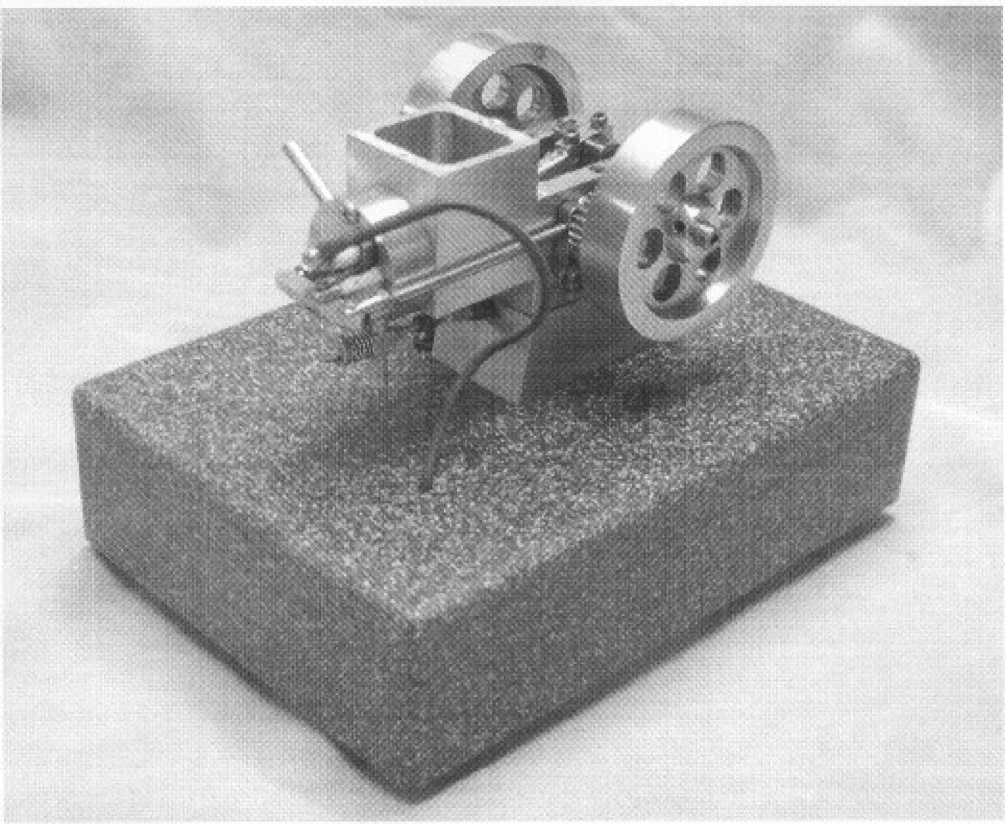
Tiny I.C. Engine

By PUTPUTMAN



TINY I.C.

By **PUTPUTMAN**

This will be some added notes that may help you build the Tiny I.C. Engine. If the prints and these notes do not answer all your questions, please feel free to ask on the HMEM post or PM me and I will try to answer any and all questions. Like I stated in an earlier post, my drawing are not professional nor are they up to industry standards. They are drawn so the I can understand them and am allowed to assemble the units on the computer prior to machining the parts.

For photos & added notes: **http://www.homemodelenginemachinist.com/index.php?topic=8096.0**

1) FRAME -- SHT 1 & 21 REV B
The frame is machined out of 6061 aluminum. The entire frame can be machined less the bore for the cylinder sleeve, tapped hole for the head assembly, and the bore for the crank shaft bushings. All other tapped holes can be completed.

Next machine the two crank bushing retainers (sheet 1A) and bolt them in place. Once they are mounted, the holes for the bushings can be drilled & reamed or line bored for a 5/16 O D - 3/16 I D bushing.

The hole in the hopper can be bored next. It should be centered crosswise on the frame and in line with the center of the crank shaft. I personally prefer to line bore the holes and bore the hole nearest the crank shaft about .030 smaller than the bore at the head end. This allows me to drop the cylinder sleeve almost all the way in before having to press fit the final distance. I also prefer to heat the aluminum in boiling water so the cold sleeve will drop right in place without having to press it in. The print for the sleeve will accommodate this method.

The three 2-56 tapped hole for the head can be finished at this time also. I doubt that you will run the engine long enough that it will require cooling water in the hopper, so you can drill all the way through the hopper wall without fear of leaking.

