The E-Z Engine build documentation

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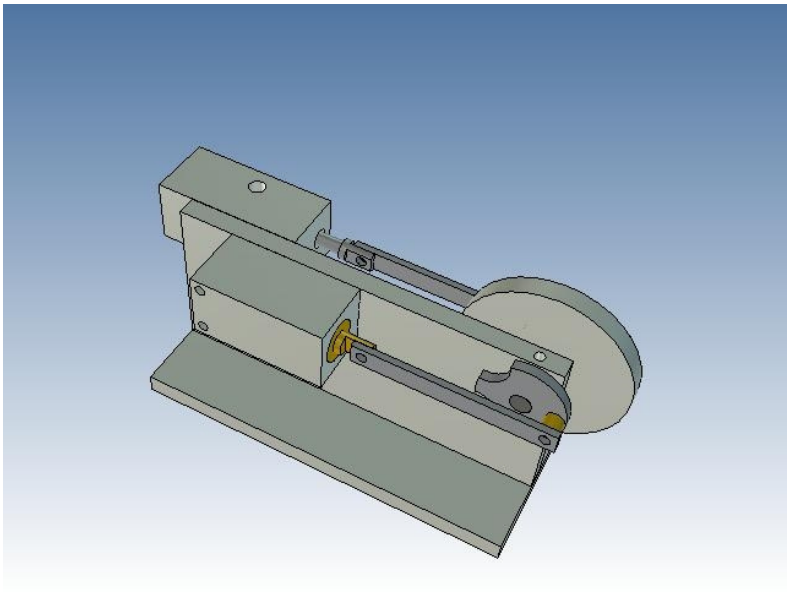


There are two sets of drawings that accompany this document. There is a metric and US version of the plans. This document only uses the US measurements but can be used as a guide to building the metric as the techniques and methods are the same.

Safety

Can't say enough about this. YOU are responsible for your own welfare. Do not attempt anything you don't understand and if something doesn't not seem right or feels dangerous don't do it until you have checked with someone who can help.

Go over to the post on safety and read this section:

http://www.homemodelenginemachinist.com/index.php?topic=87.0

It has a lot more information. Bottom line is: If you are not sure, ASK before proceeding.

Here are the guidelines we established for this project. They set the direction for the design of the engine:

MATERIALS

Minimum number of parts of easy machining materials
Should be small to keep material expense down.
Very little machining i.e use bar stock where possible
Use a single material size as much as possible.

TOOLS

Minimum number of tools
Requires a small lathe / may not have 4 jaw or faceplate
No mill or milling attachment - might give options if they do
Prefer a drill press
Bench vise / files
Hacksaw or better a band saw
Measuring and layout tools - square / dial caliper / dial indicator w/ magnetic base
Critical bores should be able to be made using reamers rather than boring bars.
No custom tools, jigs, fixtures...etc
Use commonly available drills, taps and screws

PROCEDURES

No overly complicated setups/geometry.
Little or no soldering.
Any threading needed should be achievable with common sized taps and dies.
Use screws with nuts where possible to reduce tapping
Should be small to keep material expense down.
Very little machining i.e use bar stock where possible
Fasteners would be common sizes, 4-40 or larger

Here are the tools, materials and operations needed for this build:

TOOL LIST

Lathe
- 3 jaw chuck
- parting tool
- live center optional but useful

Hacksaw or Bandsaw

Center Drill Set - cheap and useful

Tap / 4-40 taper tap

Drills
- #43 .089” for the 4-40 tap or use a 3/32nds which is .094”
- 1/8th inch
- 7/32” to predrill for 1/4 inch reamer
- 15/32” to predrill for 1/2 inch reamer
- 1/4 inch reamer
- 1/2 inch reamer

Drill press - preferred

You can eliminate the the drills and reamers if you drill to size, hone the cylinder smooth and then fit the piston / valve to the hole. Fit is not critical and a little loose is OK.

MATERIALS LIST

1/4" x 2" aluminum flat bar / 10" long for the frame
3/4" square aluminum bar / 4" long for the valve and cylinder
1/2" diameter brass rod / 2" long for the piston
1/4" diameter rod in mild steel or brass / 4" long for the valve
1/4" x 1/16" flat brass / 6” long for the two connecting rods
5/8” round brass stock / 2” long for the bushing or turn down some of the 1/2” piston stock.
4-40 screws 1" long 15 pieces / brass was used here but you can use what you want.

Not all the 4-40 screws need to be this length. You can order shorter ones or just cut the 1" down to the size you want. It is sometimes cheaper to buy a box of one size.

The flywheel can be made of 3” round stock cut to the desired thickness or flat stock large enough for the 3” diameter. You can use brass or aluminum.

OPERATIONS

Lathe
face
turn to diameter / length
cut to length

Metal saw
cut to length / about 6 cuts
no cut part is critical or mated to another part so no milling required

Drill
center punch
center drill
drill pilot hole
drill to size
ream
drill to depth (cylinder)

Layout
measure and mark holes for drilling

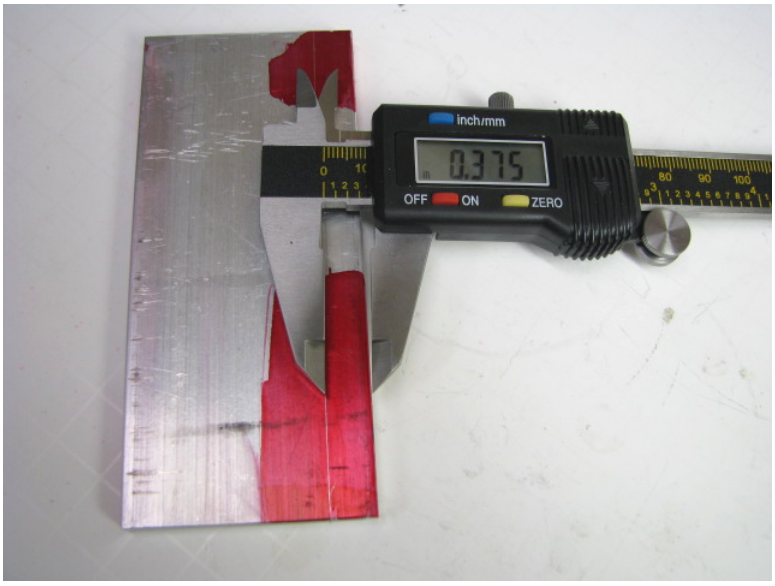
Tap
tap through and blind holes

File
file a flat spot on the piston / valve stems for connecting rod (a mill or grinder can be used)
file cut ends smooth

