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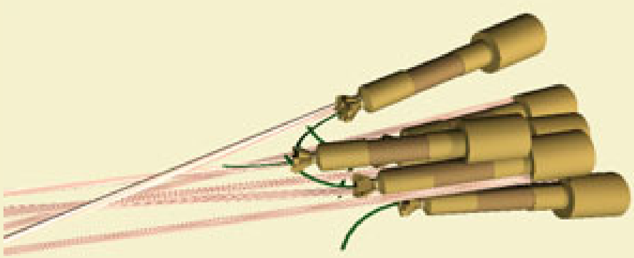
Volume 5, Issue 1

Build This...

1/2" Black Powder Rocket



Summary:

This 1/2" I.D. black powder rocket, known as a 4 oz. rocket in the traditional nomenclature, is a great starting point for anyone building their first rocket. This little rocket can carry a 20 to 25g payload straight up without a struggle, with nice headings that put most similar sized commercial rockets on the market to shame. The entire process of creating all components is covered, including making the tooling, rolling the engine tubes and cutting your own rocket sticks.

Formula: 4 oz. Black Powder Rocket

Materials:

- (1) 4" x 14-3/4" long manila file folder paper strip
- (1) 4" x 5" 30 lb kraft
- (1) 3" x 12" 60 lb recycled kraft
- (1) 3/16" square x 24" long wood stick
- 1 TSP powdered clay
- 3" visco or black match fuse

Tools:

- 4 oz. rocket tooling
- brass hammer
- solid ramming base
- hot glue gun
- drill press or hand drill
- 1/8" drill bit

Unmeasured Materials:
hot glue, waxed linen twine or wire, powdered clay, 2Fg, stars

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Figure 1: Home-made rocket tooling.

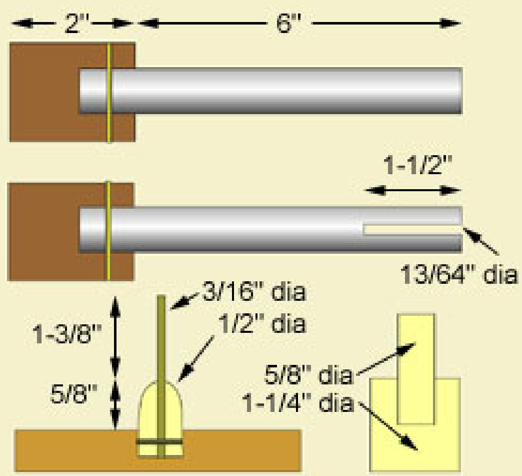

Figure 2: Dimensions for rocket tooling.

Figure 3: Feathering the edge of manila strips using sand paper.

Introduction

At one time in pyro history, rockets were the primary means for creating aerial displays. Aerial shells naturally replaced them due to their ability to lift considerably more effects into the air using less materials and effort, but the rocket is actually among the oldest effects next to fire crackers and roman candles. For most pyros like myself who retain vivid childhood memories of their backyard 4th of July experiences, rockets were always the most exciting type of firework to have in your possession. Not only did they simply look cool by design, having rockets in your 4th of July arsenal gave a sense of power. While your neighbors would be standing around ground fountains or other land-based spinners, you would be getting everyone's attention with swooshing rockets traveling 100s of feet into the air!

The rocket described here is one of my favorite sizes, due to the speed of construction, low volume of powder consumed yet still enough lift to take up an attractive header. The small size allows firing them in your backyard without worrying about heavy sticks doing damage when they come back down, a problem that plagues larger rocket use in all but spacious, uninhabited clearings. This is also one of the most popular sized class C rockets for the same reasons, although most commercial versions I've seen tend to have sparse, disappointing headers.

The traditional nomenclature for this 1/2" I.D. rocket would be a 4 oz rocket. This strange, seemingly meaningless weight designation has nothing to do with the actual weight of the rocket or how much it can lift. From what I have been told, the weight represents the weight of a lead ball that would fit into the engine tube. I never weighed a 1/2" diameter lead ball to verify if it does in fact weigh 4 oz, mainly because it doesn't matter. Pyro literature is already cursed with this bizarre rocket size designation and, probably out of tradition, people continue to use it to this day. Thus you, the aspiring rocket builder, must memorize a table that maps rocket I.D.s to irrelevant weights in order to converse with your fellow rocket builders.

