

APOGEE

PEAK OF FLIGHT

NEWSLETTER

Fin Shapes Revisited

By Tim Van Milligan

This week's article is a little different from previous ones. I got into a conversation with a youngster about fin shapes.

I print this, because it gives us a glimpse into the mind of youngsters, and how they come up with conclusions. From this, we can hopefully find some way to teach them the things they really need to know.

The background surrounding this article is that a couple of youngsters were teaming up to do a school science fair project. Of course, they decided to do the obvious project that most kids come up with: "what fin shape is best?"

Part of their project was to do background studies to try to find information on their topic. Everything was going fine for them, until they discovered the Apogee Components web site. In particular, they stumbled onto the article I wrote on this very subject.

That article can be found at:

http://www.apogeerockets.com/technical_publication_16.asp

The conclusion of the article was that they probably wouldn't be able to get any conclusive results from any flight tests they performed. Finding this out was a big set-back for them. Knowing the results beforehand is bad enough. But knowing that those results would be pointless was a real blow to them.

However, they had already chosen their topic, which was approved by the teacher, so they decided to proceed anyway.

Another part of their project was to interview an "expert." Somehow, they thought I was a good choice. What follows is the list of questions they sent me, followed by my answers.

> 1. What's the most important part of the fin?

The airfoil that you sand into it.

> 2. Why?

The purpose of the fin is to produce "Lift." This is the force that is needed if the rocket should be deflected from its

intended flight path. It always happens on every flight.

A fin with a good airfoil will produce a force quickly to restore the rocket to straight flight. The better the airfoil, the quicker it will happen -- hence the rocket will flight straighter.

The airfoil will also reduce the drag of the model -- making it fly faster.

The two reasons combined: straighter flights, and faster flights -- means the rocket will fly higher too.

> 2. Would it matter if the fin was not present?

Yes. The rocket would go unstable, and crash. It could cause harm to people or property.

> 3. How is the fin helpful?

Without it, the rocket will crash.

> 4. What fin shape do you tend to use?

The fin shape (outline) is not significantly important to the flight of the rocket. So I just use whatever shape looks pleasing to my eye.

> 5. How do you determine this?

It is just personal preference.

> 6. Do you record your rockets altitude?

Sometimes. Mostly in flying rocket competitions.

> 7. If so, what's the highest a rocket you've built has gone?

I've been fortunate to launch really really really big rockets when I worked for McDonnell Douglas. We launched rockets from Cape Canaveral, Florida. All of those rockets ended up in orbit around the earth.

I really don't understand this question, because there really isn't a challenge in flying high. It's easy to do if you have a lot of money. Just buy a bigger motor. Everything else is trivial. If you have a bigger motor, things like fin shapes, airfoils, and construction methods don't matter. The excess power of the bigger motor will more than make up for all that stuff.



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My goal with small model rockets is to launch as high as possible using the smallest (cheapest) rocket motors. Altitude vs dollar-amount spent is really a good challenge. I've had "B" motor flights that have gone over 1/2 mile (2500 feet) into the air. The cost of the model and the motor for that type of flight was less than \$5.00. I think that is pretty good.

> 8. Do you think fins had any impact on this?

Yes. Definately. I worked really hard to sand a good airfoil into those fins.

> 9. What type of rocket do you prefer to use?

I don't understand this question. Sorry.

> 10. Why?

I don't understand this question. Sorry.

> 11. Do you build rockets from scratch?

Yes. I rarely build from a kit. I find a challenge in building rockets from nothing, and coming up with ideas and methods that no one else has thought of before.

> 12. Is using a 1/4 inch thick body tube a good idea?

It depends.

> 13. Why or why not?

If you need the strength and are using a weak material; you may need a thick tube.

But if you need to save weight; a thick tube means a very heavy rocket.

The rockets that fly into space (that I worked on), had skin thickness of less than the width of a dime.

> 14. What's the best material to use when making a fin?

It depends.

I personally like balsa wood. It is very light, and you can sand an airfoil into it pretty easily.

But some bigger rockets need fins that are very very strong. So you either have to reinforce the fin to make it stronger, or switch to another material -- like fiberglass, plywood, or some type of plastic. The drawback is that these materials are a lot heavier, so the rocket won't fly as high.

> 15. How can you be sure that all the fins you construct are exactly the same?

The only way to be absolutely certain that all the fins are "exactly" the same is to mold them in plastic. But plastic is heavier, and it is very expensive to make the mold tooling.

A good way to make balsa wood fins is to sand them all at the same time out of the same strip of wood. This means that the final shape of the fin can only be rectangular or a parallelogram. But by doing the fins all at the same time, you can get fins that are really close.

> 16. Does the thickness of the fin matter?

To some extent -- yes.

> 17. Why or why not?

Generally, a skinny fin will have less drag than a fat one. So the rocket will fly higher. But it is much more difficult to sand an airfoil into a skinny fin. So what you gain by using a thin fin is lost by losing your good airfoil. Remember, the airfoil is more important than the thickness of the fin.

Also, skinny fins can be weaker than a thicker one. So you need to use thick enough material depending on how much strength you need for that particular flight.

> 18. How long have you been working with rockets?

I started building model rockets when I was in the 6th grade. That was about 1976.

> 19. Have you experimented with different fin shapes?

In the past -- but back then, I didn't know that shape didn't have much to do with performance.

> 20. If so, what is your conclusion?

There are so many variable that could affect the altitude of a rocket. Fin shape is one of the least ones.