The .030 oil hole on top of hopper should be drilled after the cylinder sleeve is installed.

2) GAS TANK -- SHT 2 -- REV B
I first used this style gas tank in one of my larger engines so thought I would try it in this one. It worked out fine. It does not use a check valve but apparently does not need it. You may be required to choke the engine by blocking the air intake with your finger if you have not run the engine for some time.

To make the gas line I cut a 1/16 wide groove in a 3/8 dia piece of brass. I was then able to bend the 1/16 O.D. Brass tubing without annealing. It held its' shape without collapsing. Brass tubing is bonded in place with JB Weld.

3) CYLINDER -- SHT 3 -- REV B
The cylinder can be made from cast iron, steel, or SS steel. As you can see on the print, there are 3 different diameters on the O.D. . The two end diameters should be .001 - .002 larger than the matching bore in the frame. The center diameter should be at least .005 smaller than the outer bore of the frame. This allows you to insert the cylinder sleeve into the frame almost all the way before having to press fit in the final position. If you heat the aluminum, the cylinder may go all the way to the shoulder without pressing. This system works even better on larger engines.

4) CRANK -- SHT 4 -- REV B
The crank shaft is made from 1144 steel. That is a stress proof steel that is very nice machining. I left the counter throw on the crank as the engine is so small and high speed that I thought it would run smoother. They are optional.

5) FLYWHEEL -- SHT 5 -- REV B
The flywheel can be made from either steel or brass. I think aluminum would be too light and the engine might run too fast. On my engine I ended up mounting a magnet on the inside surface of one of the flywheels. This worked out fine for using a Hall Effect Sensor for the ignition. A brass flywheel is probably best when using a magnet.

6) GEARS -- SHT 6 -- REV B
You will need a couple gears to provide a 2:1 gear ratio for the 4 stroke engine. I happen to have a set of 48P involute gear cutters so I was able to cut a 15T and a 30T gear. Therefore I ended up with a center to center distance of .469 as shown on the frame print. The 48P gears fit this size engine well. If you are able to cut a different pitch series of gear, you may have to change the center distance.

If you do not have involute gear cutters, they are quite expensive, you might want to make your own gear hobb as shown in this set of videos. If I am ever required to cut a different pitch series of gears, I will certainly go this route.

http://www.youtube.com/user/Hobbynut#p/u/15/MItgd-faHFw

I used a small 6" horizontal/vertical rotary table with index plates to cut my gears. Fortunately these two gears are even numbered degrees and can be cut using a spin indexer. These tools are much less expensive.

It would be wise to cut at least 1" of teeth as long as you are set up and going through the process. This will allow you to make several gears if necessary. I had to make a couple of cams on the larger gear before I got the proper amount of dwell on the exhaust valve. Cutting longer teeth the first time save me from having to go through the whole set up again.

The smaller gear is a two piece assembly. First you cut the gear and then turn a .281 dia. hub on it. You will then have to make a collar and then press it onto the gear hub. This will allow you the room for a set screw to secure the gear to the crank shaft.

The larger gear was made out of brass. The cam was cut on the same piece as the gear teeth. Brass was used as the steel cam follower that activates the exhaust valve will be rubbing against the cam.

7) PISTON -- SHT 7 -- REV B
There is not much to say about the piston. You might want to purchase some 3/8 O.D. X 1/16 O-rings before you make the piston. O-rings from different manufactures very slightly in thickness. When you cut the O-ring groove it should be a couple thousands deeper and wider than the O-ring.

To hold the wrist pin in the piston I merely prick punch around the hole after the con rod & piston were assembled. Stone off any raised portion before inserting it into the cylinder.

8) CONNECTING ROD -- SHT 8 -- REV B
The connecting rod is built a little different than most rods. Because of the tight space constraints I split the crank journal horizontally rather than the conventional vertical split. The rod just about touches the floor of the frame when the crank is in the lowest position.

9) HEAD -- SHT 9 -- REV B
I think you will find this to be the most difficult of all the parts on this engine. Getting two valves and a spark plug into a 3/8 diameter doesn't allow for much error. A lot of valve seats for model engines are made from brass so I decided to make the entire head from brass. It is easy to machine, the valve seats finish up nice, and it adds a little bling to the finished engine.

First turn the O.D. and the 3/8 diameter concentric. I also added an O-ring groove around the 3/8 diameter boss. This is optional, but when I was having problems getting the engine to run, I suspected some leakage around the head so I added the O-ring. It turned out that was not part of the problem, but it is added insurance the prevent leakage. I have used this technique on some of my larger engines also.

