Correll

Glass Studio

66 Hidden Ledge, Conway, MA 01341
413/369-4283 Fax 413/369-4769
ccorrell@attbi.net
www.correllglass.com

Control of Forced Air and Gas Burner Systems

Let’s look at how to control a burner system with forced air and gas. We’ll look at it from the viewpoint of using the most simple controls and work our way up to using a full auto control system.

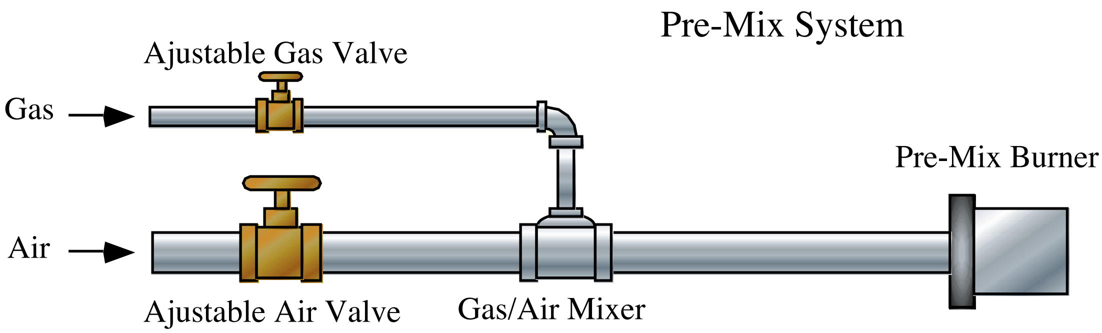
We have a blower delivering forced air to the burner. We have low pressure gas, under a pound, feeding fuel to the burner. Typically, the air line is either 1 1/2” or 2” pipe. The gas line is typically 3/4” pipe. The simplest control system consists of an adjustable valve on the air line and an adjustable valve on the gas line.

It is necessary to keep a good air/gas mixture ratio for a good efficient flame in the furnace. Theoretically, the best mixture consists of having just enough air to supply just enough oxygen to burn one hundred per cent of the gas. A perfect air gas mixture like this is called a “stoichiometric mixture.” A mixture with too much air results in what is called an “oxidizing atmosphere.” It has too much oxygen in it and wants to oxidize more fuel, thus the term “oxidation.” A mixture with too much gas is called a “reducing atmosphere.” It has too much gas, and wants to combine with more oxygen, reducing the oxygen content of whatever it comes in contact with. A reducing atmosphere will grab the oxygen from the metal oxide you have put on the surface of your piece, reducing its oxygen content, leaving the metal, and producing that familiar sheen on you glass.

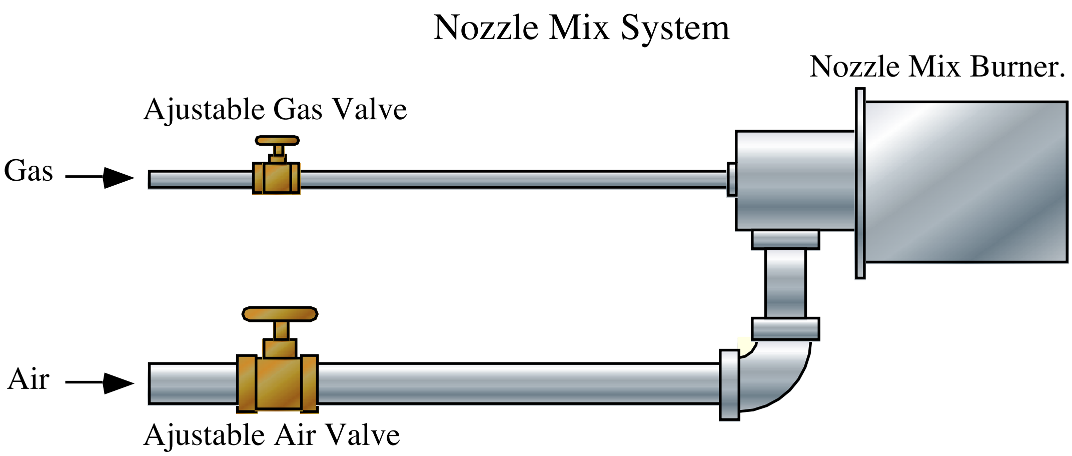
Either an oxidizing flame or a reducing flame results in an inefficient use of fuel. Too much air cools the furnace down. Too much gas cools the furnace and also wastes gas because it does not oxidize in the furnace, and does not produce energy to keep the glass hot.

