Building a Gas Forge

by Dan Jennings

Some New Thoughts on Gas Forges

"Knowledge is just a placeholder until there is better knowledge." Mark Aspery

Teaching in a blacksmithing lab with a flow meter on a forge has been able to help us figure out relative flows of different types of burners, and gas pressures. We have found the single 1" pipe burner to be more fuel efficient and hotter than 2 of the ¾" burners. They will run on less gas pressure and still get hotter, and that translates into better fuel economy.

The blacksmithing lab provided another bit of information that seems counterintuitive. The lab has 12 forges whose housings are made from pipe. Some are 12", some are 10" and others are 8" diameter. They all use 1" thick ceramic fiber blanket and all have the same the heat source: 2 burners, made from ¾" pipe with .023 MIG tips for jets. And they are all plumbed into the same 500 gallon propane tank and each has a regulator set to around 12 psi.

It would seem that the 8" forges would get hotter than the 12" forges. After all, there is less volume to heat and keep hot. We all know that the bigger the house, the larger sized heat pump is needed to heat or cool.

In the lab however, observation tells us that the 12" forges get hotter than the 8" forges. Why? The answer was provided by one of my students who is an HVAC engineer. The flame needs room to complete its burn before it is interrupted (in this case, by the opposite side of the forge). Disrupting the burn means that some of the fuel is not burned, which not only means it doesn't produce heat, but it actually cools off the flame in the same way that richening the mixture in a car engine makes it run cooler. In practice we have found that a 12" forge has more room to work, gets slightly hotter and uses no more fuel than a 10" forge. However, the 10" is still a viable option.

Ideally, our new forges are 12" diameter pipe, 9" long with 2" thick, 8 pound ceramic fiber blanket (Kaowool or Cerewool are 2 brand names); powered by a single burner made from 1" pipe with a .045 MIG tip for the jet. You will need an adjustable propane regulator with a gauge (acetylene regulators work), and about 5 feet of hose that is approved for propane. A 5 gallon (BBQ size) propane tank fits in the forge stand.

This arrangement of pipe fittings was influenced by work done by Frank Villars, David Starr, Larry Zoeller and others. However, any arrangement that uses some kind of venturi and a 1" pipe nipple with the .045 MIG tip might produce similar results.

What follows is a photo build of the forges similar to what we're building now. I had a couple pieces of 10" pipe and welded them together to get a housing 9 ¼" long. If I had 12" pipe I would have preferred to use it.

Burner parts: (Left to Right) 1" x 10" black pipe nipple, 11/2 x 1 x 11/2 black pipe tee, 11/2 black cored plug, .045 MIG tip, 1/8 x 4 1/2 schedule 80 pipe nipple, 1/4 x 1/8 MIP x FIP brass bushing, 1/4 threaded ball valve, 1/4 brass 90 degree street elbow, 1/4 MIP x left hand gas fitting. Note: The MIG tip should have 1/4-28 threads. Get that size nut and take it to the welding supply, they will have no idea what you are asking for. While you're there get the 1/4 MIP gas fitting. Source: PEXSupply.com has most of the fittings, Grainger 1/8 sched 80 nipple (pn 1LLV2), Airgas MIG tip and left hand gas fitting.

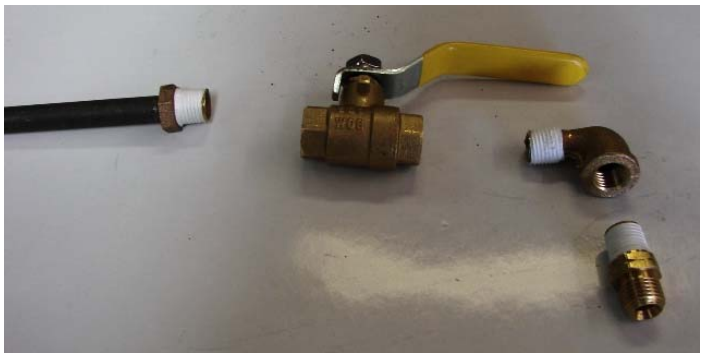
Machining: drill a hole through the center of the plug the same size as the 1/8 nipple (mine was 13/32). Ideally the hole should be concentric with the 1 1/2 pipe threads. Drill and tap a hole for a screw to hold the nipple in place .

Run a 7/32 drill into one end of the 1/8", schedule 80 nipple . Tap that end 1/4-28 .

Right: This plug can be used as is, but some plugs are cored a lot more and do not have enough material to provide support for the nipple. To solve that problem, fill the cavity with MIG weld before you drill.

Left: When you assemble the 3 pieces and screw them into the tee, the hole in the MIG tip should be in the center of the opening. If not, a little bending is in order.