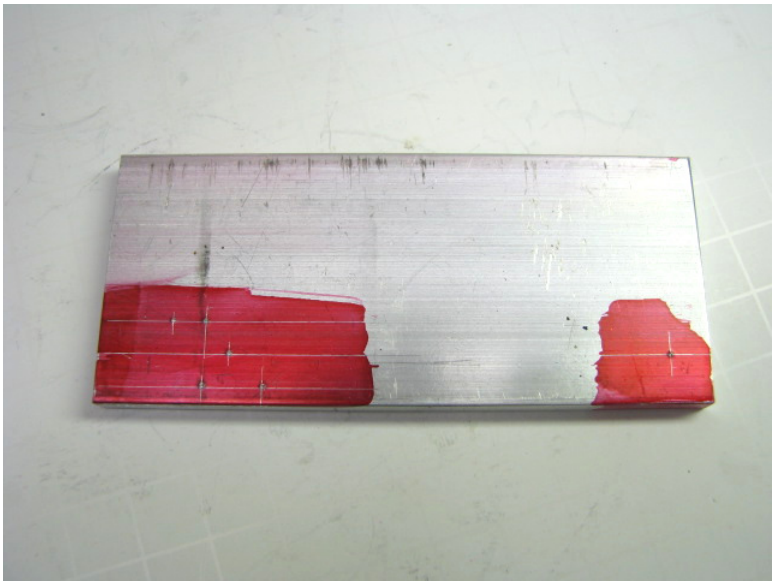
GETTING STARTED

A note on measurements. Every measurement on this is given in decimal inches but if you do the math you will find that almost all of them are some multiple of 1/16”. You can layout most of this with a square marked in 16ths. However when working with dial or digital calipers it is easier to have the decimal measurement.

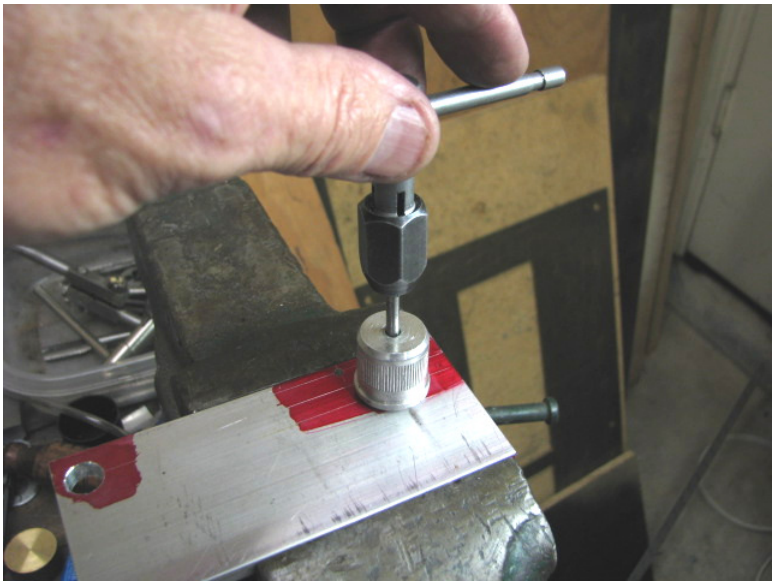
First cut the two pieces for the frame from the 1/4"x2" aluminum. Both pieces are 4.5” long. Layout the location of the holes. I used layout dye but a large permanent marker works fine. Use your calipers to scribe lines both horizontally and vertically. A machinist's square and scribe could be used here also.



Center punch each of the hole locations including the hole in the top edge for the bushing set screw and the two holes in the bottom edge for the screws to attach the base. The air passage is 1/8". All the other holes are tapped for a 4-40 screw. A 4-40 thread calls for a .089" drill bit. In aluminum I prefer to use a 3/32" bit which is .094". It makes tapping a lot easier. Mark and drill the 1/8" holes in the base. For the .375" (3/8") hole, you should first drill it with the 1/8" bit. The two holes in the bottom should be about 3/8" deep.



To aid in tapping make a simple guide by using a piece of scrap round stock. Put it in the lathe and using your tail stock chuck, drill a hole large enough for the shank on the tap. Doing it in the lathe helps assure that the hole is centered and square. Hold the guide firmly in place with one hand and start the tap with the other.

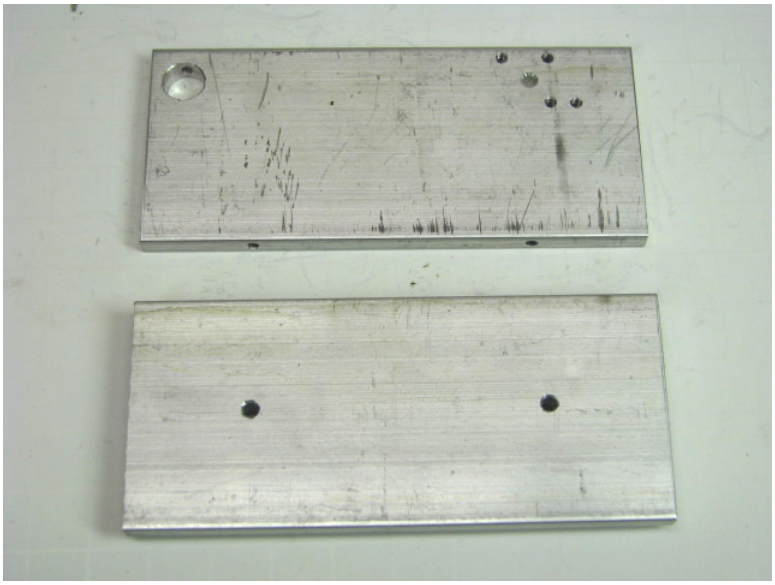


Do the same thing for the holes in the edge by clamping the piece in a vise flush with the top and then use the vise as a wider base to help keep the tap perpendicular to the work.

