How to Make the 1/2 Inch Rocket Motors

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But first, a couple of words…

Motor construction should not be undertaken lightly. If you are just starting to build your own motors, best to start off with the kind of habits that will keep you happy and healthy for the duration. Couple of tips:

- Propellant- Make sure you fully understand the properties of the propellant you are going to use. If you don't want to buy any of the many good guides in book form, then at least review all the on line information available. Search for any web page out there where someone has used the same propellant and get the benefit of what they have learned. No sense in repeating their mistakes and most will prove happy to help you. For these motors, Richard Nakka's site is a must! Click here to go see Richard
- Simulations- No sense in stumbling along in the dark. Many kind souls have created software to help you design your motors so that they work right the first time. I am happy to report that I have not yet over-pressurized one of these aluminum motors while firing them over 100 times with about 10 different grain configurations. I never put a grain in a motor without simulating first to insure the nozzle size is correct for the grain. Remember that the type of grain (c-slot, bates etc.) as well as the propellant (KNO_3/Sucrose, KNO_3/Dextrose, KNO_3/Sorbitol) will all work to determine the proper nozzle diameter. The wrong combination will most definitely turn your motor into a "pipe bomb". See the links at the bottom of this page for excellent FREE software.

- Safety- I will leave propellant making safety to the many excellent web sites out there like Richards and limit this to testing these motors. Always assume that any motor you test WILL blow up. Test the motor in such a was as to insure that WHEN it blows up, it will do no bodily injury or property damage. Where in your backyard for instance would you be comfortable setting off a small bomb. If no ideas spring to mind, then your backyard is not the best place to test. As I said, I have never actually had one of these blow up, but I still ALWAYS assume that they will each time.
- Scale- Size does matter. I like to do all my development with small motors. If things go wrong, the scale of the "problem" is more manageable. In early testing of 1 inch PVC motors, I had a CATO in the backyard that prompted a number of calls from the neighbors. That motor went wrong in a very spectacular way! Also, small motors can be easily put into a model rocket for testing in the local park which is pretty handy as well.
- Who Should Try This- This page is not intended as a "Beginners" tutorial. I will not be giving instructions on how to make propellant, or giving you nozzle dimensions and recommendations. I will not be selling any of these parts but instead encourage everyone to make their own. Amazing what you learn when you do it yourself! Once you have simulated propellant grains with software, and familiarized yourself with the propellant of your choice, you will be able to fill in the "missing" dimensions.

Project Parameters:

The following are a list of parameter I set up initially when creating these motors, just to give you an idea of the "why"

- Simple to make- I will probably lose a few so I should be able to make a new motor in an evening
- Cheap to operate- I want to do many static tests and flights so keep it cheap!
- Built from scratch with tools on hand- In the spirit of keeping it cheap, my time is free (this being a hobby and all) and while a lathe would sure be fun to have, I am going to have to get by with a drill press and hand tools
- Easy to fly- Should be able to fly it in the local park so that I can test it often
- Utilize KNO3/Sugar fuel- In the spirit of keeping costs down I will utilize this fuel. I will not get into the details of preparing this fuel, and will instead direct you to "the source" for all that is sugar. Richard Nakka has an excellent page detailing everything you need to know about preparing these grains safely. Go there; read everything carefully, read it again, then you are ready to start! Click here to go see Richard

Construction Details:

Making the Casing

Starting with the right parts is the key to simple construction here. I purchased 1/2 inch 6061 tubing with .049" wall thickness from McMasters (part number 89965K48). Cut a length (Pipe cutter works best) to match the length of your grain plus 3/4 inch. Tap both ends with a 7/16 32TPI tap (part number 2595A229) to about 3/8 inch. Make sure to use cutting oil for all of these cutting operations. I bought aluminum cutting fluid from McMasters and am amazed at the difference it makes in cutting and drilling (part number 1413K42) .The most accurate way I have found to get the thread started properly is to put the casing in the drill press, clamp the tap in a vertical orientation, then push the part into the tap while turning the part by hand. Alternatively, you can just put the casing in a vise and tap it without any alignment but the final parts will not be as nice as with the threads perfectly aligned. While the casing is in the drill press, I sand it a bit with 400 grit sandpaper to make a clean finish, but this is not required.