So we need to maintain a mixture that is close to stoichiometric, hereafter referred to as “neutral” We do that by adjusting the mixture using the air and gas valves. When you turn up the gas, you have to turn up the air, too, and vice versa. This simple system is nothing more than manually opening and closing the air and gas valves to keep a reasonably neutral flame.

There are two kinds of air/gas mixing systems. The first is called a pre-mix system. Air and gas are fed into a mixer, and the resulting mixture is delivered to the burner head.

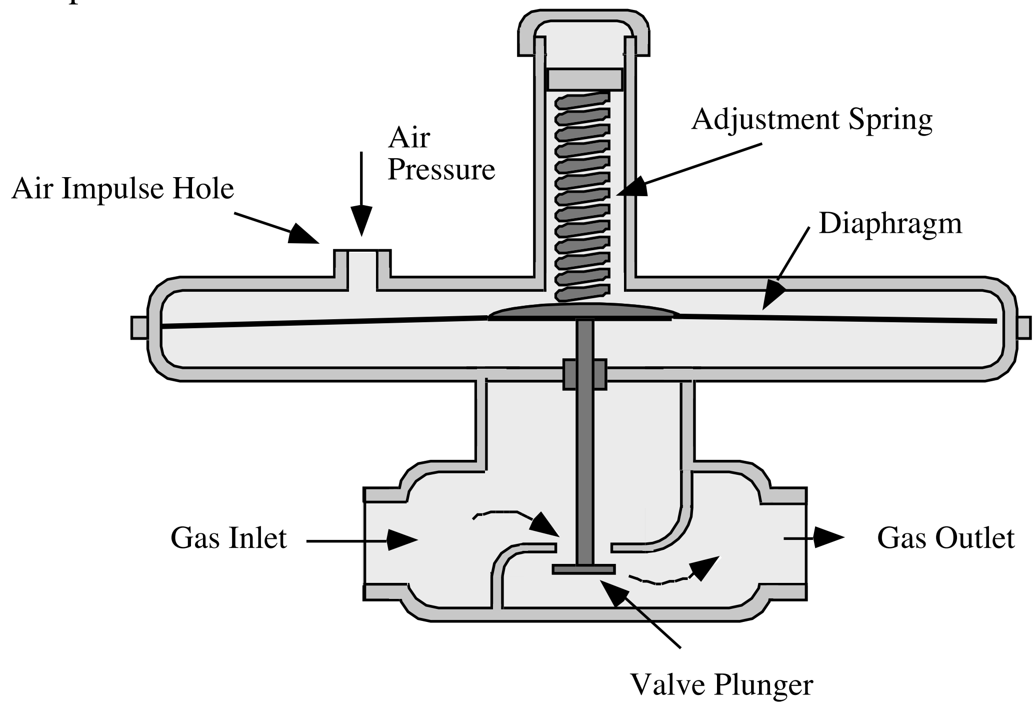


The second is called a nozzle mix system where air and gas are delivered independently to a nozzle mix burner where they are mixed at the point of combustion, in the nozzle of the burner. Both systems can be controlled manually using air and gas valves.