Now you have the frame of the engine ready. If you ordered all of your screws 1" long you will need to cut these down to about 1/2 inch. Cut them to a length that will not bottom out in the hole.

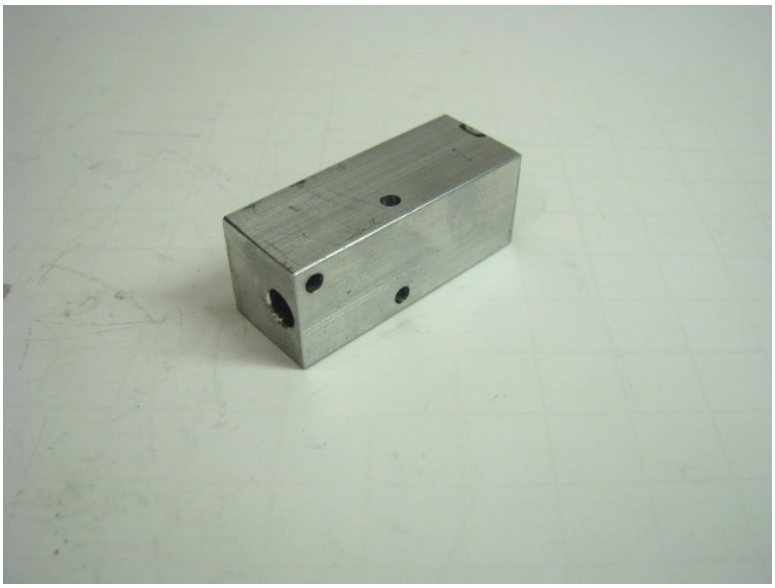
Look at the picture above. It is a scrap piece of 1/8" steel strap held in the vise. Drill and tap it to 4-40. Put the screw in and then cut it off. When you remove the screw the steel piece will clean up the threads for you. If you are using a hacksaw put a nut on the screw on the same side as the head of the screw. Tighten the nut down when you have the screw where you want it and the screw will not rotate when you cut.

Put the frame together with a couple of screws.

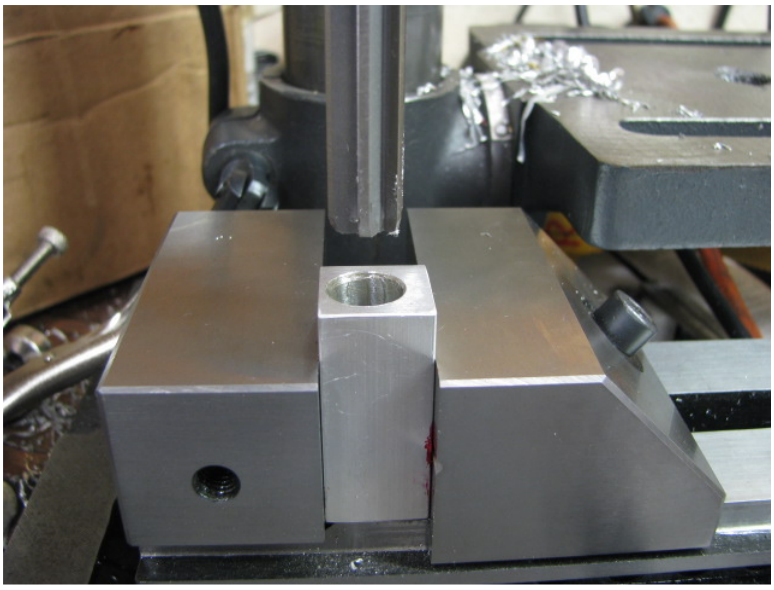


Rubber feet on the bottom are nice and you won’t have to counter sink the screw heads.

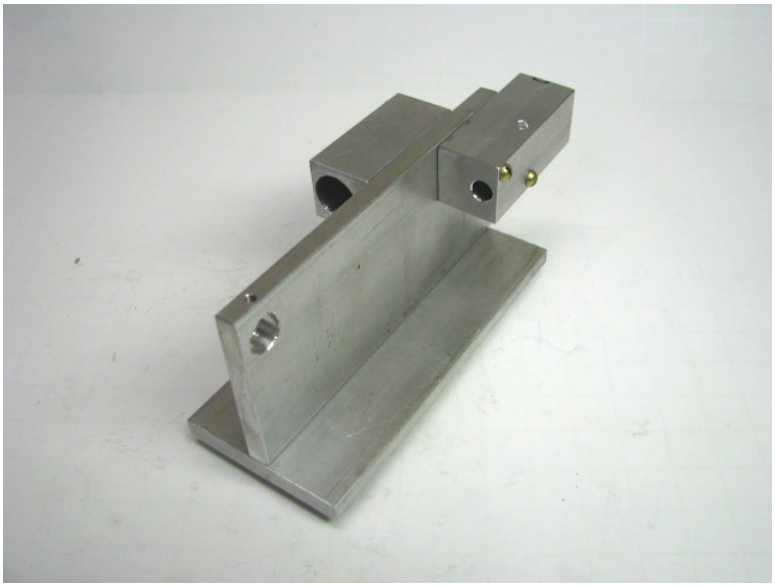
Time to make the valve and cylinder bodies. Cut the 3/4 inch square stock to 1.625" and 1.875". My preference is to drill the large holes first so that if something goes wrong I don't have to redo all the other holes. Layout the center for the valve, center punch it and then drill it with a 7/32” drill all the way through. Be sure the piece is vertical and square on both sides. Drop your drill down next to it and verify that it is parallel to the body before drilling. Then switch to a 1/4” reamer and finish the hole to size. Use plenty of oil when cutting and pull the reamer out often to clean the cuttings off of it. Now you can drill the 1/8” mounting holes and the two air vents. Since the air vents will penetrate into the hole you just reamed you will need to run the reamer down it again to clean up any burrs. You can do this by hand. Hold the piece in one hand and turn the drill chuck with the other. Turn it just long enough that the reamer turns freely.



