Forging and Using a Wrought Iron Tuyere

For the past 6 months or so, I have been exploring this design of side blast tuyeres, using them in both my forge and in one of my bloomeries. Below are iterations #8 and #9, one for a friend and one as a travel tuyere for me, and I think I've refined the design to point that is useful to share.

Background:

I have been using a side blast hearth, rather than the typical cast iron bottom blast firepot, exclusively for about 8 years now, and I'm convinced that the bottom blast cast iron firepot is a degenerate technology. I find the side blast hearth to be more efficient, more versatile, and far superior for forge welding. It can utilize coal, coke, or charcoal as fuel with equal facility.

The side blast is really indispensable if you’re working bloom iron, especially in the early stages of refining the bloom, because the copious slag flows below the tuyere to form a slag cake, leaving the blast unimpeded, (at least for some time), whereas the slag blockage is a constant battle with the bottom blast.

In England, where side blast seems to be the most common setup, the tuyere is usually water-cooled. Before I found this tuyere design, I have been using the same design of copper tuyere that I use in the bloomery, and this has been quite satisfactory. The copper tuyere would usually last about a year in the forge before I screwed something up and melted it. My friends at Colonial Williamsburg have been using heavy cast iron tuyeres, and these also seem to last about a year before they burn out beyond usefulness.

The smiths at Colonial Williamsburg have had a hard time finding solid historical information about pre-industrial tuyeres, and based their use of cast iron tuyeres on a single illustration in Diderot’s Encyclopedia.

A few years ago, I revisited the forge at the Cyrus McCormick farm for the first time in many years. This small forge produced the ironwork for McCormick’s reapers until he moved to Chicago, and the shop was basically preserved as a shrine thereafter. As I peered into the dimness from behind the barrier screen, I noticed an object on the floor that I now recognized as a tuyere! I later obtained permission to examine the forge more carefully, and Steve Mankowski from Colonial Williamsburg, Chris Furr from Frontier Culture Museum, and I went to examine the forge in detail.

Here is the tuyere we found, after some conservation work:

I had already tried a wrought iron tube as a tuyere, and despite wrought's high melting temperature, it had burned out almost immediately. We were intrigued by this design- by building up the end of the tube by forge welding, perhaps we'd get something more durable.

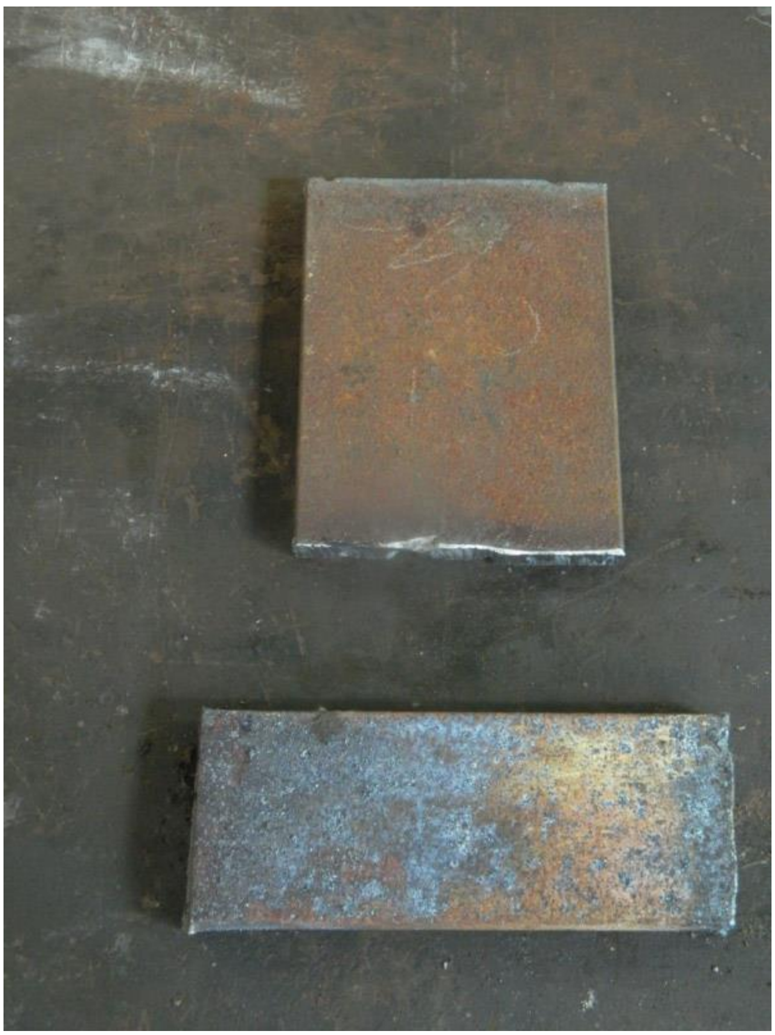
Steve, Chris and I set out to adapt and explore this design. And like any other tool, it's taken awhile to learn how to set up properly- we've burned up quite a few of them! But I now have developed this design to a point that it's very durable. The tuyere in my forge now has been in service for 5 months with only minor erosion, and I'm pretty confident it will last more than a year (unlike a lot of firepots I've used in my time!) And since my work concentrates on bloom forging, and lots of forge welding, and I like to forge big lumps of stuff, I'm way harder on my tuyere than the typical blacksmith!