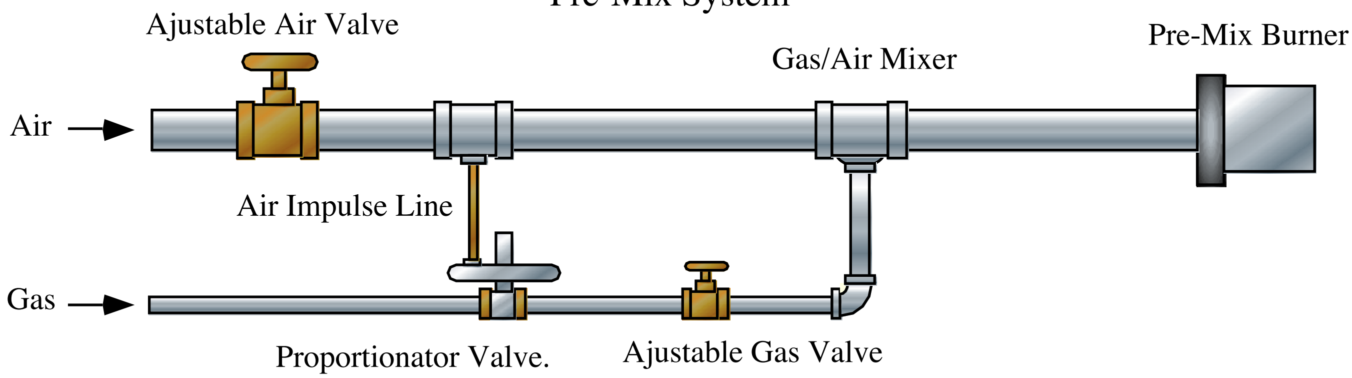
The next more complex method of control I refer to as single valve control. Equipment is used that can be adjusted to maintain a neutral flame as you open and close a single air valve. This piece of equipment is called a proportionator valve. Good to its name, when properly adjusted, it keeps the mixture “in proportion” as the air valve is opened and closed. This valve is installed on the gas line feeding the burner or mixer. It consists of a gas valve and a diaphragm, and looks very much like a gas pressure regulator. (Next page)

Proportionator Valve

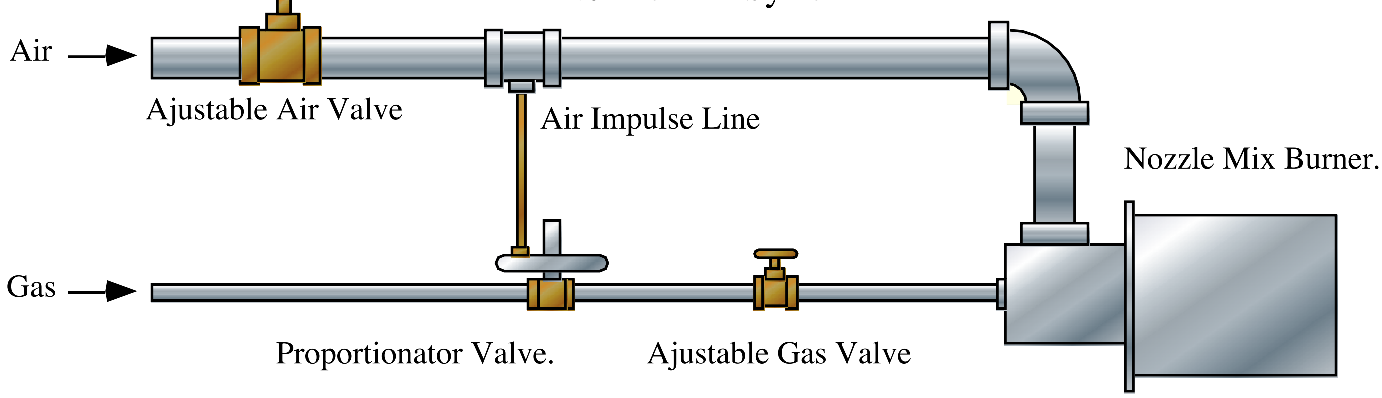


It does indeed regulate the gas pressure, but it is keyed to the air pressure in the line going to the burner. This feat is accomplished by use of an air impulse line, usually a one quarter inch copper tube or eighth inch NPT black pipe. As the air valve is opened, air pressure builds up in the air line downstream of the air valve. The impulse line is attached to the air line downstream of the air valve, and to the impulse fitting on the gas proportionator valve. As the pressure increases, the diaphragm in the proportionator valve is pushed downwards. The valve plunger attached to the diaphragm goes down also, opening the gas valve to let more gas through the proportionator valve. This is the basic single valve control system.

