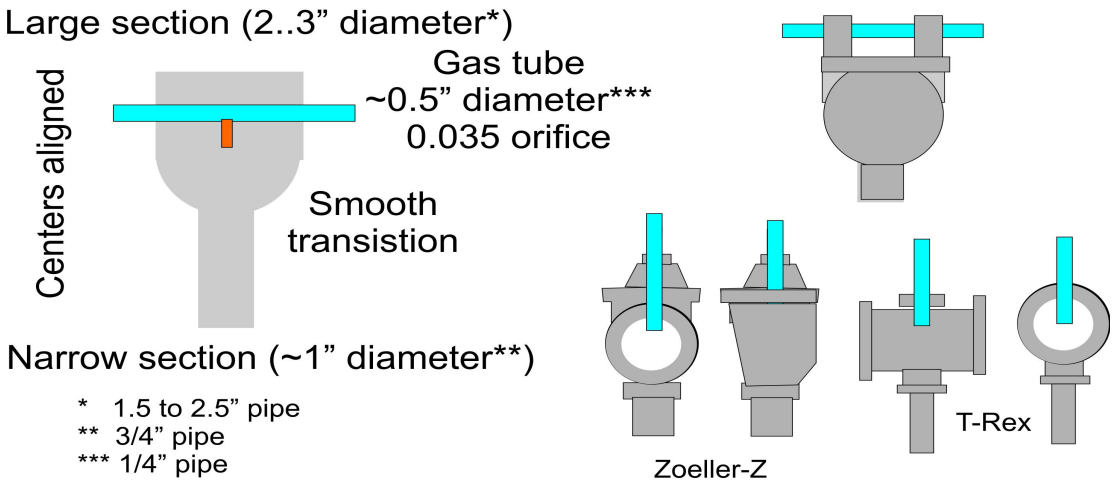
Making a Bell Burner

Dr. Steve Bloom, Ironflower Forge

One of the useful tools in a blacksmith/bladesmith's shop is a gas forge. For a number of reasons (some historic), I prefer venturi burners which do not rely on electric power to function. The basics are fairly simple...

Overview



Variants using plumbing fittings

There is a large opening connecting to a smaller diameter down pipe with a gas stream directed down the center of the down pipe. The gas stream creates a Bernoulli effect and air is drawn into the large opening and accelerates down the down pipe. Typically, the gas is delivered using a 1/8" to 1/4" pipe connected to a regulated LP source (2..15 psi) and emerges through a 0.035" to 0.040" orifice. There are a large number of variant designs and a great deal of "information" available detailing just why one variant is FAR better than others. Take that with a certain grain of salt. What I am going to describe here is a version that runs on as little as 1 psi gas pressure and can accommodate a blower if needed to reach welding heat (if the forge volume is low enough or the burner count is high enough!).

Shown here are three variants (left to right) – a bell burner with a cross tube, a bell with a center tube, and a T-Rex burner. The first is tuned by rotating the tube and sliding it back & forth until the maximum burn is reached. It is then locked in place. This design works well but if the burner is moved, the tuning can be compromised. The second has the gas tube locked in place in the center, is not tune-able and should never need tuning. The third is like the second except that the air flow is forced to make a 90 degree turn. This design appears to be more sensitive to air flow near the forge than the second. Neither the second or third can conveniently accommodate a blower.

The bell burner version can easily be turbo-charged by adding axillary air pressure provided by a small blower. Shown here is a manifold that locks onto two bell burners and is powered by a small squirrel cage. At 10 psi, this forge easily exceeds 3000 F which is why there is a slide gate on the air line to prevent melting the refractory. This particular forge was designed for welding pattern-welded steel and has been in service for better than 10 years without touching the burners.

The required materials include black pipe – 2", 3/4" ,maybe 1" and a 1/4" nipple (4") - all Schedule 40. You will need at least 12" of the 2" material and may have to order a stick (21'), so think workshop to spread the cost (~$1.50 per bell). The 3/4" & 1" are available at Lowes and the nipple at most ACE stores. The 3/4" material set me back ~$0.80 and the nipple was $2.50. A 3" piece of 1"x1/8" flat stock is also needed as well as a scrap of 3/8" round. The damages are therefore around $6.00 per burner.

The first step is to make sausages out of the 2" pipe. I used my 50lb Little Giant and a home-made mandrel (from 3/4" mild steel round stock). Be sure to weld the pipe end closest to you closed or stuff a wet rag in that end – you do NOT want the pipe to act as a chimney! Make the first squeeze about 6..7" from the end. When it compressed to ~3/4", cool the pipe and saw the 1st bell free. Return to the forge and make another squeeze about 12" from the end. Separate that sausage and saw it in half to produce three bells. Repeat for however many units you are building.