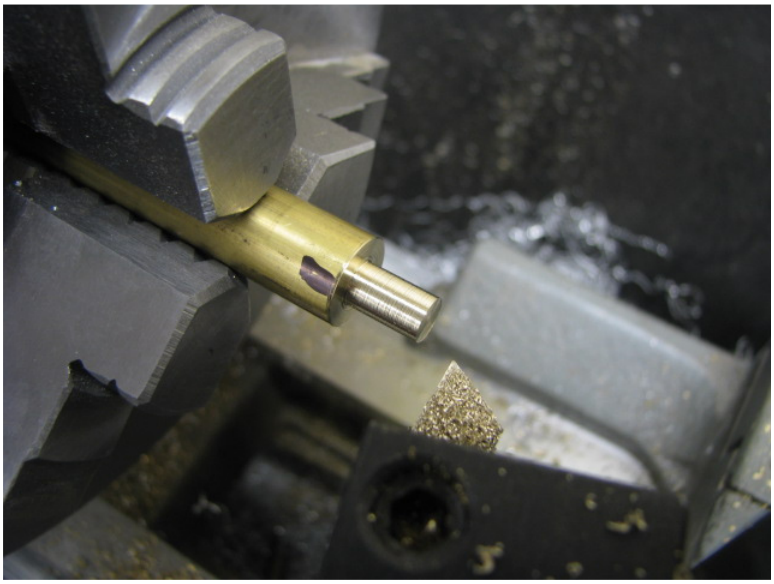
The cylinder is done much the same way except the cylinder hole is 1.375” deep. Put a piece of tape around your drill bit so you know when to stop. Drill the hole with a 1/4" bit first then a 15/32". Finish it off with a 1/2” reamer. Mark, center punch and drill the 1/8” mounting holes and air vent. Check to see that the air vent is fully open into the cylinder.

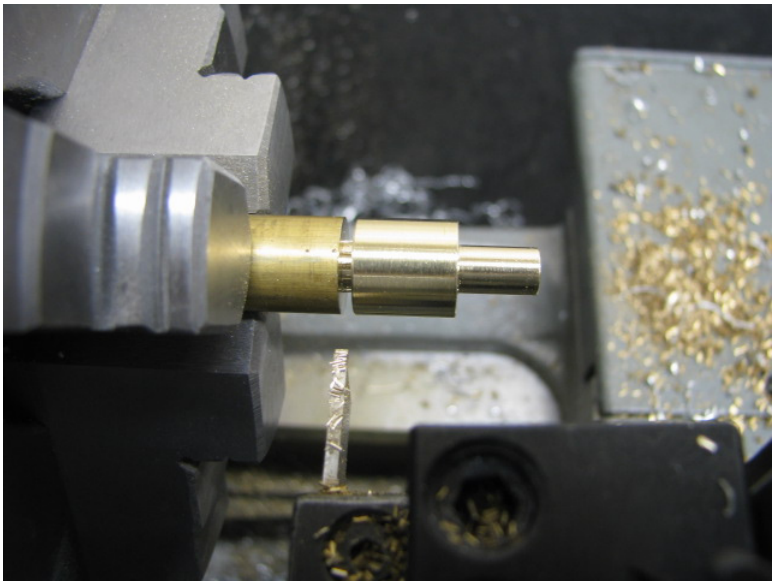


Mount the valve body and cylinder to the upright part of the frame with 1" screws. That takes care of the chassis. Next will be making some round parts on the lathe.

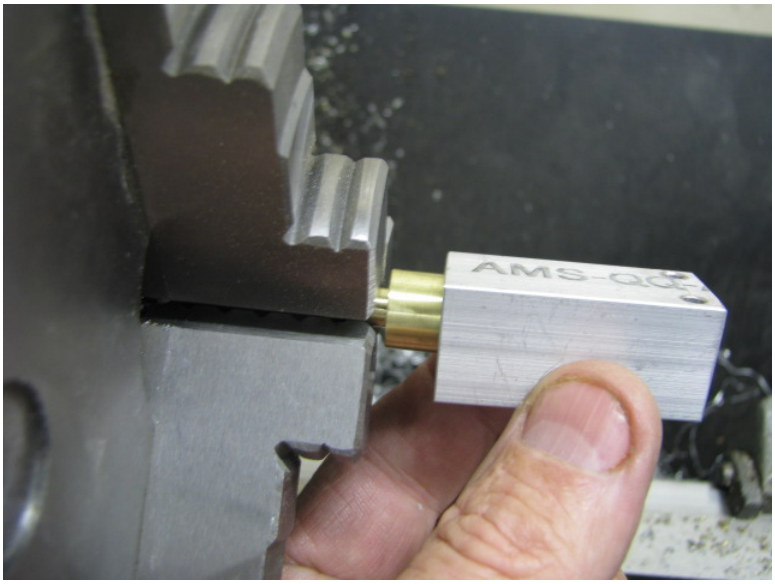


Turn the piston from brass .5 inch round stock. Turn the .250 inch part so that it is .4375 inch long. The piston body is .5 inch long. Mark it and using a parting tool cut it off.