Common BP Rocket Engine Sizes

Size	I.D.	Length
2oz	3/8"	2-3/4"
4 oz	1/2"	5"
8 oz	5/8"	6-1/4"
1 lb	3/4"	7-1/2"
2 lb	7/8"	10"
3 lb	1"	10"
4 lb	1-1/4"	12"
6 lb	1-1/2"	16"

Figure 4: Rolling the rocket engine tubes.

Figure 5: A cement filled ramming block and brass hammer for loading the engines.

Figure 6: Container lid modified to make leveling the measuring scoops easy.

Building the Tooling

Special rocket tooling is usually required due to the inner cavity required at the center of the powder core when building black powder rockets. This cavity increases the surface area of burning powder, thus giving more thrust than if the powder core were merely burning from end to end. This trick allows you to use slower burning fuel that has more charcoal added in order to produce better tail effects.

Usually the powder core is conical in shape, but this small rocket employs a simple cylindrical core. This feature makes it possible for you to build your own tooling, since a simple brass rod can be inserted into a wooden nipple that has been sanded to produce the rounded off shape shown in Figure 2. Two rammers are required, which are known as "drifts" in the rocket world. One rammer has a hole in the center so that it can fit over the spindle when ramming the clay plug and the powder increments up to the end of the spindle. The final increments and clay plug are then rammed with the second rammer that does not have the hole.

Larger rockets with a tapered spindle would require several drifts, each having a progressively smaller hole in the end. The spindles are used in order from largest hole to smallest in order to keep the clearance minimized as the powder core is built up around the spindle. Each drift has to be marked in order to indicate when the next drift should be switched to. Switching to the next drift too early can result in the spindle getting wedged into the rammer hole and damaging the tooling.

You don't have to worry about switching out multiple drifts when building this simple rocket, just load until you can't see the spindle anymore, then switch to the solid drift. In fact, you could omit the spindle altogether and just ram a solid core if you wanted, then bore it out on a drill press using a 3/16" bit to a depth of two inches beyond the top of the casing. This of course requires that you put up with the uneasy feeling of drilling a rather long hole into live composition. Drilling into BP is actually pretty safe at low speeds since black powder has very low sensitivity to friction, and I have made many rockets this way.

The most difficult part of making the tooling shown in Figure 2 is drilling the 13/64" center hole into the end of the first drift. A drill press is necessary for this, and a good clamping device that can hold the rammer rod exactly perpendicular to the drill table. A right angle gauge must be checked all around the rod to make sure it is perpendicular to the table in all directions.

While wooden dowel rods can be used to make the drifts, I prefer to use aluminum. When wood is used, the center hole in the first drift tends to become larger over time due to glancing blows off the spindle during loading.

The other object in the tooling diagram is a special case former for making the header, which is just a 2-1/8" long 1-1/4" dia. dowel rod with a smaller 5/8" dowel rod recessed into it at the center. The

Figure 7: Adding a 1 TSP (5 ml) increment of BP fuel.

Figure 8: The clay end plug rammed in place.

Figure 9: 1/8" passfire hole drilled through end plug.

smaller rod should extend about 1-1/2" out from the larger one.

The other tools you will need include a solid ramming block, a brass hammer and a small paper funnel. The funnel can be easily made from a scrap of paper, with the hole sized to just under 1/2" diameter. A regular hammer can be used if your rammer has a wooden head, otherwise brass or other non sparking metal is required. I prefer the brass mallet style hammers for their heavier weight and the ends which are smoother, flatter and wider than a normal hammer. This helps prolong the life of your ramming drifts compared to using a typical carpenter hammer.

Figure 5 shows a rocket ramming station. The central ramming block is a long plywood box filled with concrete to eliminate vibrations while ramming. Be sure to embed a metal T handle through the box before pouring the concrete if you plan to make one of these, otherwise it is very difficult to move around! A solid block of wood can also be used for this purpose. The height of the block should be such that it sits at waist level when seated in front of it.

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Figure 10: Rolling the header on a special former.

Figure 11: Reducing the diameter on the end that connects to the rocket.

Figure 12: Using a spiking horse to apply a tight half hitch over the glued header collar.

Making the Fuel:
The formula for the rocket engine is designed to work with home-made spruce charcoal, which makes a very fast burning black powder. If you are using commercial air-float or some other source of charcoal, you may need to increase the potassium nitrate percentage in order to account for the slower burn rate.

Ingredient	Parts	Ball Mill (800g)
Potassium Nitrate (KNO3)	14	589 grams
Charcoal Airfloat (C)	3	126 grams
Charcoal 30-100m (C)	3	not milled
Sulfur (S)	2	84 grams

NOTE: 126 g of coarse charcoal is screened in after the other components are ball milled.