Pre-Mix System

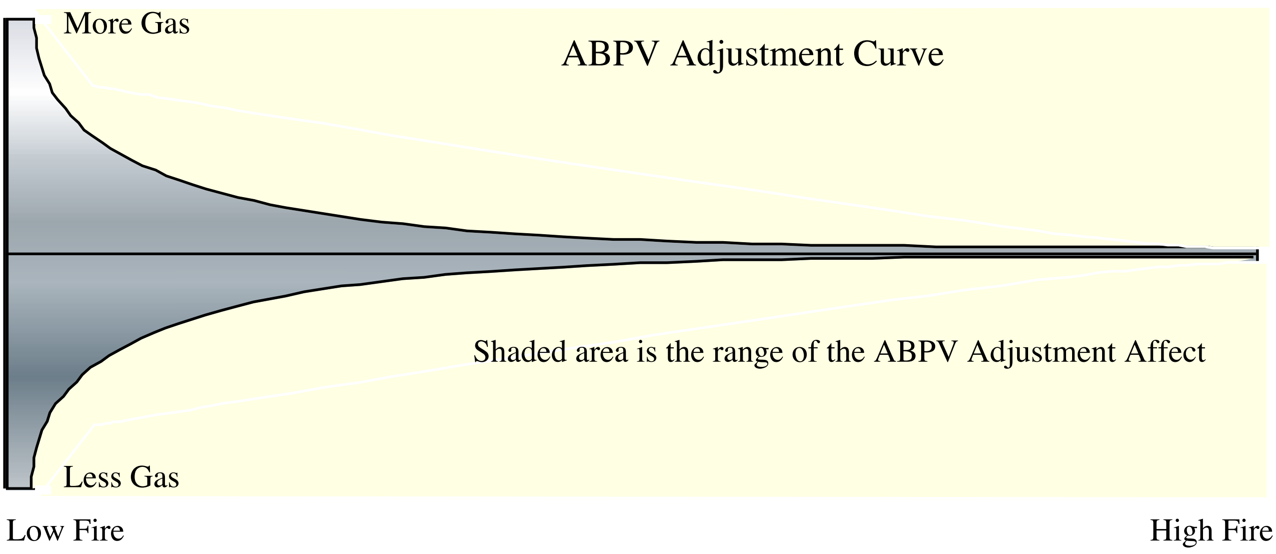


Nozzle Mix System



This system works well with a glory hole, where the air and gas pressure stay within a reasonably narrow range. A glass melting furnace, with its large turndown ratio from high fire for melting to low fire for cooling after a melt presents some additional problems for single valve control. We don't want a system that is too small for melting or one that is too large to let the furnace cool down after a melt. Even with a properly sized system, the combustion characteristics of the furnace, such as furnace size, flue size, positive pressure differential in the furnace between high and low fire, piping size, and air and gas pressure, affect the mixture ratios from high fire to low fire. Fortunately there is equipment available to handle these problems.

There are four units used to control the mixture. Two are already in place, and two more must be installed. We change the name of one, and replace the standard proportionator valve with a more versatile unit called the adjustable bias proportionator valve. The adjustable bias proportionator valve, hereafter referred to as the ABPV, arriving from the factory, works exactly the same way as the standard proportionator valve, but has an additional characteristic. The adjustment screw in the stem can be used to alter the gas flow so that it only affects the mixture at the lower range of firing. It can compensate for the combustion characteristics of the furnace system that can cause a shift in the mixture over the range of firing. Suppose we light the furnace, turn the air up to maximum, and adjust the gas valve by opening it so that we have a nice strong flame at high fire. Then we close the air valve to its low fire setting. The air pressure drops in the line downstream of the air valve, lowering the pressure in the impulse line leading to the ABPV diaphragm, causing the plunger valve to close, limiting the gas flow to the burner, hopefully in proportion to the air flow. If the mixture looks good, fine. No adjustments are necessary. The ABPV is working as a standard proportionator valve would. However, it is likely that the mixture will not be just right. Then we need to make an adjustment to the ABPV. If it looks like there is not enough gas in the mixture, it means that there is not enough pressure in the air impulse line to allow enough gas to pass through the ABPV. We open the top cap on the ABPV and see an adjustment screw. Remembering that the air pressure from the impulse line is pressing DOWN on the ABPV diaphragm, we turn the screw down, clockwise, to put more pressure on the diaphragm, thus letting more gas through the ABPV. If there is too much gas in the mixture, (more likely,) we turn the adjustment screw counterclockwise, relieving pressure on the diaphragm, lessening the gas flow until we have a good mixture. The beauty of the ABPV is that it has most of its effect at low fire. As the air valve is opened, the effect of the adjustment on the ABPV lessens, until at high fire there is little or no effect on the mixture. The result is that we now have a tool for independent adjustment of the mixture at the lower ranges of firing. The following drawing illustrate the range of effect of the ABPV.