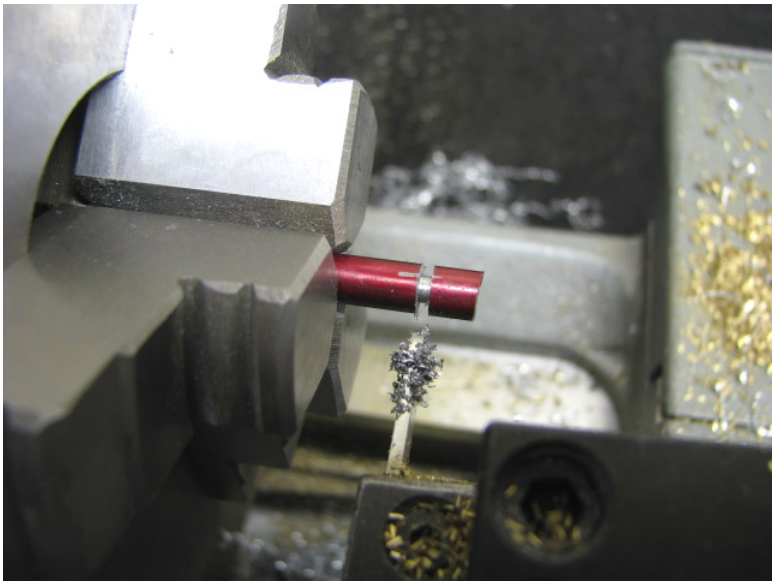
Put the .250” end in the chuck and using a file and some fine grit emery paper smooth the piston and fit it to the cylinder. Stop and check fit often and wipe the piston clean. You want the piston to move freely in the cylinder with light oil. It does not need the compression of a combustion engine so a little loose is OK.



The valve is made of .250” steel stock but you could make it from brass also. If you are hand filing the flat spot on the end of the valve brass is much easier. Cut it at least 1 inch longer than the valve needs to be so you will have something for the chuck to hold on to. I like to make the initial cuts with the parting tool to the depth needed. Mark the first cut, position the parting tool, zero the cross slide and then make a cut .0625” deep. Remember the cut is measuring depth on one side so it is like a radius. A .0625” deep cut will reduce the diameter by .1250”. That will be a good size for the smaller diameter part. Move the work piece out for the second cut.

Some pointers:

1. Rotate the chuck by hand to be sure you will not hit the carriage or anything else before you turn on the motor.
2. Keep the cut as close to the chuck as you can
3. Use a low speed for a parting tool and feed slowly
4. Always keep an eye on the chuck and carriage so that they don’t hit while you are cutting.

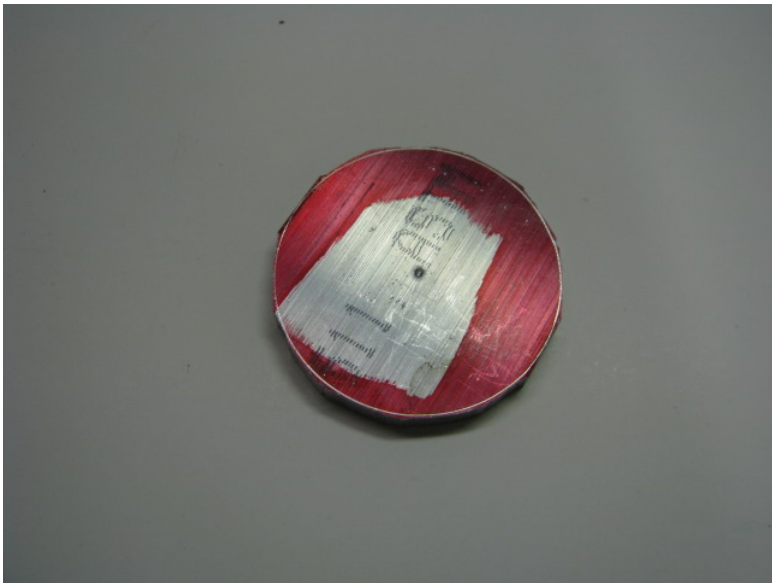


Do the same thing for the next small diameter. Finally remove the work from the chuck and file / mill / grind the flat spot for the connecting rod. Also, go ahead and drill / tap the 4-40 hole for the connecting rod. Put the end of the valve back in the chuck so you can file and sand it to size. As with the piston check the fit often until you have smooth action back and forth.

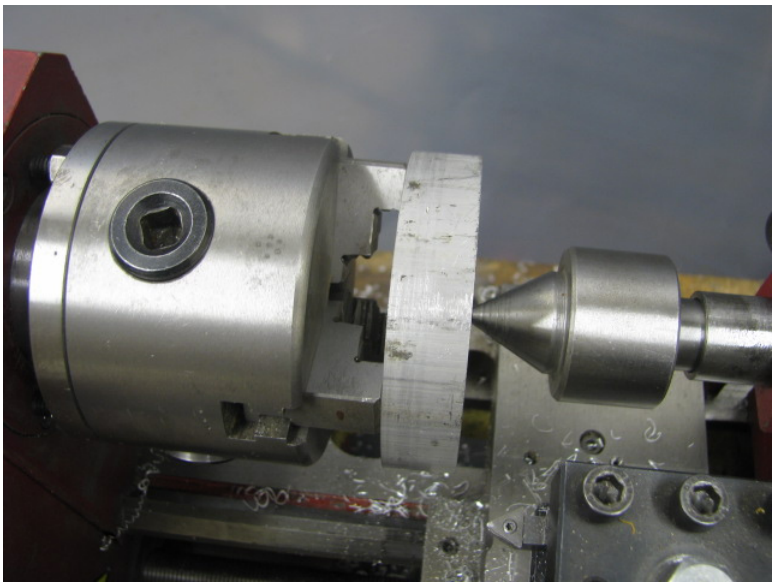
Grind the flat, drill / tap the hole and fit to the body before you cut the valve free from the parent piece. This allows you to hold or clamp using the end that will be cut away and discarded and not mess up the valve pieces.