This is what the units look like after sawing (okay – not exactly – I missed taking the pictures during this initial phase).

The next step is to forge the bells as smooth and radially symmetrical as possible. The tools consist of a set of tongs that can easily grip the 2” pipe sections and a mandrel. The first one I built used a 2” trailer ball welded to some round stock. The current one uses a 2” ball bearing welded to a 1.5” pipe section. Both were equipped with a hardy stub for my anvil.

The bell is run up to forging temperature, dropped on the mandrel and then hammered to force the bell to approximate the mandrel's 2” hemi-spherical shape. The neck formed by sawing the sections apart is driven down as shown, What is critical is the interior of the unit, so some wrinkles on the outside can be tolerated.

One possible problem with the saw cut is shown here – the opening of the bell is not perpendicular to the sides. That has to be fixed, so it is time to visit the machine room.

But first the bottom was ground a bit on the 2x72 knife grinder to remove any major wrinkles and to create a quasi-flat on the bottom (as shown). The next task is to face the opening.

The goal is to position the bell in the three-jaw chuck as close to square as possible. I found that using a 13/16 drill bit and an alignment slug (more on this later) inserted into the bell acts as a rough bull-nose live center to align the unit. Once the chuck is closed, the tail stock is slide out of the way and the bell edges are faced.

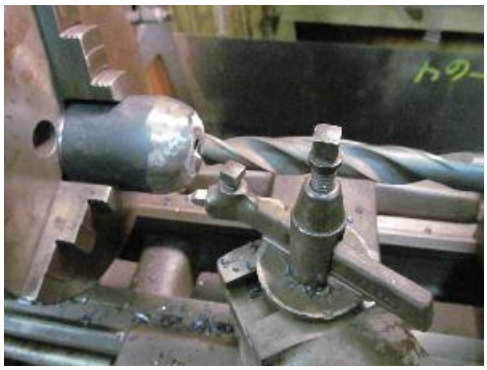
The result is that the opening is now perpendicular to the sides as required.

It is now time to drill an opening at the base of the bell – hopefully the same size as the interior diameter of the 3/4" pipe (about 13/16"). This can be done on a drill press if an alignment slug is created. The slug should be 2" in diameter (and just slide into the bell) and a 13/16" hole be drilled in the center. The bell is clamped on the drill press and drilled as shown. Since you don't want to drill the table, a piece of wood under the bell is a good idea. You may find that a set of V-blocks may help to keep the bell in position. Alternatively....

Use the lathe. Face the bottom and create an opening by removing any excess material resulting from the forging of the neck down into the bell.

The idea is to enlarge any opening sufficiently to allow the drill bit not to wander.

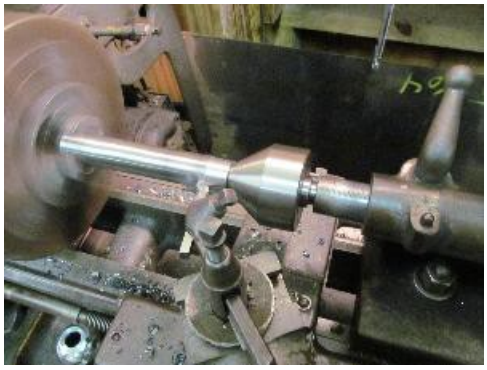
The next step is to shove a 14/16” Morse Taper bit into the tail stock and create the hole (nicely centered!).



The last operation is to face the bottom to create a flat area surrounding the opening. This will be the seat on which the 3/4” down pipe will be welded.

Face the down pipe on both ends.

If the down pipe is to eventually slip into a section of 1” pipe, you can either reduce the exterior diameter of the down pipe (by ~0.020”) or bore out the diameter of the 1” pipe. The first is actually easier and this step can be done after the bell is welded to the down pipe. Note the use of a bull nose live center.



There may be flashings on the edges of the openings. They are easily removed with an air die grinder and a carbide bit.

While not critical, it is nice to smooth the exterior with slack belt position on the knife grinder.

The next step is to drill two holes along the center line of the bell (in line with one another) and near the top but not too near. Of course, I built a jig. It stands off the drill press vise by 1/2”, has lateral flat plates for a firm grip by the vise, a center well just big enough to slip a 2” bell into, two heavy lock bolts and a top tube to prevent drill wobble. Is this really necessary? Well....no...but it doesn't eat much stored with the rest of the tooling.

