A Propeller’s Pitch (Tutorial)

LukeWarm
Top Gun

Posts: 3,827
Likes: 941
Points: 133

A Propeller's Pitch

I haven’t seen very much written on pitch; but if you do not understanding it, you can make some bad decisions. Here are some effects.

- Increasing the prop’s pitch or length will cause a higher amp draw.
- Decreasing the prop’s pitch or length is the easiest way to solve a heat problem with the motor.
- Low pitch numbers tell you it’s a torque prop. With this type of prop, the motor generally does not work as hard so it pulls fewer amps.If you want to do a lot of stunts, a torque prop has a lot more acceleration, and the power system will rarely need any heat management.
- High pitch numbers tell you it’s a speed prop. This type of prop will push your plane to faster speeds. This is not your best choice for stunts. A speed prop has a lot less acceleration, and the motor will run hotter.

The measure of a prop:
Pitch is measured in inches for a specific reason. A 6x4 prop is a 6 inch long prop, and the prop is at such an angle as to (during one rotation) move forward 4 inches. In real life with air, there will be losses. But in this tutorial, to make things a little simpler, we will need to look at this from a "no loss" perspective.

The available props will have a usable balance between speed and torque. Let’s look at a 6x4 prop and a 12x8 prop. Both have a different pitch number, but in reality, the pitch angle on those props will be basically the same. Pitch wise, a 12x8 prop is an enlarged 6x4 prop. That is why you will never see a 12x4 prop, it's too slow to be practical.

Let’s look at a 6x4 prop and a 7x4 prop. Both have a 4 inch pitch, but the pitch angle on those props will not be the same. But it’s even more complex than that, the pitch angle changes as it moves away from the center of the prop. Let's see why this is true.

Blade design:

To better understand these explanations, you need to look at thrust as "the high pressure area behind the prop". There are ways of making this thrust work for you more efficiently. Let’s take a look at how the blades do their job. Circle Circumference = ? × diameter = ? × 2 × radius. SO a 6 inch prop x 3.14 = 18.84, This means the end of a 6 inch prop travels 18.84 inches in a circle to complete one rotation. Using this trig Triangle Angle Calculator, for the end of a 6x4 prop to travel 18.84 inches to complete one rotation and to move 4 inches forward, the prop angle must be at 11.99 degrees. On that same prop, let's look at what happens half way down each blade: For the middle of a blade on a 6x4 prop to travel 9.42 inches to complete one rotation and to move 4 inches forward, the prop angle must be at 23.1 degrees. As you can see, for the prop to move forward 4 inches and push the air straight back, the prop angle must progressively decreases as it gets farther away from the center of the prop.

Let’s take this to the next step. What happens if the prop designer does not want the air to go straight back, what if he wants the prop to be designed with the blade shaped to focus the air flow toward the middle of each blade? To find out how he does that, let’s talk about one blade of a prop. With respect to what the prop angle in each particular spot should be; If we made the prop to where each of its blades had less thrust in its center part, then in both directions going away from the center of each blade, progressively increase the prop angle. This would organize the thrust toward the center of each blade. It would greatly increase the props efficiency because the air volosity would be faster 3 inches behind the prop then it would be at the prop. Organizing (focusing) the prop’s thrust is like having a nozzle behind a jet engine.

To some it all up:
The pitch shown on the blade is the average pitch. The prop’s pitch angle progressively decreases as it moves away from the center of the prop. Most blades are shaped to focus the air flow toward the middle of each blade. Focusing the thrust will increase its velocity and effectiveness. The propeller's length will give you power, and its pitch will give you speed.

Why do we care?

- An EDF's (Electric Ducted Fan) fan does not progressively change the pitch angle the same way as a prop does. This is why an EDF needs a graduated tube behind it to organize the thrust. The EDF Thrust Tube behind the EDF needs a 15 to 25% diameter reduction at its exit, and it needs to be long enough. With it, the EDF has more than 20% more power. Not having it is like removing the nozzle from behind a jet engine.

- Never trim or shorten a prop: On each side of a propeller, the blade is computer engineered to cup and focus the air that it pushes. The blade’s tapered prop tips are computer engineered to be aerodynamic and quieter as to minimize the shockwave at the ends of the prop. Both things let the prop and the thrust it produces work more efficiently. If you cut the ends off of the prop or change the prop in any way, you drastically change the prop's characteristics, this destroys its design. Even if you are able to balance it correctly, it is now a poorly designed less efficient propeller. Many have tried and found that an untouched 6x4 easily out performs a trimmed 6x4 prop. If the prop is damaged, or you need a shorter prop, Buy a new prop.
- It’s nice to know how and where the thrust is coming off of the prop, this will help you design planes to better utilize the strengths of the thrust by not interfering with the air flow. It will also help you place motors and control surfaces.
- If you install the prop backwards, you spray the thrust. When the prop is correctly installed, the thrust is organized, the air velocity increases because you are funneling it through a smaller area. An improperly installed blade will have at lest 40% less power, its unorganized thrust moves slower because it’s the same amount of air moving through a much larger area.