The flywheel can be made of .250 inch aluminum flat stock. Punch a center mark and then scribe a line to draw a 3 inch diameter circle. While you are doing this scribe a line .250 out from the center and make a punch mark anywhere on that radius. It will be used for the pivot point for the connecting rod to the valve. It is easier to do this now than when you have drilled the center hole for the shaft.

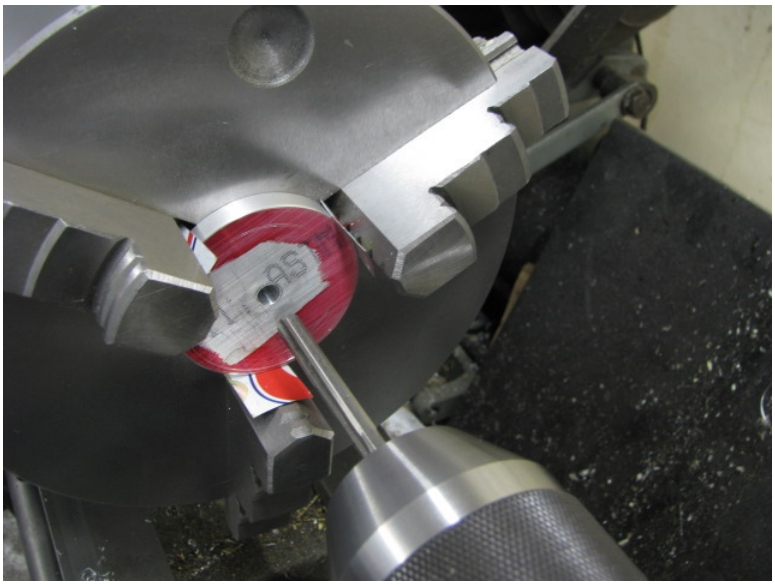
Using a bandsaw or hacksaw cut close to the line and remove as many corners as possible.



Center drill the punch mark you made and using a live center push the flywheel up against the chuck jaws. Have the chuck jaws set to less than the diameter of the flywheel. You can use double sided tape if you like to help turn the flywheel. Do not over tighten the live center as it will flex the aluminum plate. Making light cuts reduce the diameter of the flywheel until it is smooth all the way around. Now you can mount the flywheel in the chuck using pieces of soda cans cut into strips to protect it from the jaws of the chuck.



Drill the center of the flywheel with at 15/32nds drill and follow it with a .025 inch reamer. Take the flywheel out and drill / tap the punch mark you made for a 4-40 screw.

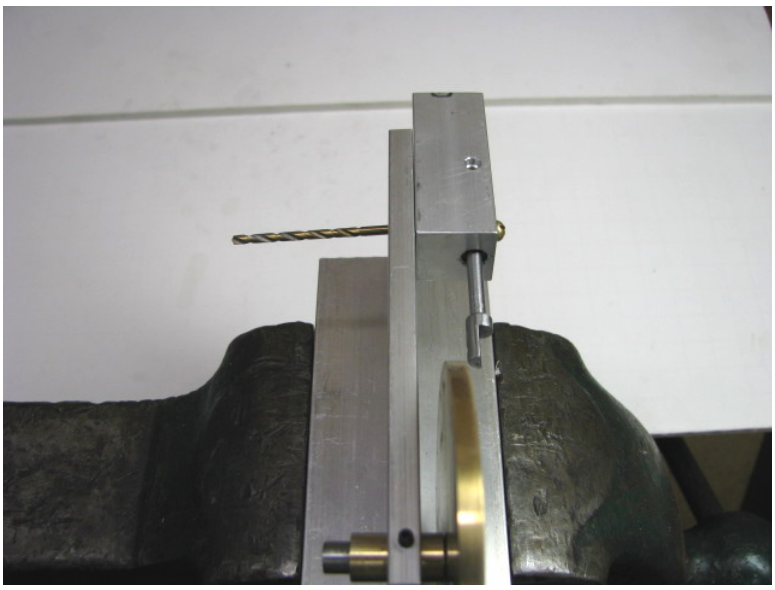


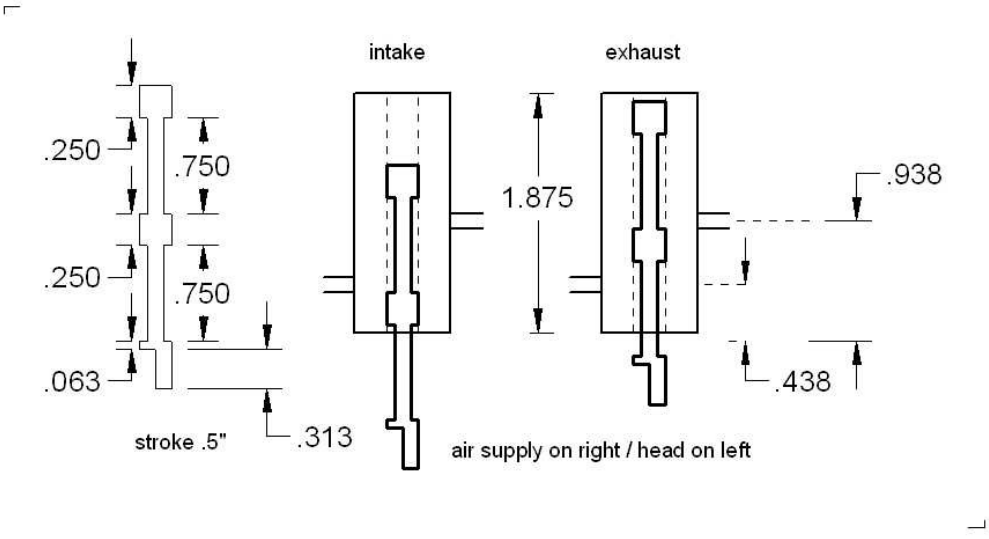
You will glue the flywheel onto the shaft with epoxy. Adjustments will be made with the set screw in the crank.