The process starts with slipping a small drill (letter size “T”) adapter over the top pipe and running the 'T' bit through the side of the bell clamped in the jig.

The small drill adapter is removed and the bit replaced with a 33/64th bit. It is then run through the wall of the bell. Cooling fluid does help if available.

Hole Number one is done. The bell needs to rotated 180 degrees and the drilling procedure repeated.

To insure that the holes are aligned, the bell is inserted and rotated past the bottom hole. When a 1/4” pipe section can be inserted through the hole and into the bell, the bell can be locked in position and the second hole generated as described above.

If all goes well, a gas pipe now runs through the center. Any drill flash should be removed with the air die grinder.

The down pipe needs to be welded to the bell so that it is dead straight and aligned with the hole in the bell. This is most easily done with another jig. It can consist of the drill adapter slug and a piece of round stock that will fit the ID of the down pipe. I happened to have the lock mechanism from a weight lifting bar in the scrap bin, so a few seconds on the lathe made essentially the same thing.

Just slide the components together, tack weld one position, rotate 180 degrees and start running a complete bead around the junction of the bell and the down pipe.

After the weld, clean up on the knife grinder and...

Add a coat of high temperature silver paint (from the ACE hardware) meant for BBQ rigs,

What is left is the fabrication of the gas pipe and that includes precisely drilling an orifice in the dead center of the bell. This starts with the creation of a strap that wraps part of the exterior of the bell and that starts with a pilot hole – here an 1/4" hole centered in the 1" x 1/8" x 3" flat stock.

The idea is to curve the strap to the desired curvature and it just so happens that my set of Yater swage blocks has just the right swage.

So heat the strap and drive it into the block with a spare bell or anything else that will get the job done.

Use a 13/64 bit and drill the strap so as to accommodate the gas pipe.

A quick pass over the 1/2” contact wheel on the #3 grinder removes the flashing.

Trial fit the tube and strap and check the fit. Good but not acceptable.

So clamp the assembly in a machinist vise and use a trashed pipe section inserted over the tube and a hammer blow or two to correct any discrepancy in the fit.

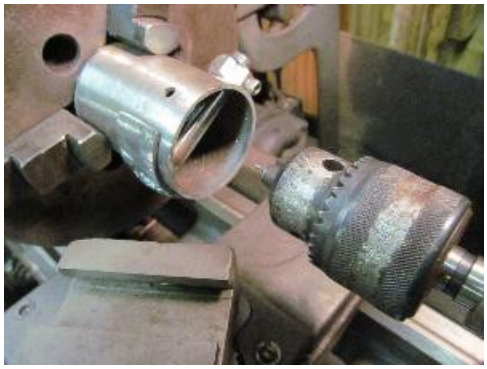
Since the gas pipe is one of the more expensive items in this build, you can just buy a 4” nipple or an 8” nipple and saw it in half. Either way, you want a length that spans the bell plus ~0.5” (not including the threaded section). Run a 3/8” bit into the pipe for maybe 1/2”.

Take a piece of 3/8” round scrap, grind a bevel on one end and then saw off that end to generate a plug ~ 1/2” long. Tap it into the non threaded end of the nipple and position the strap as shown. All that is needed is to weld the plug over the entire 360 degrees and weld the strap to the pipe.

After a good deal of experimentation with MIG tips and 1/4” pipes, I have decided that drilling a hole is far superior. You need a #60 (0.040”) or #65 (0.035”) wire drill (about $0.85 from Enco – you will have to buy a dozen which -of course- insured that you will never break a bit). Add a precision drill chuck (Enco stock # 891-5837 < $10) and you are ready to make a hole.

The drilling will be on the lathe. The tooling consist of a substitute for a bell (note the flat bottom) and a retainer for the gas tube (a 1/2” nut drilled out and tapped for a set screw).

The first step is to use a centering drill bit to make a tiny depression in the tube (NOT all the way through!).



The switch to the #60 bit and micro-precision drill chuck and make the hole (very gently!).

When done, this is what it look like.

So invert the gas pipe (orifice has to pointed down the down pipe and not in your face), clamp it in place and tack weld the ends of the strap.

Add the fittings on the gas pipe to connect to the LP source and you are done.

If needed for hitting welding temperatures, add a small blower (15 cfm seems sufficient in my forge).

And given the jigs and time of setups, make more than one.