It is important to remember that air pressure and air flow are not the same thing, nor are they necessarily proportional to each other. Flow is measured in volume, how much air or gas actually gets to the furnace. Pressure is defined in terms of resistance to flow, or “back pressure.” Let’s say we have an air blower rated at delivering 20,000 cubic feet of air per hour at 12 ounces of pressure. This means that it will deliver that much “flow” of air against a resistance to flow (back pressure) of 12 ounces. This doesn’t tell the whole story. Let’s put a pipe on the air outlet measuring one foot long by four inches wide. Let’s attach a pressure gauge through a hole in the side of the pipe. We turn on the blower. Huge volumes of air come out the end of the pipe. The pressure gauge reads “zero” because there is no resistance to flow. Put your hand over the end of the pipe, blocking off the flow completely. The pressure gauge jumps to 12 ounces, the maximum rating of the blower. Yet there is no flow. The gauge is reading back pressure, resistance to flow.

These two extremes illustrate that flow and back pressure, what you read on the guage, are not proportional. We must make adjustments in the equipment so that the result is proportional, that the air/gas mix stays proportional over the entire firing range.

We’ve already done a lot to alleviate the problem using the ABPV. Sometimes this is not enough. Say we’ve adjusted the high fire setting, turned the furnace down, and the flame is too gassy. We unscrew the ABPV adjustment in order to limit gas flow at low fire, and we run out of adjustment room. Maxed out, the flame is still too gassy. We have a situation where the gas/air mix is not proportional over the firing range, and we’ve made all the low fire adjustment that we can. We must turn the main gas valve down at low fire in order to get a good mixture. But this valve affects the gas flow over the entire firing range. The result is that we have a good mixture at low fire, and a mixture that does not have enough gas at high fire. It’s too “lean.”

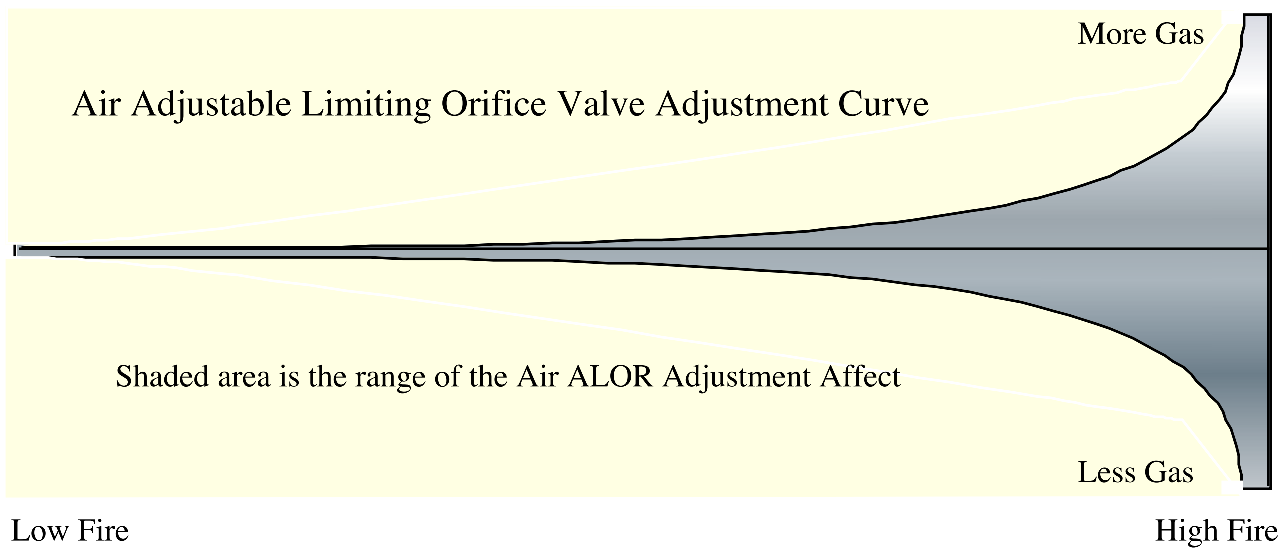
Here is where that lack of proportion between flow and pressure causes a problem. The air flow increases more quickly as you turn up the furnace than the back pressure, or resistance to flow. The equipment in use, the ABPV, uses back pressure to regulate the flow of gas. So we need more back pressure on the ABPV to increase the gas flow. We need a way to increase the back pressure at high fire without increasing significantly the back pressure at low fire.