Propeller manufacturer:

APC (Advanced Precision Composites): This prop’s design is the one I’ve been mostly talking about. It is a harder more ridged prop. I feel that this, for us, is the best all-around prop because it has reliably good power all throughout the entire RPM range. RCPowers recommends this prop, and it is the one I see on our jets the most.

GWS (Grand Wing Servo): This prop is made of a softer material and it is engineered simpler. The softer material lets the prop deform at high RPMs, so it is better suited for a Lower KV applications. It is designed to do a specific RPM range very well, it is strongest and most efficient at the top of is operating range.

Propeller maintenance:

The shape of a prop is far too technical for someone to fix one with a balancer, a cutter, and some sandpaper. The rough, or sharp edges on a prop are supposed to be there. I sanded the edges of a prop smooth, and it lost more than 20% of its performance. Balancing is the only maintenance you should ever do on a propeller. Never use an unbalanced prop; it will shorten the life of a motor or even destroy it.

LukeWarm, Sep 13, 2012 #1

oOFutteOo, Flybyknight22, stanlley and 17 others like this.

colorc
Airman

Posts:	982
Likes:	183
Points:	43

when the pitch increases, does it become less efficient? i know the thrust speed increases as the pitch increases, but does it get to a point where instead of focusing the thrust backwards it is pushing it to the sides? or do the high pitched props need to operate at higher speeds before becoming efficient?

colorc, Sep 13, 2012 #2

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

- The high pitch speed props do have higher losses.
- And you are correct about a high pitch prop's inableity to be focused as well.
- And you are also correct about a prop being more efficient when it is doing what it is designed to do.

Normally when the losses get too high, that pitch is not available; The manufacturers do not want to offer a prop that people will not be happy with.

This is a good discussion topic for after post 1.
Colorc ask some great questions and he deserves great answers. I know a bit about the losses part , and i did my best, but I am no expert. Maybe another member will chime in and help me out.

THANKS TO ALL for the likes you all have given to post 1.

LukeWarm, Sep 14, 2012 #3

stanlley and phillplunsford like this.

LukeWarm
Top Gun

Posts:	3,827

I make a post like post 1 in this thread , then I polish it, sometimes for days. I pick at it till I deside it's good enough to put my name on it. I am very critical of myself and my work. But I think am done picking at it for a while. So, hopefully, it is now worth rereading.
Signed: Wes Lott

LukeWarm, Sep 15, 2012 #4

Likes: 941
Points: 133

HiFlite
Ace Pilot

Posts: 889
Likes: 353
Points: 63
http://www.youtube.com/user/MauiAviator

APC= All Purpose Cutter

HiFlite, Sep 15, 2012 #5

LukeWarm
Top Gun

Posts: 3,827
Likes: 941
Points: 133

AccidentalStuntPilot said: ↑

APC= All Purpose Cutter

Do you know what happens when you turn your radio on and don’t check the throttle first, the prop walks your plane off of the hood of your car. Although a hood is a lot better than your lap.

We all warned my nephew not to throw the plane like that. He said "What!! do you really think I'm going to let that prop cut my hand? 10 second later he's asking for a Band-Aid.

LukeWarm, Oct 3, 2012 #6

stanlley, EvilTessmacher and Steel Wings like this.

northstarflyer
Cadet

Posts: 309
Likes: 17
Points: 18

Thanks for the info luke warm!!

northstarflyer, Oct 5, 2012 #7

EvilTessmacher
Cadet

Posts:	73
Likes:	24
Points:	8

This is a pretty good forum for n00bs like me.

I've just now gotten a handle on what I don't know, which is making it somewhat easier to learn what I need to know. thanks to guys like LukeWarm, Grey, and many others.

EvilTessmacher, Oct 5, 2012 #8

Luke Warm likes this.

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

This is somewhat from another post, but I thought some people reading this thread may find the info useful. Today, I also added another paragraph to post #1.

Let’s look at an APC prop. If you mount it backwards, the thrust is the same, it still moves the same volume of air. Why won’t the plane fly? Or if it does fly, it feels severely underpowered. Putting a prop on forwards then backwards in a thrust test set-up, will show the same amount of thrust. This may prove to some people that a backward prop will work fine on a plane, But this is not true.