> 21. On your web page, from what I understand, and in my own words, you mentioned that the tip of the fin was the most important part because it is in the direct flow of air, why is being in the direct flow of air important?

Fins are most effective when they are in smooth flowing air. This is called "laminar" airflow.

As air flows near the body of the rocket, it can easily become turbulent; or all mixed up. This type of air doesn't allow the fins to be as effective as possible.

It is similar to this: You can move a motorboat through

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smooth water faster than it is to go through choppy or turbulent water.

The fin tips have better chance to be moving through smooth air. Therefore, that portion of the fin is more efficient at creating lift than the root of the fin where it attaches to the tube.

> 22. What is the easiest way to make sure all of the fin shapes and thickness are exactly the same?

Your eyeball is pretty good. Also, the human hand can feel subtle differences between fins. For example, you can tell by rubbing your finger along a table top if it hits a human hair.

But you have to practice. Look closely at the fins, and feel them often. Here is an experiment. Make two fins that you think are pretty alike. Then blindfold yourself. Have a friend hand you one of the fins then the other. Now have them randomly give you one of the fins. Your job is to tell which of the two fins it is. Most times, if you really feel the fins, you can tell by its touch.

For things like thickness and weight, you can actually

measure those. That is pretty easy to do.

> 23. Do the exact measurements of model rocket fins matter?

To an extent: yes.

But we are never perfect. So when we build a rocket, we always make the fins a little bit bigger than they actually need to be. This is called a "safety margin." In a rocket, the safety margin is built into the relationship called the "static stability margin." This is the distance between the CP and the CG of the rocket.

> 24. Since there is a margin of area measuring with a ruler, is there another more accurate way to measure the fins, or for that matter any part of a rocket that needs to be identical to another?

Measuring with a ruler is actually pretty good. For model rockets, it is "good enough."

> 25. Do you know why airplanes wings are triangle shaped?

It has to do with a lot of things. One is aesthetics: or how it looks to the designer. Actually, this is a pretty big reason. When

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Rocket length: 19.400 in., diameter: 1.573 in., span diameter: 6.073 in.
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Static margin Analysis
2.46 The rocket is stable.

Sim #	Results	Engines loaded	Max. Altitude Feet	Max. Velocity Miles / Hour	Max. Acceleration G's	Time to apogee Seconds	Velocity at deployment Miles / Hour	Altitude at deployment Feet	Optimal delay Seconds
0	[B6Q-4]	258.27	91.80	14.61	4.11	14.69	251.82	3.36	
1	[B6Q-4]	251.96	91.17	14.61	4.06	18.32	244.38	3.31	
2	[C6Q-5]	564.20	140.10	12.92	5.93	23.65	556.31	4.30	
3	[C6Q-5]	589.75	140.62	12.92	6.07	12.10	584.67	4.44	
4	[B6Q-4]	261.08	92.04	14.61	4.14	13.12	255.05	3.38	

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people buy a ticket on an airline, they want to fly on the jet that looks like it will go the fastest. They don't know that "looks" are deceiving. But the airlines do -- so they buy the airplane that looks fastest; to make their customers happy.

The other big reason is "ease of manufacturing." A wing with straight edges is easier, and cheaper to make than one with curved edges.

> 26. Are model rockets a big part of your life?

Yes. I own a rocket company, and spend 10-12 hours a day working with, and talking about rockets.

> 27. Why did you choose rockets as a hobby?

I liked Space; and wanted to be an astronaut. So I decided to study about rockets by building model rockets.

> 28. We were contemplating on whether we should try using the shape of the nose cone as our variable, do you think that this would have been a better variable than the fin variable?

Yes.

> 29. Why or why not?

It is easier to compare the altitudes of the rocket with different nose shapes than with different fin shapes.

For one thing, you eliminate a lot of variables. As you pointed out in your questions, on each rocket you have to make sure all the fins are identical. Where you have three fins on each rocket to worry about, you only have one nose cone.

As a second variable: the air flow over the tip of the nose is always smooth and laminar. Unlike a fin; which may be partially turbulent, and partially laminar.

Third: The fin produces two forces: Lift and Drag. Both of these will affect how high the rocket goes. While the nose cone is only going to produce Drag.

So the nose shape experiment is more likely to produce

"measurable" effects. But you still have to use nose shapes that are dramatically different from each other. For example, you could use a very blunt nose shape, versus one that is pointy or rounded. On these two rockets, you will see an altitude difference. The closer the shapes get to each other: such as a cone versus a pointy ogive shape; the less difference you will be able to measure.

One thing you didn't ask me about was my own history. You may need this to prove that I am knowledgeable about rocketry.

After high school, I attended Embry-Riddle Aeronautical University in Daytona Beach, Florida. I graduated college with a degree in Aeronautical Engineering. My first job after college was working for McDonnell Douglas Corporation; launching a big rocket called the Delta II. We put a rocket into orbit each month.

In 1991, I got hired by Estes Industries in Penrose, Colorado. I designed many rockets for them.

In 1994, I wrote my first book: "Model Rocket Design and Construction." This book helps modelers to build and fly their own rocket creations.

In 1995, I bought my own rocket company called "Apogee Components." I've been operating this company every since then.

About the Author:

Tim Van Milligan is the owner of Apogee Components (<http://www.apogeerockets.com>) and the curator of the rocketry education web site: <http://www.apogeerockets.com/education>. He is also the author of the books: "Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics" and publisher of the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