See George Britnells' post on making a valve seat cutter. Http://www.homemodelenginemachinist.com/index.php?topic=6205.30

Next mill the flat on the side of the head. Then clamp the head in the mill with the 3/8 boss facing up. Locate the center of the boss and drill the three mounting holes to match the holes in the frame. Next drill the holes for the two valves. I used some old hardened pin punches with a 60 deg. head on them for my valves and that is why my guide hole is .094 diameter. You should drill that hole to match what ever size valve stems you make. Next you will cut the valve seat using the cutter you made. A seat about .010 wide is plenty good for this engine.

The spark plug hole is at a 10 deg. Angle in two directions. The photo on my post should described the set up better than words. I determined the location by putting an 1/8 inch pin in the drill chuck and visibly located the hole between the two valve holes and the outer dia. of the boss. Drill and ream a .125 hole through the head.

Turn the head over and set it up at the 10 deg angle again. Put a dowel pin into the 1/8 hole and indicate center of the pin. Spot face about .281 until you have a complete circle. Now drill and tap for a 10-32 thread to the depth shown on the print. You may need a bottoming tap to get enough threads.

Clamp the head flat in the mill and locate & drill & tap the 4-40 threaded hole .

10) VALVE -- SHT 11 -- REV B
There are a couple options when making the valves for this engine. I think the most common angle for the valve head is 45 degrees. That is the angle I have used on all my other engines. On this engine I used 60 degrees for one reason only. I had some 3/32 hardened Royal Punch Pins in my tool box that were left over from some molds I built in my earlier days in life. The 60 degree heads were swaged and had a slight seam on them but I was able to grind them true & smooth with a tool post grinder. Because they were hard I had to grind a groove for a retainer ring. The valves worked out fine for me and should last a life time.

For some one making a valve from scratch it would be best to use the optional design. Make the valve out of drill rod. A 45 degree angle and a cross hole for a pin retainer would be recommended.

Be sure to make your valve seat reamer at the same time to assure a good fit on the valve seat angle.

11) SPARK PLUG -- SHT 12 & 13 -- REV B
This was my first attempt to make a spark plug and it wasn't as bad as I imagined. I have read several posts on HMEM from other more experienced members and they gave a pretty good description of their builds. Most of their plugs were larger so I had to improvise a little to fit one into Tiny's little head.

We have already established the plug size when we made the head. It has to be 1/8 dia. Where it enters the cylinder. To accomplish this I had to step the dia. Of the plug down from 1/4" hex to a 10-32 thread to a 1/8 shank. When drilling the I.D. try to get as smooth a finish as you can when drilling the .079 hole in the casing. Later when you push in the insulator you want as little drag as possible.

Next make the electrode. I used .032 music wire because that is what I had on hand. Cut the music wire about .100 longer than the finished spark plug requires. Make a ferrule out of brass and solder the assembly. I'm not sure if soft solder will work or not. I used silver solder on mine.

The insulator can be made from most any material that will insulate electrical spark. Teflon, Delrin, Corian, and machineable ceramics are most common. In my case I used Teflon.

First machine a piece 1/4" dia and the length required for the plug. Drill a .032 hole and part it off to length. Press the electrode assembly into the insulator. It should be somewhat of a tight fit. The electrode should stick out the end of the insulator approx. .100. The reason for this is that the electrode assembly will help support the Teflon while you machine the rest of the diameters.

To make the set up even more sturdy, I took a piece of 3/16 dia brass and drilled a .032 holes in it. Taper the end of the brass. Stick the brass piece in the tail stock drill chuck and use it like you would if you were machining between centers. I put just a little bit of lubricant in the .032 hole. Chuck the electrode assembly in your three jaw or collet and use the .100 overhang to support the outer end. Machine the .079, .125, and .156 diameters.

Press the electrode assembly into the metal casing. It should be just a nice slip fit on the .079 dia. Or it will bunch up on you. Most of to press should be on the .156 dia. I put a little JB weld between the metal casing and the insulator and it seemed to help. Now you can chuck up on the ¼ hex and finish machining the insulator to suit.

The last thing is to cut the electrode end back to the desired length. This can be done on a grinder or belt sander. The put the plug in the milling machine with the electrode end up. Machine about 1/32 off both sides the to metal case up to the edge of the music wire. This will leave a little piece of insulator between the electrode and the casing. Remove this with a knife or file, what ever works for you. Now you have a surface gap plug.

