft from the harmonics set up by this condition.

It was difficult to determine the cause initially and when it was discovered, Hirth immediately recalled the units and fixed the problem. This is no longer an issue but Hirth now offers additional peace of mind with a three-year prorated crankshaft warranty.

Another one I have heard on the Internet was spark plugs coming out in flight. Of course, the engine ceases to run at that point. There is only one reason for this condition: failure to follow instructions. Hirth uses small spark plugs with a low torque and an incorrect installation procedure can strip the threads out.

One more I have heard a couple times is failed crank bearings. One was a possible defective bearing from the factory. The other was due to poor maintenance procedures i.e., allowing debris into the air filters and then reinstalling them.

The number one positive about the Hirth line is the bulletproof reliability; they are virtually immune to typical 2-stroke seizures. Please check out my engine page to see how this is possible.

A big current Rotax 2-stroke problem is the relatively short life of the crankshaft end seals. All 2-strokes have a negative pressure inside the crankcase while running, when leaks occur a lean condition follows with lack of lubrication and overheating.

I touched on this earlier and it's the main reason I do so much Rotax work. Since the oil is mixed with the fuel in a 2-stroke, a lean condition causes lack of lubrication and can seize up a crankshaft or cause it to come apart and effectively destroy it and the engine case. The lean condition can also destroy pistons and cylinders and all this, can happen gradually or suddenly.

It's all about preventive maintenance because it's a huge part of your flight safety. Also, it will always cost less than replacing parts once they are damaged.

Another poor Rotax choice are the combination of steel cylinder liners with aluminum pistons in their 2-stroke aircraft engines; they expand and contract at different rates and are prone to seizure.

A real good rule of thumb is to do a complete overhaul on Rotax 2-strokes every three hundred hours run time or every five calendar years. A way to do a quick seal check is to place a finger in the magneto side air vent hole at the bottom of the engine and check for any oil. Or pull the cover if required. If you find any oil the seal is leaking.

4-stroke engines

The most popular are the Rotax 4-strokes and I believe they are a fine motor. They do have some drawbacks, number one being the incredibly high price and at T.B.O. you are better off buying a new engine because the cost of parts and labor is nearly the same.

Something many people are unaware of is the fact that if a Rotax 912 or 914 is overheated even once, the cylinder heads are destroyed. The excessive heat ruins the metallurgy and they begin to leak. Also the valve guides can drift and the engine is headed for a major failure.

Certified aircraft engines such as the Lycoming and Continental even in the experimental class are very expensive, but if you can afford it they are fine units.

Then we have the auto and other conversions. These can be substantially less money than the others but with trade offs in high weight and sometimes poor reliability. I have never seen one that is as good as an engine designed exclusively for aircraft use.