Right: My leg vise and twisting wrench work well to get the bushing tight on the 1/8 nipple.
Below: assemble the remaining fittings with Teflon tape or pipe dope.



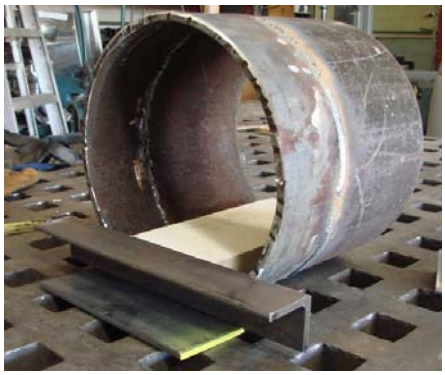
Left: I personally don't think the baffle is needed, but some smiths like to be able to create a richer (reducing or less oxidizing) atmosphere in the forge. Just remember not to block the air off completely or you risk a nasty explosion as the gas fills the forge without any oxygen. (That's the reason for the large hole in the center of the baffle.)

I welded a 1/4-20 bolt to the side of the T and welded the sheet metal baffle to a nut. The second nut serves to lock the baffle open.

Now that we've completed the burner we're ready to start on the housing.

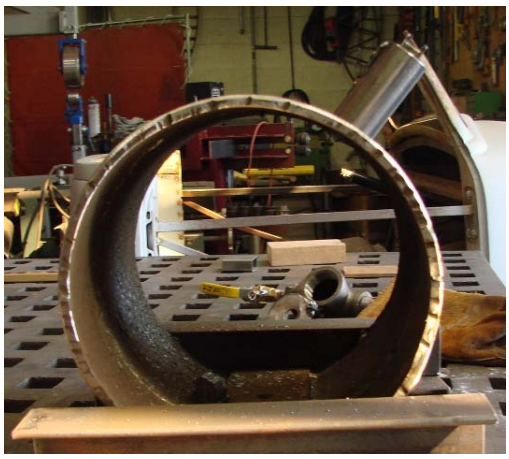
This is a lightweight refractory 2600 degree brick. I get them at Pacific Insulation (see Source on page 19 of the Anvil's Horn). Bricks are 9" long and are one of the reasons we make the forge housing 9" long.
For a 10" diameter forge, cut the brick in half as shown on the left. I use a band saw, but they will cut easily with a hack saw or even a wood hand saw.
For a 12" forge they can be left full thickness.

The brick likes a flat surface to sit on. This is a piece of scrap 1/4 x 3 and the holes were already there—they are not needed. This plate gets tack welded in place. (This housing was pieced together from leftovers—that's why the radial weld in the middle..)



With the brick in place, 2 x 2 x 1/4 angle (this is 13" long) is flushed with the top of the brick and tacked in place. I like to tack from the inside so the weld shrink will pull the angle tight to the housing. The process is repeated on the other side.
Right: Then they are welded on the outside.

Left: Burner retainer. This is a piece of tubing 3" long that the 1" pipe nipple will slide into. Drill a hole to accept a 1/4 bolt. Weld a nut to the outside to create a set screw.
Right: Torch or plasma a hole for the retainer. I have a magnet holding it in position.



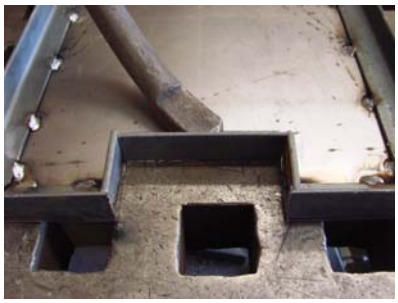
From the front view: I like the angle of the burner to be about 50 degrees from horizontal and the center line of the burner to follow the centerline of the housing. We want to give the flame as much room as possible to complete the burn. When all is good, fully weld the retainer tube to the housing. Don't leave any gaps for the heat to escape.

Add the 2" ceramic blanket and some bricks on the ends and you're done Or…..

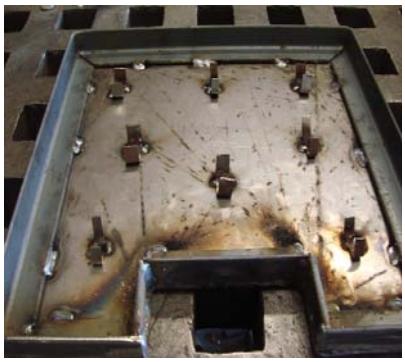
Make some doors.
This is 13 ga cut to 12" x 48" and 10' of 1 x 1 x 18 angle. IMS Cost $20

Right: The doors are 12" square. The notch at the bottom is 4" wide and 2" high. Torch, plasma, jigsaw or even a chisel will make the cuts.