I have only used this tuyere twice in the bloomery furnace so far, but there is no measurable loss, and it performed quite well. In general, the bloomery is a much kinder environment for the tuyere than the forge is- despite the higher temperatures, the environment is much more reducing, and the tuyere gets protected by a nice thin film of slag.

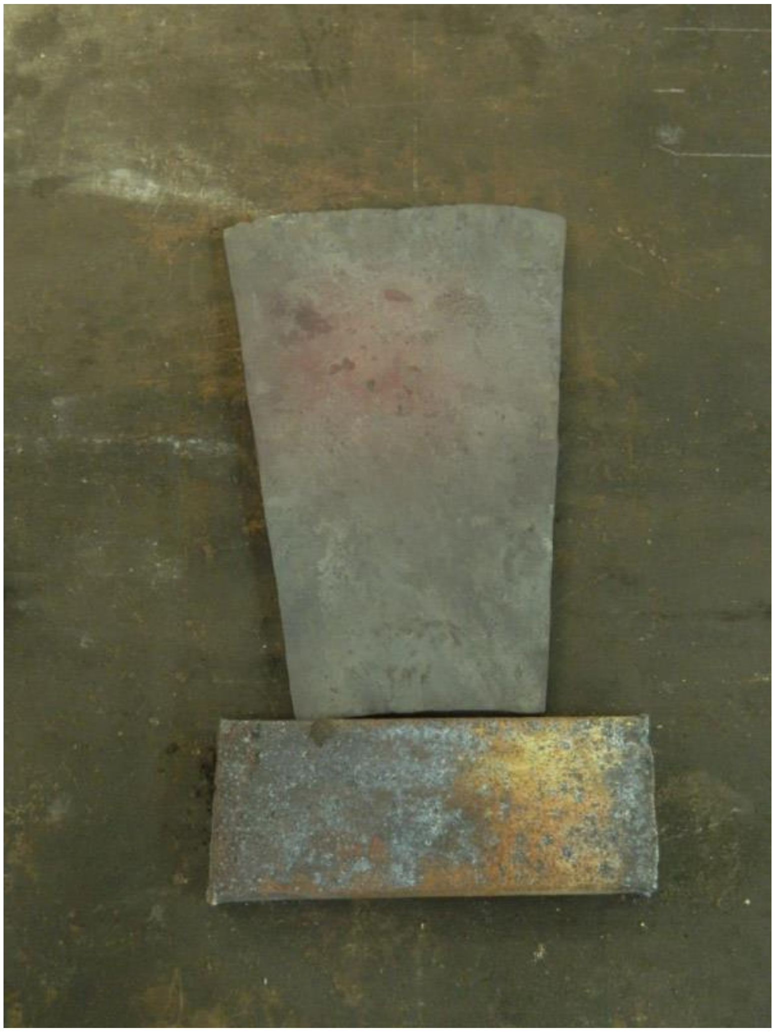
How to make it:

So we are forging this from wrought iron, which has a higher melting point, and is less prone to burning, than mild steel is. It also welds easier. I have not tried this with mild steel.

With wrought, of course, we just have to start with whatever sizes we have available. Here I am starting with a chunk of ½" x 5" x 6 ½" for the tube, and a chunk 5/8" x 3" x 7 ½" for the end:



Then I forged the ½" x 5" into a trapezoidal plate, roughly ¼" thick. The finished trapezoid is 5" wide on the narrow end, 7" on the wide end, and 10 ½ " long. If you have a nice piece of ¼" wrought plate, of course you'd just cut this out of that! The length is not critical as it is with the copper tuyere, this is just a convenient length for my set up.



Then the plate is wrapped to a tube using the swage block:

Then wrap the 5/8” x 3” stock into a collar, and drive the tube into it. You want to leave a bit of gap on the collar, say a ¼”. It’s nice to have the tube extending at least halfway into the collar, for lots of welding surface:

Then flux it, and weld it all up in the swage block. Take your time and take a nice slow heat, so the inner tube has time to get to welding heat. Don't forget you can look down the tube to see if it's really hot, just looking at the outside can fool you!

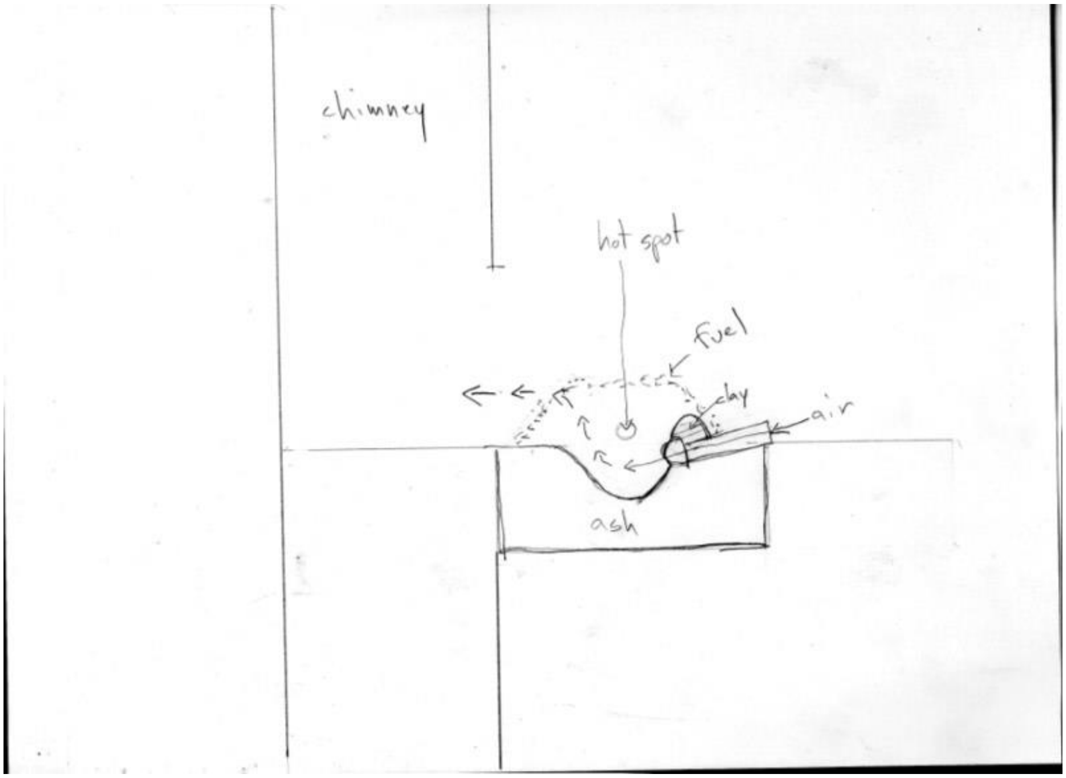
And here comes the hard sweaty part! As you close up the weld over repeated heats, start forging the end down to reduce the orifice size, by rolling it in the sedge block as you hammer. I like an orifice diameter of about 7/8" for both the forge and the shaft furnace.