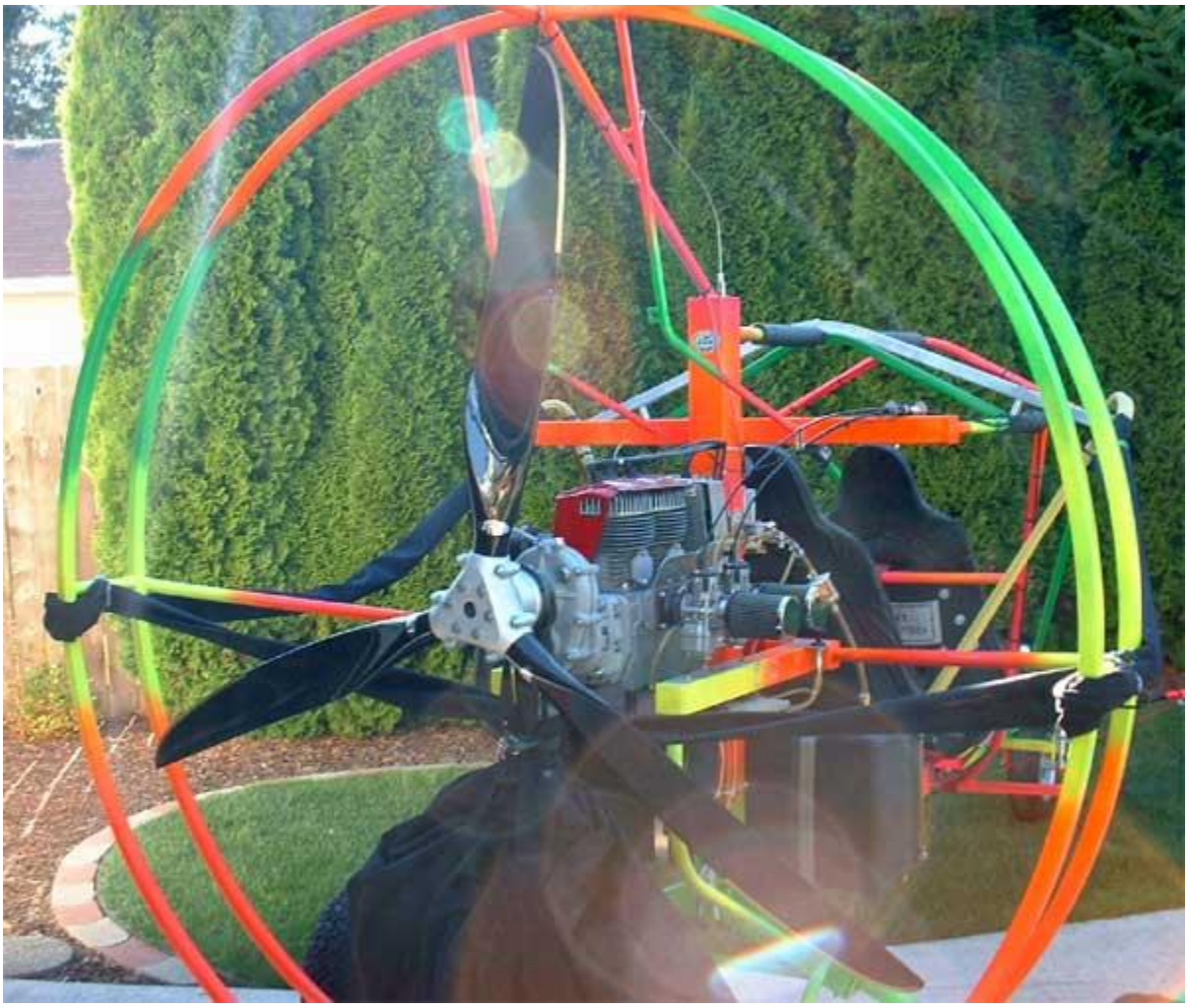
Jet engines

Turbine engines are usually cost prohibitive for most kit aircraft and have very high fuel consumption. The up side is that they have very high power to weight ratios.

Pressure Jets have shown some promise with extremely high power to weight ratios and T.B.O., low cost but with fairly high fuel consumption.

Chapter 5

What you should know about reduction drives and propellers



Many people are hung up on horsepower and torque ratings. With aircraft, the right reduction ratio and propeller for each engine/aircraft combination make a huge difference in efficiency.

I"m not going to show you a bunch of complicated formulas, I'm just going to tell you what works for me, all my customers and a lot of other highly experienced people. We know the formulas, the theories, the dynamics and the mechanics. I have done all the relevant calculations already.

Reduction ratios

Some engines run a direct drive propeller such as the Lycoming and Continental. These engines where designed from the start to produce maximum horsepower at low RPM, typically 2,000 to 2,700.

When the engine RPM red-line is higher than this it should have a reduction drive in order to slow the propeller and maximize efficiency. The exception could be if you only have clearance for a very small diameter prop.

Some typical reduction ratios are: 2.16, 2.29, 2.5, 2.58, 2.59, 2.6, 3, 3.16, 3.65 and 4 to 1. To determine prop RPM simply divide the engine red-line RPM by the reduction.

Choosing a gear ratio is dependent on your performance requirements and the propeller you use.

The distributor will give you maximum approved prop RPM.

