A Simple Temperature Controller for the Propane Forge Furnace.

By Whitney Potter

Disclaimer:

High temperature propane burning devices are inherently hazardous and unless you know and accept the associated risks you should under no circumstances attempt to construct or operate one. Unless properly constructed and safely operated propane forge furnaces have the potential to cause grave injury or death. The author makes no guarantees, warrantees, or claims whatsoever as to the safety or suitability of this device for any application.

The traditional propane furnace (if that isn't an oxymoron) is a primitive affair, a chamber with a burner pumping heat in and insulation trying to keep it in. To vary the temperature you change the gas pressure, or open and close the doors. For most iron work this is adequate as you can judge the temperature well enough by the color. But it is hard to control and inefficient. The burner runs all the time and much of the heat produced is wasted. Also most burner designs do not simmer well, making it difficult to run your furnace at a low temperature. With my temperature controller my furnace runs at whatever temperature I set it. It can be set to a range temperatures from heat treating or forging bronze, to forging iron, or welding. A digital readout tells me what the temperature is to the degree.

A temperature controller is a very complex thing requiring state of the art micro-computer circuits performing thousands of fuzzy math computations per second. Now you are saying "Whoah-there-boy you said this was simple." Well it is: you simply buy one. All that fancy stuff comes wrapped up in a little black box. The rest of the job is just hooking it up, and that took me about an hour. The "black box" or brain of the system is an industrial temperature controller readily available from virtually any industrial supply company. The controller accepts input from a thermocouple, which is simply a very high temperature thermometer. The brain compares the temperature from the thermocouple with the value you set on the control panel. If the furnace is cooler than you set it to be the brain closes a relay, which opens the gas valve and turns on the blower. When the furnace gets to your set temperature the brain opens the relay, which closes the gas valve and turns off the blower, saving gas and keeping your precious bronze acanthus leaf from becoming an expensive puddle.

So far this is simple enough but a great danger exists when the temperature drops back below your set point. The brain turns the gas and the blower back on, and if the furnace lining is hot enough it re-ignites the flame. But if the lining isn't hot enough to re-ignite the flame, the furnace spews out gas until it finds some other ignition source, potentially resulting in a very large explosion. In order to be safe my controller is equipped with a standing pilot light that will re-ignite the flame no matter what the temperature of the furnace. It must also be equipped with a thermocouple safety system that will independently shut off the gas if the pilot goes out. Like any forge furnace it must never be left unattended while in use. **Failure to understand and follow these safety rules could result in grave injury or death**.

On the plus side the normally closed solenoid valve provides a measure of safety as you can shut off the gas just by unplugging the controller, or flipping the circuit breaker.

One further refinement I made to my system is to install an override switch. This simply shorts across the relay and keeps the burner on all the time. This is useful for when I want to weld and I just want to run the furnace as hot as I can get it. It is necessary with the system I use because the controller only goes up to 2340°F with a type-K thermocouple. The furnace will go hotter, but the controller goes out of range. A possible way around this limitation is to use an R S or B-type thermocouple which will measure much higher temperatures, but they all contain platinum and cost on the order of a few hundred dollars. My type-K thermocouple cost about twenty dollars. One further note on the subject of thermocouples: You must use special thermocouple wire and a special terminal block when connecting the thermocouple. It will work with regular copper wire, but it won't be very accurate and worse the temperature readings will vary with changes in room temperature.

Depending on where the thermocouple is situated compared to the burner nozzle the thermocouple tip will eventually erode away from the flame. In my furnace the thermocouple lasts a few years. Eventually the thermocouple starts giving inaccurate readings and finally the controller displays an error code when it fails completely. You can replace the thermocouple but you can also repair it quite easily. Simply clip off the burned off tip and TIG weld the wires back together. The thermocouple is just a junction between the two wires of different materials. Be sure not to use any filler as this will introduce another metal into the junction and wreck the thermocouple.