12) FUEL MIXER -- SHTS 14, 15, & 16 -- REV B

SPRAY TUBE

One of the more delicate parts of the engine is the fuel mixer spray tube. It is made from a piece of 1/8 dia. brass. It is best to use a piece 1-2" long. Chuck it up with just over 1/2" exposed. The first operation is to turn the .085 dia.. Next thread the part for .270 full thread. You will need that much thread to hold the part in the mixer body, but must have some .085 dia. left to locate the part.

Center drill or some how make a starter point for your small drill. Drill a .025 hole as close to .357 deep as possible. Next use a .018 drill to drill to a total depth of .400 minimum. If you feel comfortable to drill deeper, do so. It is important that these two hole are concentric with the threaded O.D. and with each other.

Next you will want to machine the .065 dia X .062 wide groove on location.

Move the part to the milling machine and clamp on the 1/8 dia. Locate the center of the .065 X .062 groove and drill a .020 dia hole through the part. This hole should intersect where the .025 & .018 holes meet.

Cut part to length. Back to the lathe. Chuck up lightly on the .085 dia being careful to not damage the threads. Turn the rest of the part and drill the .040 & .062 hole. At some point you will soft solder a 1/16 brass tube to this part.

NEEDLE ASSEMBLY

The needle assembly is a brass knob and a .025 dia sewing needle. Machine the brass knob to print. Tap the 2-56 thread and finish with a bottoming tap if possible.

To assemble, screw the knob onto the spray bar until it bottoms out. Back the knob up 1-2 turns.
Put the sewing needle into the knob until it bottoms out on the .018 dia hole. You should be able to see the needle touching the .018 hole by looking through the .020 hole. At this point, solder the needle in place. Cut the remaining needle of and polish the end of the knob.

MIXER BODY

This part is also made of brass. The print is pretty self explanatory. The 1/8 dia at the top should be a slight press fit into the intake port of the had.

You will need a thin 2-56 nuts to hold & seal the spray tube in the mixer valve. Another thing you should be on the look out for is a piece of 1/16 I.D. plastic tubing to connect the fuel mixer to the gas tank.

13) EXHAUST LINKAGE PARTS -- SHTS 17, 18, 19 ,& 20 -- REV B

STAND OFF

This part was finished by securing it to the head by using a 4-40 stud that was bottomed out in the head. I faced off the bottom of the stand off until it was in proper alignment with the exhaust valve when secured tight. I then machined it the .094 slot and drilled the .062 hole on location.

ROCKER ARM & LINKAGE

Nothing special here. Machine to print or to suit. When the final part, cam follower is complete, make a lifter by threading a 3/32 rod and adjust to length. Be sure to have a gap between the rocker arm & exhaust valve. Make two .060 dia pins with heads on them.

CAM FOLLOWER

Make this part to print and it will line up properly with the brass cam. It would be good to polish the surface that the cam rides on to reduce wear on the cam.

IGNITION SYSTEM

What you use for an ignition system is up to you. I personally felt that a small engine like this one deserved a small hidden ignition system. Most of the engines that I have built in the past used points and either an old buzz coil or a large automobile coil. Either way they are just physically too large.

My friend Jim recommended looking at the *S/S Machine & Engineering* CDI units. I contacted Roy Sholl, owner/operator of S/S, and he recommended the complete CDI ignition system which included the coil, battery pack with rechargeable batteries, charger, switch, spark plug wire, hall sensor & magnet, and all Futaba connectors.

After receiving the unit I made the base that would house all the components. I guess there is plenty of instructional information install & hook up the system for anyone with electrical knowledge, but in my case, there were a couple e-mails and phone conversations between Roy & myself to make sure I didn't mess it up. I just can't get my head around electronics.

I started out using contact points but couldn't not get the engine to run. It was a system similar to what Jim is using and his runs well. Roy is trying to figure out why mine wouldn't run.

After failing to get it running and not knowing if the problems were electrical, fuel, timing, or quality of the build, I then switch using the hall sensor and magnet. I made a plastic holder for the hall sensor and mounted the magnet in the side of the brass flyw After adjusting the timing to fire at TDC, the engine immediately run.

This completes the notes and drawings for this engine.

Best of luck and I hope to see some new Tiny I.C. Engines on HMEM.

Arv (putputman)