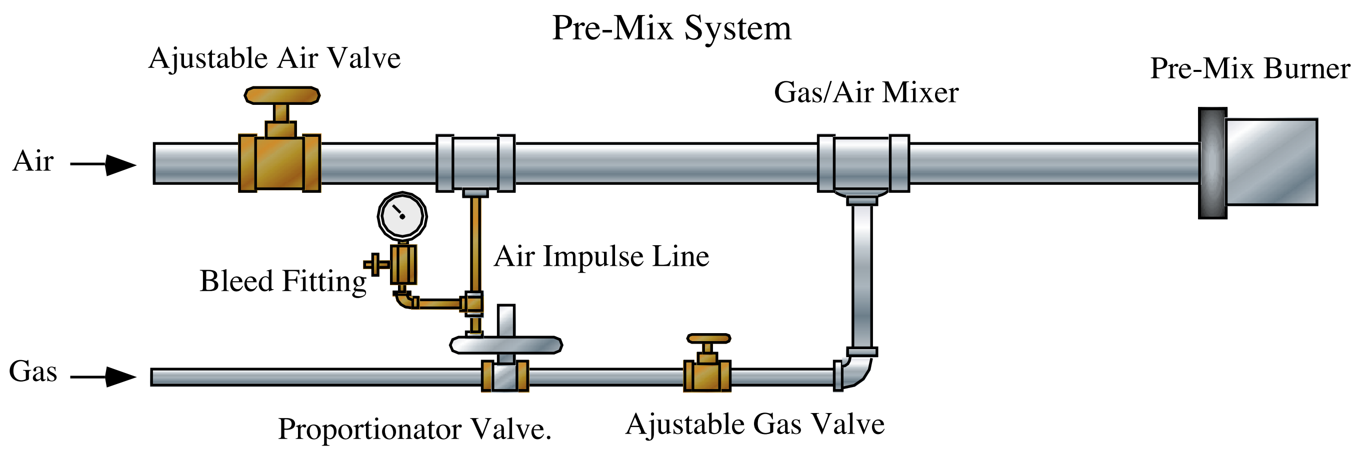
This is accomplished by installing another valve in the air line downstream of the air impulse line. We run the furnace to high fire. The flame is lean. We begin to close the new air valve, called the air adjustable limiting orifice valve, or air ALOR. The flow begins to be limited somewhat, but the more dramatic effect is the increase in the back pressure in the line, putting more pressure on the diaphragm, increasing gas flow. So we close the valve until we have a good flame. This adjustment has little or no effect on the low fire mixture because at low fire, the main control valve is almost completely closed and the air ALOR is still mostly open. The ALOR causes almost no additional back pressure at low fire, so the mixture changes very little on the bottom end. The idea here is to make these adjustments, and then alternate between high fire and low fires, making small adjustments in the ABPV and the air ALOR until we have good mixture at high and low fires.