The shaft for the engine is a 1.125” piece of .250” diameter steel rod. Polish it with fine emery paper and check its fit through the bushing to be sure it rotates freely. Glue one end of the shaft into the flywheel with epoxy glue.

The crank is not critical and you can make it any shape. It just needs a .250” hole and another hole .375” from it drilled and tapped for a 4-40 screw that will be its pivot point for the connecting rod.

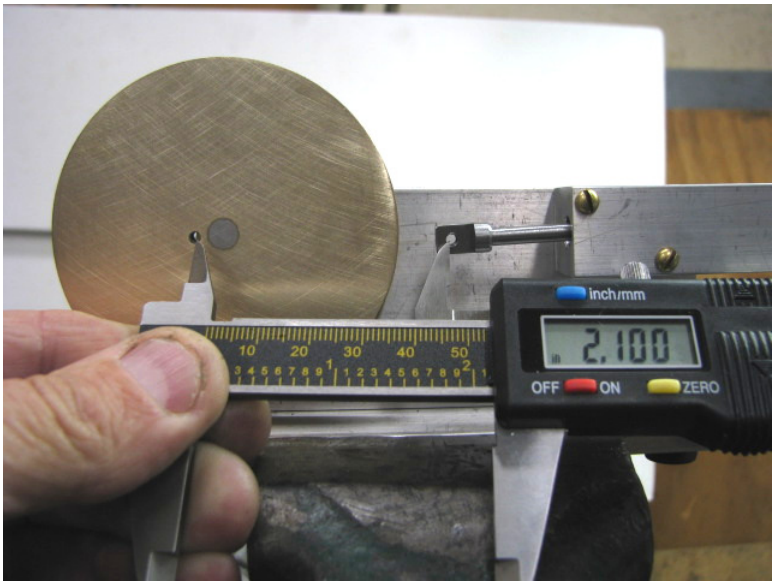
You will need to make a connecting rod for the valve to the flywheel pivot. Here is the functional way to do it: Insert the valve and then stick a drill in the air vent with the piston / cylinder removed. Push the valve in until the piston just touches the drill. This is the “open” position and the valve needs to be completely clear of the air vent during the power stroke.

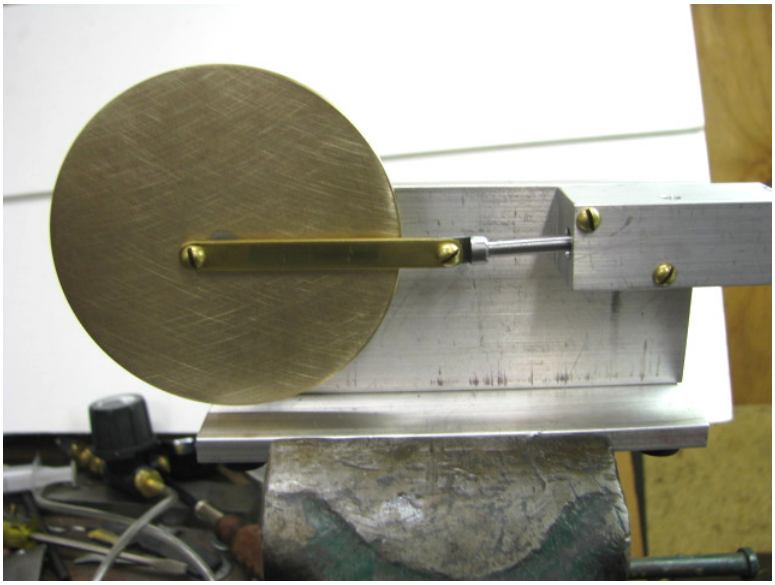




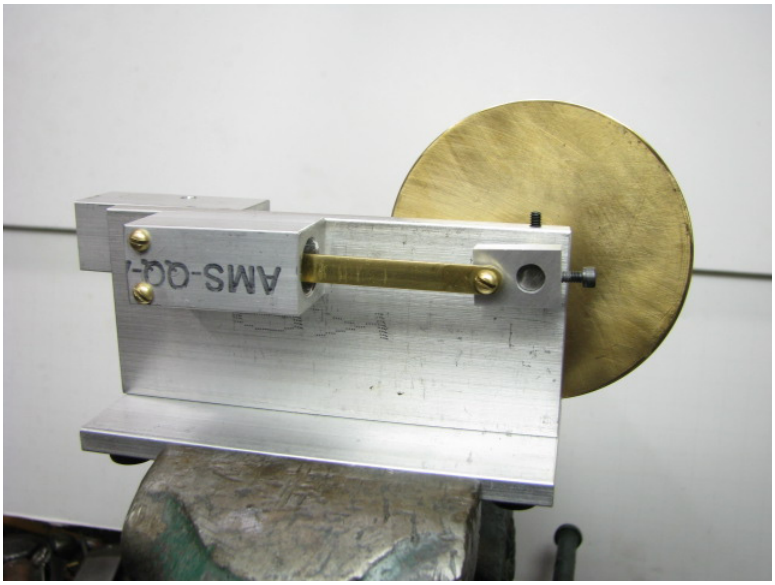
Valve needs to be in the “intake” position to determine the length of the connecting rod.

At this time the flywheel pivot point is at its furthest point away from the valve assembly. With the valve just past the hole in the intake position, rotate the flywheel so the pivot is at 9 o'clock and measure the distance between the holes and then use that distance to make a connecting rod. Use .250" x .063" brass strips and cut them .125" longer on each end than the center of the hole. Place a .063" thick washer behind the connecting rod on the flywheel end only. This will give it some clearance so it won't rub on the flywheel.