Clean up the ends with emery cloth

Tap the thread while the part is still in the chuck

Making a Plugged Forward Closure:

Cut a 3 inch length of 6061 1/2 inch diameter rod (I got mine at home depot, but that was before I "discovered" McMasters) and place in the chuck of the drill press. Put a piece of emery cloth on the bed of the drill press, and lower the aluminum part onto the cloth. With a little bit of grinding, the end will be nice and square. Now clamp a cutting tool (part number 3364A23) to the bed of the drill press, and lower the part into the tool. You will quickly get a feel for how fast to go, based on the ribbon of aluminum that you cut off. Cut the part down to a 7/16 inch diameter for about 3/8 inch. While the part is in the chuck, thread the 7/16 end with a 7/16 32 TPI die (part number 26005A131, yes a little pricey at $43 but well worth it if you make a lot of these. I have made about 15 parts with it so far so am not complaining. Let me know if you find a place to get them cheaper since this part is probably overkill for aluminum). I have been cutting the parts off with a hacksaw blade placed on the bed of the drill press. Goes pretty fast with cutting fluid. You can also just put the part in a

Cutting the thread area

Threading closure with die

vise and cut it normally since no accuracy is required here. Drill out the threaded end before cutting it off if you want to actually fly with this one, I use it primarily for testing so leave it solid.

Making a Forward Closure with Delay Chamber:

No time to get all that in here for now, but if you complete the rest of the motor, the delay chamber will be a good next step since it utilizes all the same techniques for construction. I am working on a version of the motor now that does not require the chamber and will be much simpler to make so will wait until I try this before posting more.

Delay chamber and grain

Making the Nozzle:

This is probably the trickiest part but I think anyone should be able to do it. If you want a basic "starter nozzle" just make the above plugged forward closure and drill your nozzle hole through it before cutting it off. Get fancy if you want and make a convergent and divergent cone on the ends. To make the nozzle in the picture, start by following the instructions for making the plugged closure, but make the 7/16 diameter cut extend an inch instead of 3/8. To machine the nozzle cone exterior, I use a "loose bed machining" technique with the drill press. With the tool clamped to the bed, loosen the bed so it swings freely. Gently push the bed into the aluminum rod (don't forget the cutting fluid) as you move the rod up and down. Shape a cone from a point 3/8 inch from one end, to the opposite end. The smallest diameter of the cone should be about 3/16 of an inch. The largest diameter (the end where the exhaust comes out) should be the original 7/16 that you started with. One end should now have a 7/16 inch "band" of aluminum that can be threaded with the 7/16 die while it is in the chuck. You can also form the convergent cone at this same end either with your cutting tool or a "60 degree carbide bur" (part number 43035A93). Now drill your nozzle hole all the way through the part (go in at least one inch). The divergent cone is most easily done with a "28 degree carbide bur" (part number 43035A89) after you have cut the nozzle off the 1/2 inch stock with the hacksaw blade. Put the carbide bur in the chuck and support

Holes are drilled by spinning the part

Shaping the convergent cone

your nozzle (don't laugh but I use my gloved hand for this) and use plenty of cutting fluid. It takes a little while to cut but go slow. Make sure you have about 1/8 inch of your original nozzle hole inside between the cones.

While I have used a number of purchased parts to make these easier, a little ingenuity goes a long way here and you can probably come up with cheaper ways to make these. In building these to support my needs, my focus has been on a technique that allows for quick construction and cheap reuse. The initial outlay for cutting tools (if you don't already have them) is not cheap however and if you use all the parts I have described it will cost you a little over $100. The good news is that you could probably make 30 or more complete motor sets with the supplies above, and could make more just by purchasing more aluminum rod and tube. Sugar motors of this size will run under 10 cents each in reload supplies so you can do a whole lot of testing once you make the motors. Might be a good idea to "share" the cost of the tap and dies with a friend since these are the only real costly part of the whole setup. You could also try one of the "cheapie" tap and die sets but your on your own with that one, the standard threads on 7/16 dies are pretty coarse and would probably not work with the tube listed above. Do let me know if you get this to work though.

Final Nozzle

Motor Testing:

Drilling core in dextrose Bates grain

Finished grain ready for launch- note the kraft paper rolled on inhibitor/insulator

Now the fun part. Follow the directions in the Rolling Grains page or make any type of grain you like. Lube the tube threads with Radio Shack lube with Teflon (don't use Vaseline- temperatures are too high). Screw on the forward closure. I usually place the igniter (can be as simple as nichrome wire twisted between two leads of wire-wrap wire) in the grain before screwing on the nozzle. Make sure the igniter is in the forward end of the grain for best ignition. Insert the grain into the casing. Feed the igniter wires through the nozzle the screw in the nozzle. Screw all parts till snug with your fingers. Don't overdue it or you will see why some of my early parts have pliers marks on them! Ready to put it on the test stand and give it a rip now. Be Safe!