By now, most of us understand these TWO aspects of propulsion; the size and the speed of the thrust. Mounting an APC prop backwards increases the size and decreases the speed of the thrust. And in real world applications pushes the plane 40% slower, yet maintains the same thrust as a correctly mounted prop. This proves that the speed of the thrust is also important, and can not be so cavalierly discounted.

LukeWarm, Oct 10, 2012 #9

phoenix_md likes this.

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

A 6x4 has more torque, and a 6x5.5 will have more speed. Increasing the prop pitch or length will also increase the load on the motor.

For vertical climb, do you need torque or speed?
I'm not sure torque and top end speed determine the same things while climbing. If you have close to or less than a 1 to 1 power to weight ratio, a torque prop will climb better because it will have more sustainable RPMs.

The prop that will give your motor the most thrust, is a constant (with that motor at that voltage). But finding the best prop for a plane with that motor

is not as easy. A max thrust prop is aggressive enough to maybe cause a heat problem that is another reason it is not necessarily the best climbing prop. Also your flying style or the plane may be suited to ether more torque, or more speed. For any given plane; the max thrust prop, a good torque prop, or a good speed prop is most likely 3 different props. No matter what propeller you are using with your motor, there is another propeller that excels in a different area compared to the prop you're using. It's all a balancing act and it's all about what you value above everything else; speed, acceleration, or thrust.

With a great speed prop, the motor cannot sustain the RPMs during a steep climb. As the RPMs drop lower and lower, so does your thrust. If you like to do a lot of stunt flying, a speed prop has a lot less acceleration and the motor may over heat quickly.

With a good torque prop, you can still hear the RPMs drop a little during a steep climb and fast turns, but they don’t drop nearly as much. The motor will run cooler, longer, and at a higher RPM. This is because the motor generally does not work as hard so it pulls fewer amps. This pitch has a lot of good attributes; speed is definitely not one of them. If you want to do a lot of stunts, a torque prop has a lot more acceleration, and will rarely need any heat management.

A good max thrust prop is little faster than a torque prop. The max thrust rating is taken at 0 MPH, the motor will overheat fast during this test. The problem with this test is, that is not how the motor is used; If you took thrust ratings in a wind tunnel at different speeds, the data would be a more true to life rating because this closer to the motor's real life conditions. The max thrust rating taken at 0 MPH will use a lower pitched prop than the best max thrust prop at 50 MPH.

RCPowers recommends the 6X4 prop for general use in our planes, and if you are a new pilot, stick with the recommendations on the first plane or two. The key is, you do not want to tackle 3 or 6 problems at a time. Build simple; getting comfortable flying your new plane is your first goal. You can try 4 by4 controls, paint, landing gear, and airfoils later, but not while your leaning to fly this type of plane. When you want to experiment with different props, approach this in a very intelligent systematic way. The people that just try different props or motors without doing the lands and checks, destroy equipment and burn money. It takes time and effort to do it the right way, but in the end, you’re going to have a plane that is much more suited to you and the way you like to fly. If you want to move your motor to a different plane, The best prop pitch for it may change due to; the aerodynamics and weight of the new plane is not the same.

There are six aspects of a plane’s propulsion that come into play when you’re choosing propulsion components (motor and prop):

- The aerodynamics and weight of the aircraft
- The aerodynamics before during and after the prop
- The width of the thrust
- The speed of the thrust
- Size restrictions; using appropriately sized components
- The motors ability to maintain that thrust (how powerful the motor is)

LukeWarm, Oct 15, 2012 #10

FatherAndSons, phoenix_md, northstarflyer and 1 other person like this.

northstarflyer
Cadet

Posts:	309
Likes:	17
Points:	18

Thanks!

northstarflyer, Oct 15, 2012 #11

Luke Warm likes this.

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

The main reasons pusher props exist is because:

- One reason a reversed (pusher) prop exist is because, if you use two motors, you can completely eliminate torque roll by using a normal prop on one motor and using a reversed prop on the other.
- The original and biggest reason is, some motors cannot be reversed. If you have this type of motor, you must use a fan or prop that is functional in the direction of their mounting application.
- On planes with the motor mounted in front of the prop, the pusher prop works better with the available adaptors because the retainer nut tightens in the same direction as the prop rotates. But if you do a good job tightening the retainer nut on a regular prop, it will still work reasonably well. Normal Props are more readily available, so (for us) they are the perferred prop for both mounting applications.

LukeWarm, Oct 25, 2012 #12

erajomppa
Ace Pilot

Posts:	1,025
Likes:	48
Points:	48

Man do I learn something new everytime I read your posts I thought that the pitch angle stayd the same in 6x5, 9x5 and 11x5 props. Never did I bother to check with my eyes. Now I did and what do you know also I like to know the science behind these sorts of things. Thumbs up man!