All components except the coarse charcoal are ball milled together just as if making meal powder. The coarse charcoal is then screened in after milling. The charcoal I use for the coarse type is anything that passes a 30 mesh screen after grinding my homemade charcoal, so that has a particle range from 30 mesh all the way up to fine dust.

While spruce charcoal makes a very strong powder, it lacks in producing the optimal spark trail compared with other charcoals like yellow pine. A better tail would result from using yellow pine as the coarse component.

Rolling the Casing:
While commercial tubes can usually be found for this size rocket without much trouble, it is also easy to roll your own high quality tubes from manila file folder paper. Four rocket tubes can be made from a single legal size file folder, which will provide 14-3/4" long strips of paper that allow a casing to be made from just a single strip. The folders are cut up into 3-1/2" or 4" wide strips, depending on the length of the engine you want to make. Smaller strips of 30 lb kraft of the same width and 5" in length are also prepared for making the casings.

Because manila folder paper is fairly thick compared with kraft paper, I prefer to taper the edge that will be located inside the engine. This is done so that the inside seam will lay flat, thus removing the tiny channel of less compressed powder that can sometimes cause engine failure when rolling cases with thick paper. The manila paper is thin enough that this is probably not an issue, but it is better to be safe than sorry. Figure 3 shows how this is easily accomplished on

Figure 13: Loading the header with 20g of 1/4" stars and 2Fg.

Figure 14: First fold of closing with a triangle fold.

Figure 15: Second fold of a triangle fold..

several sheets at once by fanning them out and using a sanding block pulled across them in the long direction of the paper. Be sure to start rolling your tubes from the sanded end when doing this.

Because only a single strip is required, these tubes are quite fast to roll. A mixture of 50/50 white glue and water is painted onto one side of the strip as seen in Figure 4, including the short strip of kraft that is used to form the last two turns. The tubes are then rolled around a 1/2" former and set aside to dry. The manila/glue combination produces a rock hard case that does not shrink or deform upon drying, unlike cases rolled from kraft and paste.

If you are buying typical hobby supplier kraft tubes, you will want to get ones that are at least 3/4" O.D. Because the manila tubes are stronger than kraft, rolling your own allows you to get away with using a 5/8" O.D. tube and thus shed a little weight. The manila tubes are also less likely to split open when loading the rocket, unlike some of the lower quality kraft tubes on the market.

Loading the Engine:

The first step to loading the engine is to ram the clay plug at the exhaust end. This is done using 1 TSP of powdered clay, as seen in Figure 6. Cutting a "D" shaped hole in the top of your container lids gives you an easy way to level off your scoops when pulling them from the container, since you don't want heaping scoops that would result in inconsistent increment sizes.

The powdered clay used here can be just plain bentonite, or you can optionally add some grog to give the plug more bite into the casing. Grog is a type of fine grained gravel with sharp edges that will bite into the paper. However, the plug created by the tooling specified in Figure 2 provides almost 3/4" of contact with the case wall, and I've never had a problem with plugs blowing out.

After ramming the plug with the hollowed out drift, you will need to clean the clay off the end so that it doesn't get deposited on the fuel increments, since you will use the same drift to load the fuel. Each fuel increment is also 1 TSP (5ml) in size, which will result in about 5 or 6 increments to complete the rocket. Each increment should be consolidated with 4 or 5 blows from your mallet. These are not overly hard blows like when driving a nail, but they should be good, solid hits. You will get a feel for when to stop ramming when the rammer stops compressing the fuel and the hits start feeling rock solid.

When the fuel rises above the spindle and it is no longer visible, switch to the solid drift and load the casing to about 1/2" from the top. Fill the remaining space with clay and then ram the plug in place as seen in Figure 8.

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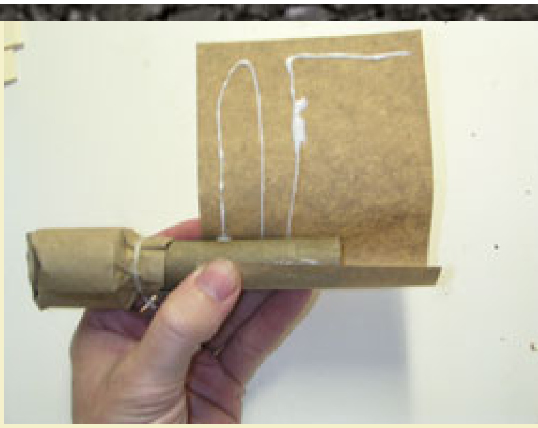

Figure 16: Applying the nosing paper to the engine prior to fusing.