Left: The angle forms a perimeter around the sheet. I allowed for the 1/8 material thickness when I measured, cut in notches and cold bent the 4 corners.
Right: I filled in around the notch with strap and angle.

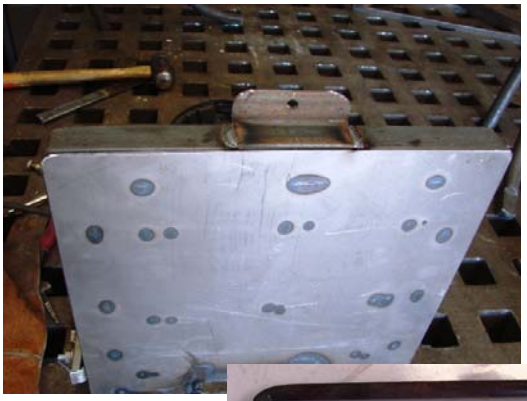


Left: the bottom of the door sees a lot of heat, so I weld it all along the bottom I'll smooth the nibs up a bit with a grinder later.



Left: 18 ga sheet cut 3/8 x 2 is bent for hanger clips. (You could use 20d nails or?)
Right: The clips will hold the Kaowool in place.

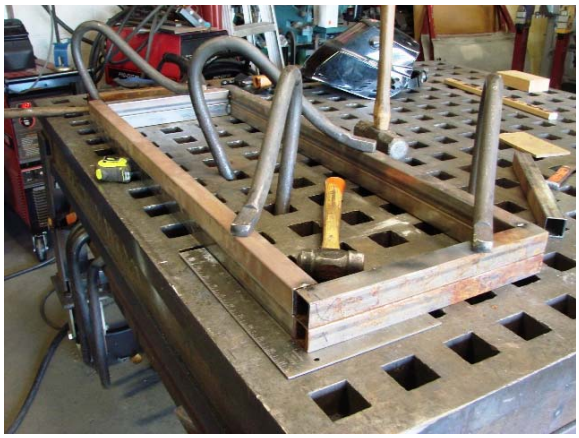
Forge Building Continued



Left: A 3" long piece of angle with a 3/8 hole in one flange welded to the center of the top of each door.
LL: The hooks are forged from 3/8 round. Wait until later to weld them in place

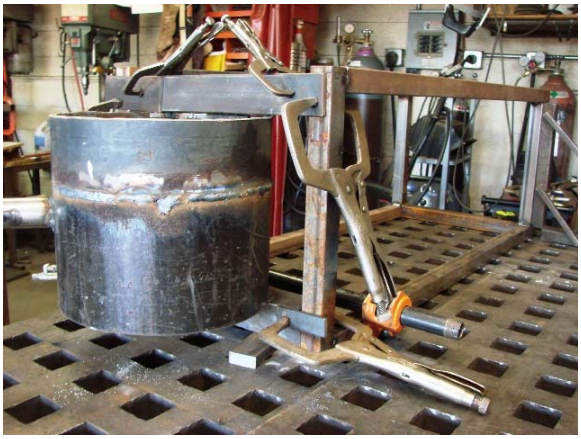
Above: Door hanger. I used 1/4 x 3 but these could be made from anything. They could be fabricated ladder style from stock. The holes are 3/4" diameter spaced 1" apart. They get installed later.

Still with us? How about a stand, a place for the propane tank, and wheels!



I start with 20 feet of 11/4 x 11/4 box tube.. Pick a wall thickness that allows 1" box tube to slide inside. The legs are about 39" long. The top bars extend over the tops of the legs and can be 15 1/2 " long. That means the bottoms will be 13" (15 1/2—1 1/4 —1 1/14).
Tack one side and get it as square as you can, then build the other side on top of it.. Be sure to mark the same corner of each side so you can line them up the same way you built them.
You'll need 2 more pieces of box tube the same length as the 2" angle you used on the forge.

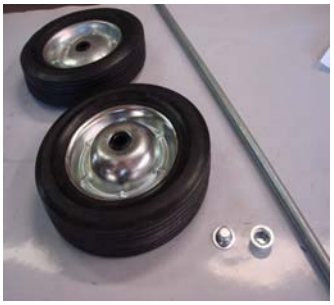
The angles on the forge go between the top bars on the stands. The 2 remaining pieces go at the bottom between the legs. Center the forge between the legs (north and south in the photo), square everything and weld it all.



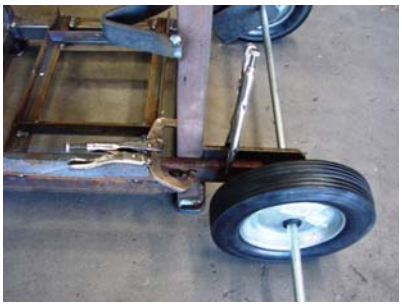
Left: stand it up and finish weld. I add plates to the feet to keep it from sinking into the dirt.