Sent via tapatalk

erajomppa, Oct 25, 2012 #13

Luke Warm likes this.

F1wanabe
Administrator

Posts:	12,305
Likes:	10,571
Points:	133
http://www.frcfoamies.com	

Luke is the man! I learn something new from every one of his posts.

My youtube :
www.youtube.com/gstrysky

F1wanabe, Oct 26, 2012 #14

Luke Warm likes this.

ASD
Top Gun

Posts:	3,438
Likes:	762
Points:	133
http://www.youtube.com/user/DollarTreeFlyer/videos	

Yup me too

Its just foam not perfection. build it close to the plans and it will fly, then learn to customize. But most of all, JUST HAVE FUN!!!!!

ASD, Oct 28, 2012 #15

Luke Warm likes this.

Very interesting post.

What about quietness. I know that the more flexible GWS style props are are more quiet than the stiffer APC props. Can this simply be put down to them moving less air?

phoenix_md
Airman

Posts:	539
Likes:	221
Points:	43

I also noticed that using a flexible GWS prop reduced amp draw compared to an APC style.

phoenix_md, Oct 28, 2012 #16

Luke Warm likes this.

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

> phoenix_md said: ↑
>
> *Very interesting post.*

I'm glad you liked it. I enjoyed writing it.

> phoenix_md said: ↑
>
> *What about quietness. I know that the more flexible GWS style props are are more quiet than the stiffer APC props. Can this simply be put down to them moving less air?*

The GWS style props are more quiet For three reasons, the first having the biggest influence:

1. The airfoil shape of the blade.
2. The softer more flexible material they are made of.
3. The shape of the bade tip is engineered more toward quiet.

There are a few things that you should do to reduce the noise. Noise is wasted power.

- First, make sure your motor and prop are in good shape. A dirty motor or unbalanced prop work like they sound, BAD.
- Second, the prop slot sould be formed or cut back so that it does not interfear with the prop wash. There is very little prop wash in front of the prop, but you should have a fair amount of open space at the ends and but especially behind the prop.

> phoenix_md said: ↑
>
> *I also noticed that using a flexible GWS prop reduced amp draw compared to an APC style.*

They do so only at mid to low RPMs, but the difference is very small.
I prefer the stiffer APC props because thay have good power throughout the entire RPM range.

LukeWarm, Oct 29, 2012 #17

phoenix_md
Airman

Posts:	539
Likes:	221
Points:	43

Thanks Luke Warm,

I also enjoyed your article on the prop slot.

phoenix_md, Oct 29, 2012 #18

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

> phoenix_md said: ↑
>
> *Thanks Luke Warm,*
> *I also enjoyed your article on the prop slot.*

Thanks for your kind words.
I have made a few threads, quite a few of mine and many others are listed in the Resources thread.
These are also good information resources:
Ultimate RC Course
RCPowers Blog
SCRATCHBUILD BEGINNER'S COURSE (Pre-Release!)

LukeWarm, Oct 29, 2012 #19

LukeWarm
Top Gun

Posts:	3,827
Likes:	941
Points:	133

How to choose a prop: Some of these is from another post.

You don't have to know how to calculate motor amps and loads, this is not that hard. After you’ve shopped around and seen prop data on a few motors, and you've been through a few motors of your own; From experience, you can now look at the weight and the KV of a motor, and tell about what prop to use. Heavier motors are more powerfull, and can drive more prop. Now, look at the load the plane will impose upon the motor and make an adjustment on your first choice. You can normally get pretty close. The third step is the heat test, it is the only way to be comfortable with your final choice. Read here about the heat test. >> Some ways to Managing the Heat.

If you go up one inch pitch or prop length at a time, and do the checks;

- If the heat is good no matter what you do, that is a safe prop. This may or may not be the best prop for your plane. You are looking for the edge; a prop that works your motor hard, but not too hard. You may wish to go up one in pitch or prop length to see if a more agressive prop will work with your motor.
- If the motor is a little too hot; you have found the edge. With a little heat management, this is the prop that will give you the most thrust.
- If the motor is a too hot; With a lot of heat management, you may still be able to use this prop, but you will need to be very careful. If you go this route, make sure that your battery and ESC are rated high enough to take the motor being over driven. This, done wrong, Will shorten the life of your motor. It would be safer to go back one adjustment and use a lesser prop.

When choosing whither to increase prop pitch or prop length, this is a good rule of thumb**:** Prop pitch gives you speed, prop length gives you power (acceleration and stamina). Per inch; prop pitch uses less amperage than prop length.

LukeWarm, Nov 28, 2012 #20

HiFlite likes this.

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