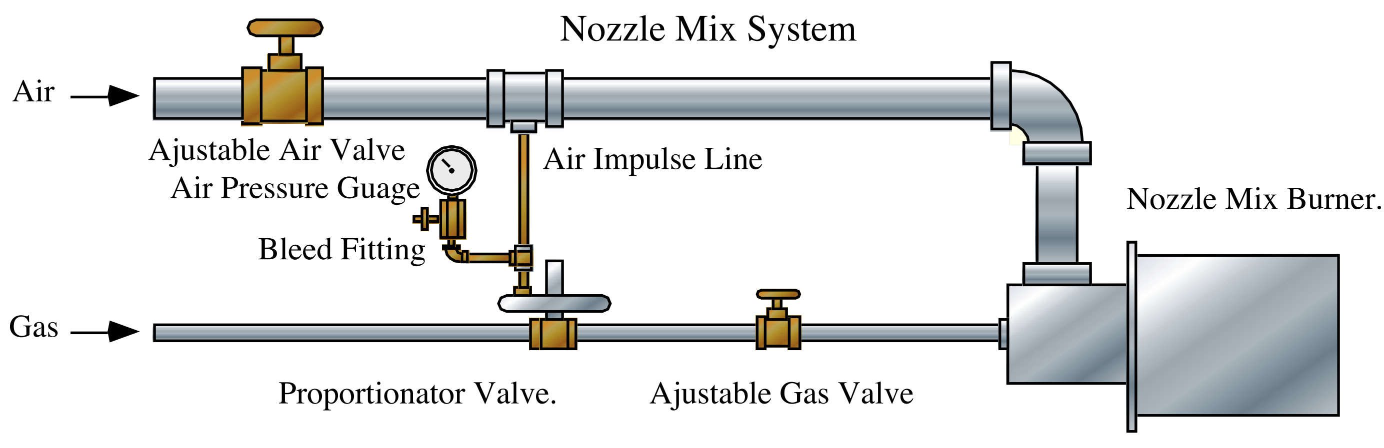
This usually does the trick. I have run into a couple of cases where it was possible to get good mixtures at high and low fires while the midrange mixture remained too gassy. This can be caused by a number of factors, such as an undersized blower, or air pipes that were sized too large. Closing the air ALOR resulted in not enough flow for a melt. The system was maxed out at high fire, using all the air flow and back pressure available to get the furnace hot enough for the melt. Low fire balance could be obtained with the ABPV, but mid range mixture remained too gassy. The ABPV adjustment caused too much gas at mid range, while there was barely enough gas and air at high fire.

Typically, I install what is known as a bleed fitting on the air impulse line. Industry uses this unit to bleed off pressure before it reaches the ABPV in the case of too much back pressure at high fire. What we had was too much pressure on the ABPV at mid fire. So we set the burner at midfire and opened the bleed fitting until the mixture cleaned up. High fire and low fire required only minimal adjustment, and we then had a clean flame over the whole firing range.

We now have tools to independently adjust the air/gas mixtures at low, medium and high fires. These three adjustments have enough overlap in their effects to provide a proportional mixture over the entire firing range.