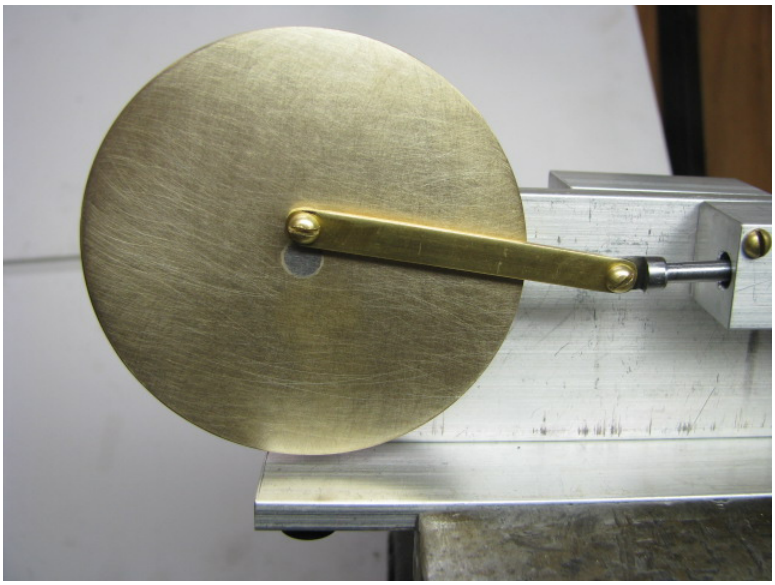




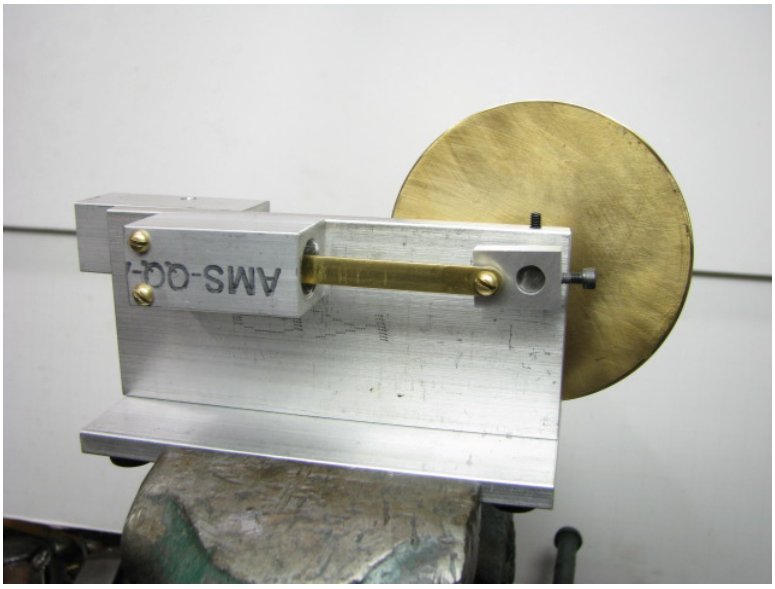
Do almost the same thing for the piston except position the piston .063” before it hits the bottom of the cylinder and put the crank pivot towards the piston. Measure and make a connecting rod for that side also.



Timing is easy. Put the pivot on the flywheel at 12 o'clock then put the pivot for the crank at 9 o'clock. They are 90 degrees apart to start out. Tighten the set screw for the crank allowing some clearance for the bushing so it does not bind. The bushing can be moved left and right to line up the connecting rods which should be straight with the piston and valve. If you want a thicker flywheel just make the bushing shorter to keep the alignment correct.



Flywheel at 12 o'clock

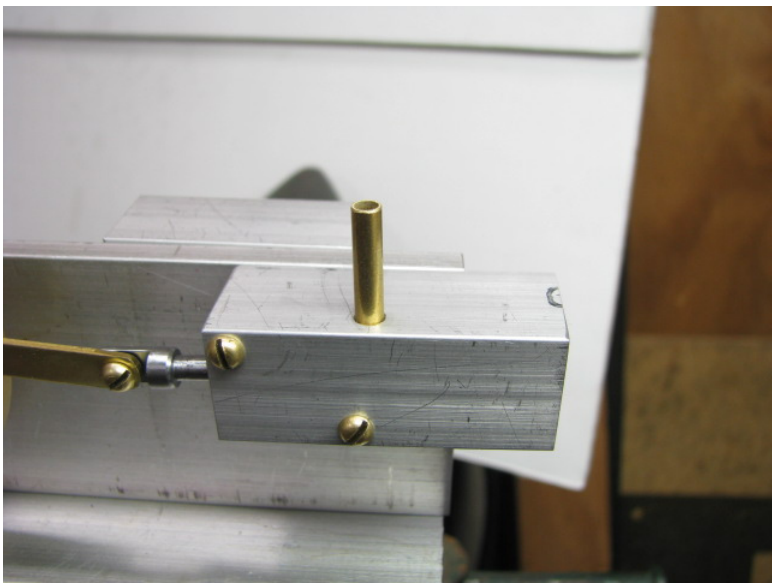


Crank at 9 o'clock

This also determines which way the engine will run. You can put the flywheel at 6 o'clock and the engine will run the opposite direction. You just need to keep them at 90 degrees to start out.

Here are the small parts just for reference.

The air connection is up to you. I used some brass tubing with an inside diameter of .125" and enlarged the air vent to allow it to be glued in place with epoxy. Just make the hole about .125" deep and do not allow the epoxy to run into the valve cylinder.



Clean everything really well. Flush out the valve and cylinder bodies with solvent to remove any specs of metal. Flush the piston and valve. Set everything on clean paper towels to avoid getting dirt or grit into the moving parts. Spray all the parts with WD-40, assemble the engine and spin the flywheel. If every thing is right you should get 3 to 4 revolutions with a flick of your finger. Track down and resolve any friction, interference, or binding issues.

Now the fun part. Hook up some compressed air at about 10 lbs and give it a spin. If it seems stiff you can increase the air until it continues to run. After running for a bit you should be able to reduce the air to under 5 lbs. After it is running smoothly try moving the timing in both directions and see if there is a spot where it runs the best and tighten the set screw there. Run it pretty wet with oil for some time then take it apart and clean out all the stuff and then just give it a thin coat of light oil