If you go through a lot of thermocouples you may be tempted by a ceramic thermocouple protection tube. I know some smiths using this controller design who use the protector tubes, but they can cause trouble. The problem is that the heat must penetrate through the thin ceramic before it reaches the thermocouple and activates the controller. This delay causes much greater temperature fluctuations in the furnace. When working at low temperatures the furnace has enough time to cool that it has trouble re-igniting. The other downside of these tubes is their cost and fragility. They cost as much or more than a thermocouple and if you drop them they are history. All in all I think you are better off replacing the thermocouple a little more frequently.

In addition to being a cool controller the brain also works as a dandy digital temperature readout, and it costs less than many standalone digital thermocouples. I find it very handy for tuning my furnace. I can tweak the damper on the blower a tiny bit and watch the temperature rise or fall in response. It is also very handy for experimenting with new burner designs. Incidentally, the controller works with venturi burners as well.

Obviously the efficiency realized by this controller will depend on the construction and more specifically the insulation of the furnace. My furnace shell combines Kaowool for insulation with an inner lining of castable refractory for durability and thermal mass. At high temperatures the gas cycles off about 30% of the time, not a bad savings. But the controller really shines at low temperatures. I can leave bronze in the furnace all day with no fear.

What follows is a parts list and wiring diagram:

Temperature controller:

OMRON E5CN 120V relay output
MSC order # 05337811 $143.10

Thermocouple:

Type-K thermocouple with connector block and wire
Creative Ceramics call 707-545-6528 about $50 total

Gas Solenoid:

120V gas solenoid valve normally closed
McMaster Carr #47545K33 $52.60

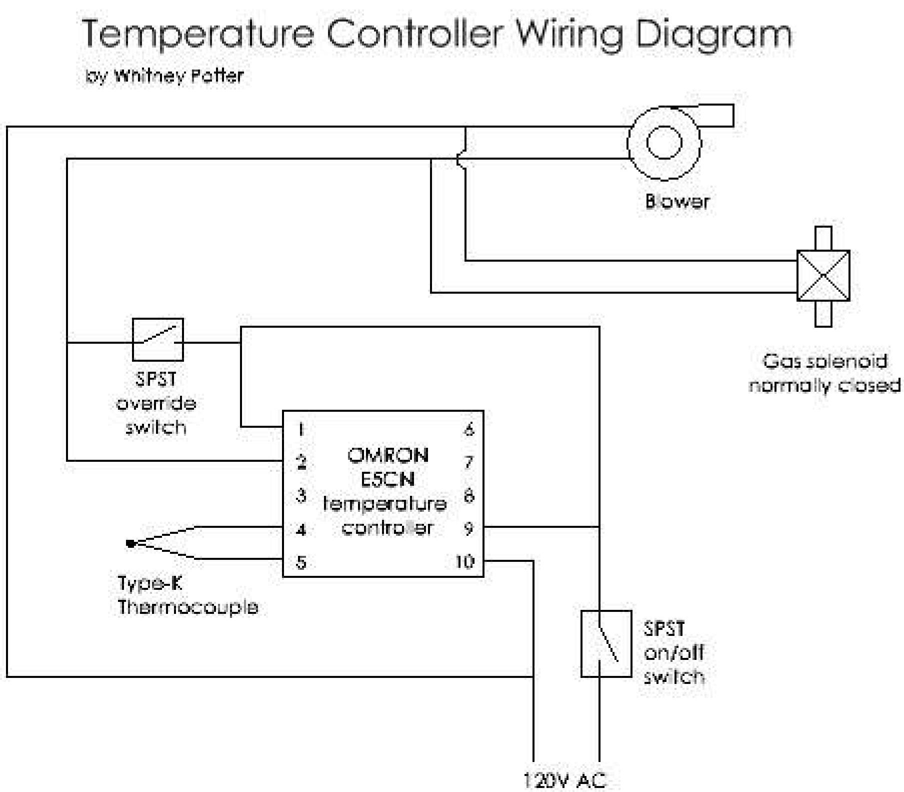

Figure 1