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Figure 17: Making a slice off the edge of a knot-free 3/4" thick board.

Figure 18: The slice is laid flat and is ripped into three sticks.

Making the Header:
Next you will need to roll the header casing using a strip of 60 lb recycled kraft that is 12" long and 3" wide. Virgin kraft could be used, but it will be harder to crimp the end onto the rocket casing if a stronger paper is used.

The casing is rolled on a special former as seen in Figure 10. The smaller dowel rod sticking out of the former should match the O.D. of your rocket case. Once the case is rolled and glued at the end, the overhanging paper is crimped around the smaller former as seen in Figure 11. Rolling the former along the edge of a table helps flatten down the paper.

The header is now attached to the engine by first applying glue to the end of the engine and then inserting the engine inside of the header nozzle end first. The engine is pulled through the header until it sits over the glued area. The header is now locked in place using a half hitch of waxed linen twine. Using a spiking horse when tying the header on allows you to apply a lot of tension for making a really tight knot, as seen in Figure 12.

Next the header is ready to be loaded. This rocket can lift between 20 and 25 grams of header contents, which is what a full load of color stars weighs. Start by adding 1 TSP of 2Fg black powder into the bottom of the header so that it fills the end of the engine and falls into the passfire hole. The remaining space can now be filled with either flash or stars. Cut stars will work the best, since the case does not provide much confinement and the stars need to take fire quickly. The 1/4" round stars shown in Figure 13 will still make a nice break, but a few of them are often blown blind by not taking fire before the header breaks.

The header is closed with a triangle fold, as seen in Figure 14 and 15. The last few folds can be held down by either hot glue or white glue to keep it from unfolding.

Cutting Rocket Sticks:
This rocket requires a stabilizing stick that is 3/16" square and 24" long. While you could use a 3/16" round dowel rod for this purpose, a square stick makes better contact with the rocket motor when attaching it. Square sticks are also much cheaper if you make your own, which requires a band saw.

Figure 17 through 20 shows the procedure for cutting rocket sticks from standard 3/4" thick pine scraps. Any size band saw an be used for this purpose, but the wider the blade is the less problems you will

Figure 19: Using a push-stick to safely feed the tiny strip into the blade.

have trying to keep the cuts straight.

A guide fence is setup 3/16" away from the blade, with the blade tensioners set to minimize blade flexing as much as possible. The wood used for the sticks must be free of knots or other defects that would cause the s ticks to break easily when cut to size. Pine and cedar work well because of their light weight, while hardwoods like oak and poplar add unnecessary weight to your rocket.

Start by cutting the wood scrap to the desired length of the stick, 24" in this case. Then begin cutting slices off the edge as seen in Figure 17 and 18. Each one of these slices is then fed through again to produce three completed sticks. Note that a push stick must be used when cutting such small strips, as seen in Figure 19.

Many sticks can be produced from even a small scrap of wood using this method. Figure 20 shows several sticks made from less than an inch of 3/4" thick material.

Figure 20: Dozens of rocket sticks cut from a small stick of wood.

Finishing the Rocket:
Before gluing the stick to your rocket, you need to roll some nosing paper onto the fuse end, which will be used to crimp around the fuse so that it doesn't fall out. Figure 16 shows the glue pattern for applying the nosing paper, which is a 5" long strip that should form two turns around the engine.

The last step is to glue the stabilizer stick to the engine, as seen in Figure 21. This can be done with hot glue for quick assembly, or white glue with tape can be used. Some builders attach the stick before the nosing paper, then wrap the nosing paper around the stick as an additional means of fastening it to the engine.

A 3" long stick of visco or black match is inserted at least half way up into the nozzle cavity, then tied off with the nosing paper to finish the rocket.

Figure 21: The completed rocket with stick glued in place.

If you rockets will be fired in close proximity to other rockets, such as when launching many at once using something like the Mass Rocket Launcher described in this month's Tool Tip article, then it is a good idea to add an extra spark barrier to the header so that exhaust sparks coming down on it from above do not work their way into any gaps and ignite the header. A piece of pasted 30 lb paper or even foil tape placed over the top of the header will do the trick. Alternately you could fabricate nose cones out of paper to be glued on top, which would also help reduce drag during ascent.