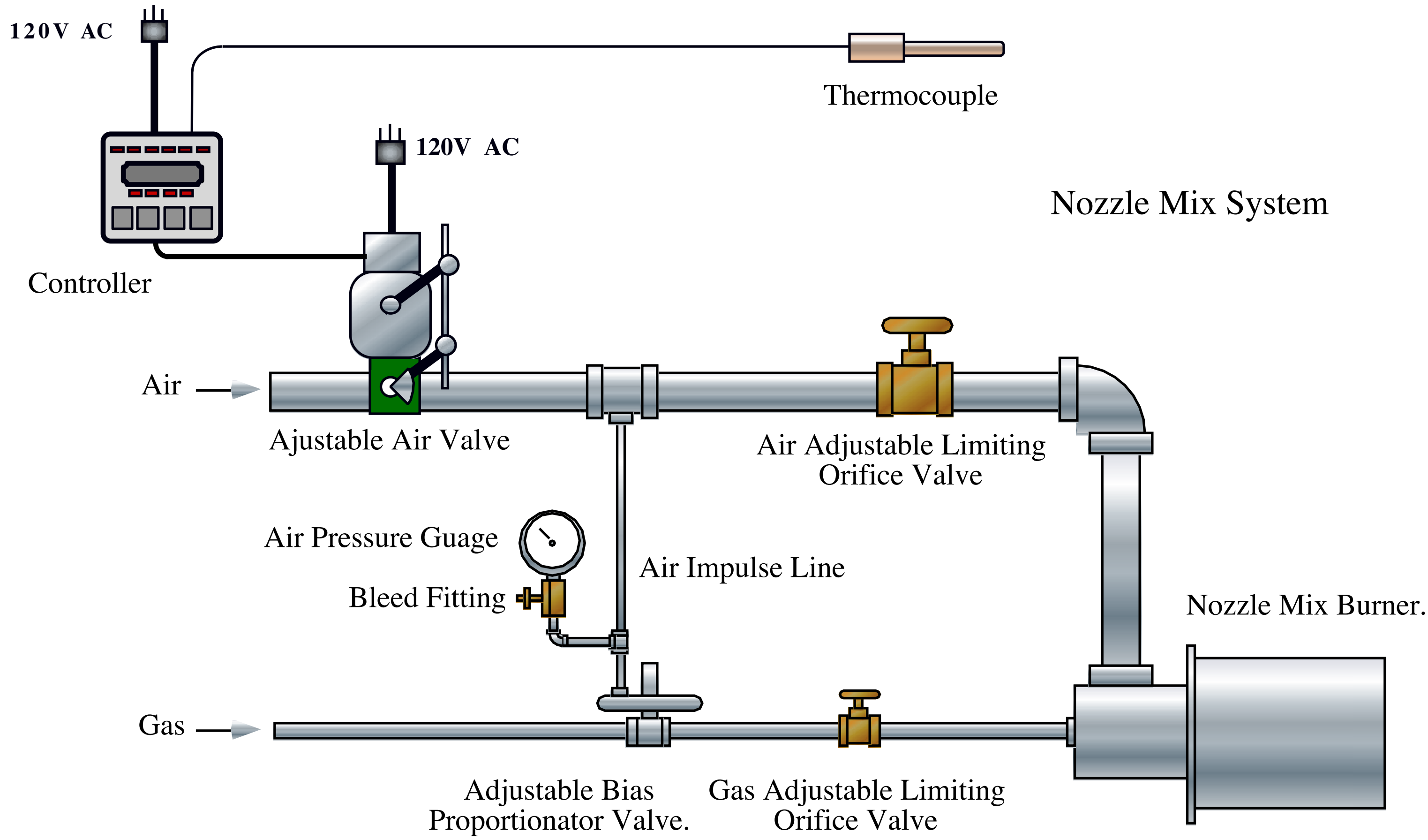


The system is now set up for manual single valve control of the furnace firing range. To turn the furnace up, open the main air valve. To turn it down, close the valve. Now we can install a programmable controller and motorized air valve to control the firing of the furnace.

We need the programmable controller with proportional output, an air actuator motor, a butterfly valve for the motor, and a platinum thermocouple. We install the butterfly valve in place of the manual air control valve. On it, we install the actuator motor to open and close the valve, and wire it to the controller. We install the thermocouple and wire it to the controller so the controller can read the temperature of the furnace.

Basically, the system works like this: the controller reads the furnace temperature from the thermocouple and compares that reading with the value of the temperature setpoint in the program. If the real temperature is lower than the setpoint, the controller sends a signal to the actuator motor, opening the valve, turning the furnace up. If the temperature is higher than the setpoint, the controller closes the valve, turning the furnace down. The farther away the furnace temperature is from the setpoint, the more the controller opens and closes the valve.

We can program the controller to turn the furnace up for a melt, hold it at high temperature during charging and melting, then turn it down so the furnace and glass can cool to working temperature, and then hold it at working temperature indefinitely.



Now we can put in the last charge, punch a button on the controller, and go to bed, knowing we'll have clean glass in the morning, at just the right temperature.