In nearly every case, for maximum thrust, use the largest possible prop with a high reduction ratio. At O A D we can recommend the most efficient combination for your particular application.

Examples

Powered Parachute T2.3 with 65 hp Hirth, 67.7 " 5-blade KievProp and 3.65 to 1 ratio.

Powered Parachute T2.3 with 65 hp Hirth, 64" 3-blade Powerfin or 67.3" 3-blade KievProp and 2.59 to 1 ratio.

Fixed wing Rans S12 with 100 hp Hirth, 70.9" 5-blade KievProp and 3.65 to 1 ratio.

Trike Aircreation Clipper with 64 hp Rotax, 68" 5-blade Powerfin or 67.7" 5-blade Kievprop and 4 to 1 ratio.

Motor glider Monnet Moni with 50 hp Hirth, 54" 3-blade Powerfin and 2 to 1 ratio.

Whatever prop/reduction combination used, under no circumstances allow the blade tips to exceed the speed of sound. The bottom will drop out of the thrust efficiency and it can be real noisy just before everything comes apart, blades and sometimes the engine can jump ship in an instant. Here is the formula:

Prop diameter in inches, times 3.1416, divided by 12, times prop RPM, times 60, divided by 5280 = tip speed in MPH.

Determining prop diameter

For our applications i.e., slow aircraft between twenty-five and one hundred forty MPH, we generally want to run the largest diameter prop that we have clearance for.

In the pusher configuration, take a measurement from the prop shaft center to the nearest obstruction in the prop arc. Also determine which way the engine will rock on the shock mounts when you throttle up.

It may rock up or down depending on whether your engine installation is upright or inverted and also where your reduction drive prop shaft is located. In most cases the drive can be installed up or down on the engine.

A good way to check how close the prop will be to things is to attach a length of wood to the prop flange so you can tell how much the prop tip will move when you push on the engine.

A safe minimum clearance from the nearest obstruction to the blade tips on a pusher at full power is two inches. Here's the formula:

Prop shaft center to obstruction in inches, minus or plus the engine mount arm flex in inches, minus two inches, times two = optimum prop diameter in inches.

For a tractor installation put the tail up in flying position for tail draggers, and measure from the prop shaft center to the ground. A good rule of thumb is to follow the FAA's nine inches minimum clearance for tricycle gear aircraft and twelve inches minimum clearance for tail draggers. Here's the formula:

Prop shaft center to ground in inches, minus or plus the engine mount arm flex in inches, minus nine or twelve inches, times two= optimum prop diameter in inches.

Other considerations when choosing a prop are maximum rated propeller RPM, airspeed and moment of inertia.

Aircraft airspeed is relevant because at a certain point, the air being moved by the prop won't be enough to overcome airframe drag for additional acceleration. Even in-flight adjustable props have a limit.

The moment of inertia formula is a way to be sure the prop of choice won't overload the engine and reduction drive. At O A D, we know what the safe, proven and efficient reduction drive, engine and prop combinations are.

Types of props

There are a huge number of different props out there and everyone says "I have the best prop for you".

Props come with different number of blades, airfoils, wide and narrow cords, large and small diameter, q-tip, straight tip and Scimitar tip, fixed pitch, ground adjustable and in-flight adjustable, wood, carbon fiber, fiberglass, with leading edge protection such as tape, brass, nickel, stainless steel and urethane.

How many blades to use

The most efficient number of blades for a prop is one, because there is nothing disturbing the airflow. You very rarely ever see one in application though because they require a counterweight and side load the prop shaft.

Two blade props are very common because they provide a great compromise in performance between climb and cruise efficiency.

Three blades are also very popular and usually what I recommend for our applications because maximum static thrust is what most of you guys are after. That means maximum takeoff and climb performance and good cruise efficiency.

Four and five blades are great for absorbing a lot of horsepower or when diameter is limited or you want even more static thrust than a three blade. Generally more blades also make for a quieter prop due to lower RPM with the higher gear ratios.