A wise person would immediately make another one, so you when it fails or you need to reforge it, you have a good one to install. Over time, you will find the top will erode, and the orifice will enlarge, as seen in the original. Then you can just reforge it back to the proper shape and size. That’s the reason I have gone to a 3” wide end, instead of just the 2” remaining of the original McCormick tuyere, to provide a longer life and more reforgings.

Set up:

My hearth is a box filled with wood ashes that have been dampened and pounded into a duck’s nest. The tuyere is set in at a shallow angle, and then set in clay (the same clay mix for the furnace, like so:

Here’s my setup shown schematically:



I generally have to reshape the duck's nest every month or so with fresh wood ashes. The advantages of using the wood ashes are both the ability to reshape the duck's nest as necessary, and its insulative qualities.

There are many other ways to set up a side blast hearth, of course, this is just what is working for me. At Williamsburg, for example, the tuyere is horizontal, but comes in lower in the duck's nest, and comes in from the chimney side.

Troubleshooting:

In the forge: Well, I've found a few ways that can cause these tuyeres to fail (burn up) in the forge. (I have had no troubles in the bloomery.) Here's some trouble that can happen:

1) Allowing the tube section to get hot. If you let the fire creep back behind the heavy nozzle to the tube section, and you melt a bit of tube, then the air blasting through it will burn the whole thing up, and real quick, too! That's the reason for the clay on top.
2) Tuyere sticking into duck's nest too far. If it protrudes too far, you'll see it gets yellow hot. Back it up (or rather build out the duck's nest) so it just barely protrudes, and it will stay black

or dull red, mostly.
3) Not noticing a blockage. If your slag clinker builds up in front of the tuyere, it will turn the blast upwards. Not only will your fire all the sudden move towards the tuyere, you'll start oxidizing the top of the tuyere (as seen in the McCormick original).
4) After some months, there will come a time when you notice the fire has backed up towards the tuyere, because the orifice has slowly eroded to a larger size. That's your signal to take it out and reforge it.
5) Too steep a tuyere angle seems to lead to burning also.

In the bloomery: I've had few troubles here. I use the same tuyere protrusion and angle as I do with the copper tuyere. The slag creates a thin film on the nose of the tuyere that protects it very well. But that slag flows around the perimeter of the orifice, and can slowly reduce your tuyere diameter without you noticing, because it does it so gradually and smoothly (there seems to be less dripping across the tuyere than with other tuyeres). But this slag around the edge pops off very easily with a rod down the tube.

As noted above, you don't want the tube section exposed to the fire, make sure that's embedded in the clay of the furnace wall.

Some advantages of this tuyere:

Versus clay tuyere (or clay covered iron pipe): Much more robust and stable, and lasting many smelts.
Versus copper tuyere: Does not rely on airflow for cooling. And cheaper. Though more work to forge.
Versus watercooled tuyere: Simpler construction.
Versus cast iron tuyere: Can be produced by the blacksmith.

So there you go, a tuyere with historical precedent that's useful, durable, and you can make yourself. Like any other tool, it will take some time to use properly. Have fun, let me know what you learn after you try it for a while.