Left: The ring at the bottom of this propane tank is 8" . I allow an extra 1/2" and cut some angle. I welded it together, but didn't weld it in place , yet.

The tank is 12" diameter. I draw a circle and cold bend 20" of 1/4 x 1 to cradle the tank.
R: Weld it where it works.

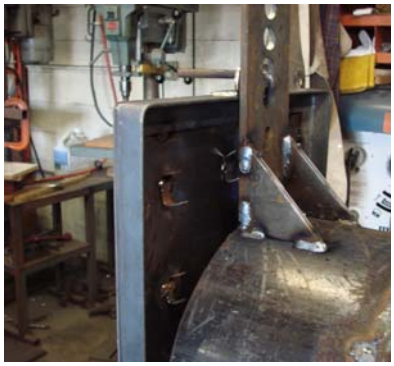


8" wheels, some 1/2" cold roll, 1/2" push nuts. From Ace. $30

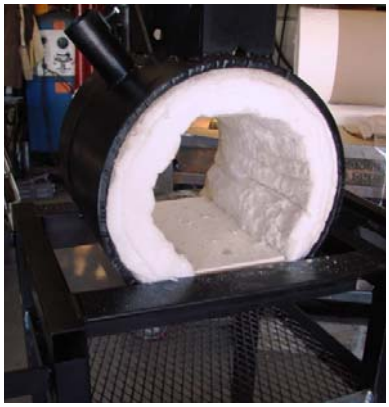


Wheels and stand are on the floor. 1/4 x 3 plates with a hole locate the wheels. A straight bar and clamps line them up.
Below: With the wheel brackets welded in and the axle cut to length, hammer on the push nuts. A little mass on the opposite end makes the installation easier.

It takes some trial and error to decide on the height of the holes that will work with your doors. Hold it with a magnet, plumb it with a level, weld in the gussets.
Weld in the hooks that hold the door on after installing the Kaowool.



I use a carpenter's square and a utility knife to cut the Kaowool. The Kaowool should stick out of the housing about 1/4" on each side and butt against the side of the brick. Cut a hole so the Kaowool fits tightly around the burner.



Tear a 12" square piece in half for the doors.

The bottoms of the doors see a lot of heat as the flame exits through the notch and under the door. I coat the bottom angle and about 3" up on the door skin with ITC 213, which is a ceramic coating for metal. I then paint the door with high temp (2000 deg) header or BBQ paint. Using stainless steel for the bottom angle and notch (or even the entire door) would provide another measure of durability, but may not be worth the extra cost.

The stock rest is made from 1" box tube to slide inside the top of the forge stand. The crossbar is 1 1/4 box welded so the top of the bar will be flush with the brick in the bottom of the forge.

There is a handle on the same side as the wheels and a tong rack on the opposite side.

The expanded metal and angle shelf is about 6" down.

Connect the regulator to the bottle and the hose and the other end of the hose to the burner. Close the burner ball valve and open the propane valve. Set the regulator at 8 pounds. Check for leaks with a spray of soapy water before lighting the forge.

Forge FAQ's

Where do you get 12" pipe? *I don't have a source.*
How thick should the housing material be? *18 ga or thicker. The 2" thick Kaowool insulates very well. Thin sheet will hold up a long time if the flame is not hitting it.*
Does the housing need to be round? *No. just remember that whatever shape you use, the Kaowool must stay against the housing. You can support a flat top surface using stainless steel bolts and fender washers, but be expect to replace them regularly.*
Why mount the burner at an angle instead of having it vertical? *To keep the propane hose away from the housing and allow it to hang naturally on it's way to the tank.*
Why is the housing 9" long? *That's the size of one brick and 9" is about the longest amount of metal most blacksmiths can hammer in one heat without a power hammer.*
At what pressure does the forge operate? *I start mine at 8# and lower it to 4# after a few minutes. However, burners, gauges and regulators vary—your results may vary as well.*
How long will the propane in a BBQ tank last? *We expect to get between 2 and 4 hours of forge time per gallon. BBQ tanks hold about 5 gallons, however, I just did a Blue Rhino swap and the label said it contained 15 pounds or 3.5 gallons.*
Why is there no flame keeper on the 1" nipple? *We have found that the forges work well without the extra piece. You can add one if you think it is needed.*
Won't the burner nipple burn up? *The end of the nipple should be recessed 1/4" into the Kaowool, which protects the nipple, eventually you will need to cut it off to get a new, clean end. Then someday you might need to replace it.*
If a 12" housing is better than 10" would 14" be even better? *The burner seems happy with about 8" of space to complete the burn. It might like 10" better, try it and let me know the result.*