Blades

Wide chord blades are generally more suited to slower machines like powered parachutes; narrower chords for the typical fixed wing or gyrocopter.

Q-tip props are supposed to reduce tip vortices and be more efficient than a squared off blade, which, in theory, is possible.

Squared off blade tips are the most inefficient. The only reason you see them is because it's a way for the manufacturer to save money on molds. They can produce several different diameters with each mold by hacking off the tip.

The most efficient and quiet blade that I have found is the scimitar tip, specifically the KievProp.

I don't recommend KievProp because I'm a dealer but rather because I have found that in practical application, it outperforms all the competition across the board. More thrust, faster climb, lower cruise RPM and less noise.

The only down side is that the wait to receive one as of March 2010 is over three months. If you can wait, it's well worth it. Nobody ever wants to return one.

My second best recommendation is the Powerfin and they are available usually within two weeks. Right now they are trying to develop a "knock off" of the KievProp, I hope it turns out to be as nice.

Fixed or adjustable pitch

I don't recommend fixed pitch props because there is no way to dial them in for maximum efficiency. The manufacturer will try to match it pretty darn close to your current airframe/engine and reduction.

It may run lower than maximum rated engine RPM in flight. Also you won't have any adjustments later when conditions change and perhaps you need to adjust or re-jet the carburetors.

Ground adjustable are a much nicer choice, that way pitch can be adjusted to get the perfect static RPM on the ground, tail tied down, brakes on and full throttle. First be sure the engine is in tip top shape and dialed in, correct ignition timing, carburetors set up and jetted correctly and in sync.

For most aircraft a good place to start is about two hundred RPM below engine red-line, then after everything is torqued and safe-tied, do a test flight and set it up the way you like it.

In flight, full throttle should coincide with engine red-line RPM, either at best climb or in level flight, which ever is more important to you. That way you get full potential out of your engine.

Construction

Wood fixed pitch props are the old standby, they are generally less expensive than composite props and if you are so inclined, it's possible to carve one in your home shop.

The down side is that they are less efficient than the ground adjustable units, are less durable and require more maintenance. Also they can absorb moisture and become un-balanced.

Carbon fiber props are nice because they are very light-weight and allow for quick throttle response, but typically less durable than fiberglass.

Fiberglass is my favorite right now, for durability, efficiency, smoothness and quietness. You guessed it, the KievProp.

Leading edge (L.E.) protection

Clear plastic tape, is used by some prop manufacturers, in my experience it does not do much good. It's too thin to provide much protection and the lip on either side of the tape disturbs the laminar airflow, by the way, any sticker or tape on a prop hurts efficiency.

There is even a supplemental type certificate (STC) plastic L.E. protection for certified props. Again it does not help much and it generally peels; it's a tedious job to finish removing it for the customer.

Metal L.E. protection is a more durable and aerodynamic material and it gives you something to dress out if you get a nick. Never roll over burrs or nicks in a metal propeller or metal L.E. Always use a file and fine sand paper to smooth it out and consult an A&P if in doubt with the repair or maximum repairable damage size.

Any crack damage to a propeller is grounds for replacement. Remember that props take an absolutely incredible amount of stress: centrifugal and gyroscopic forces.

Where to get a prop

The three places I recommend for props are the same as for the engines:

- Oregon Aircraft Design LLC 503-267-1486 Powerfin and KievProp.
- The Ultralight Place 815-529-3000 Ivo prop and KievProp.
- Lockwood aviation 863-655-6229 Powerfin, Ivo prop, Tennessee prop and Warpdrive.

If you would like to take advantage of our expertise, please have the following information available when ordering a prop:

1. Prop hub bolt pattern, metric?
2. Model aircraft.
3. Airframe Red-line airspeed.
4. Pusher or tractor configuration.
5. Prop direction of rotation from behind the aircraft.
6. Maximum diameter prop you have clearance for.
7. Reduction drive type and ratio.
8. Engine model and horse-power rating.

We can work with your reduction ratio or suggest a more efficient ratio as well.

Thanks for reading!