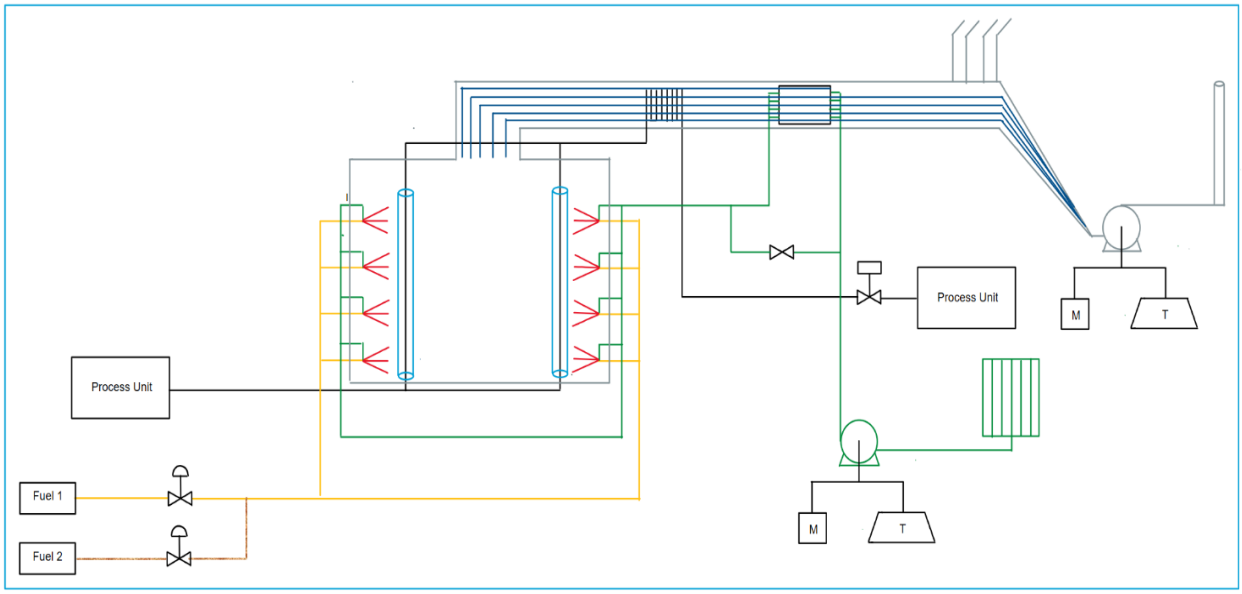
Fired Heater Process Description

Furnaces

Furnaces in process plants are used to supply heat to the process fluid by regulating fuel flow to the burners.

- Process Fluid Heating Section
- Fuel Supply and Burner Control Section
- Combustion Air Supply Section, where forced air supply or air preheater (APH) is installed
- Convection Section

Here is the typical sketch displaying fired heaters assembly:



1. Process Fluid Heating Section

In order for the reaction to take place and conversion happens, the operating temperature should be high enough. It is a typical practice to pass the process gas line through the convection section so that the gas is preheated and reaches a suitable temperature before reaching catalytic tubes. Afterwards, the process gas passes through the hair pins and catalytic tubes and alongside the tubes receives the heat and as a result the reaction happens. Finally, it exits the tubes by means of a collector.

2. Fuel supply and burner controls

Usually, two types of fuel are used. While the first fuel is used as a course of reliability, the second fuel is used as a course of optimization. Flow and pressure of each of them is regulated and get mixed if required. The pressure before burner is very low- in order of 0.1-1

barg when the fuel is gaseous. There are two means to break the pressure, control valves and restriction orifice before the burner. Here is the simple reaction:

$$\text{Fuel} + \text{Air} \rightarrow H_2O + CO_2 + \text{Miscellaneous}$$

Air is also preheated and then mixed with fuel to increase the efficiency of combustion. The flame produced shall have a nice shape in terms of direction and color. Any irregularities in the flame pattern should be corrected to avoid uneven heating of the tubes and obtain a good thermal efficiency. The oxygen content in the flue gas should be kept at about 1.6 % vol. If it is higher, it will indicate too much combustion air or leakage into the furnace. While combustion air is adjusted, the flame pattern of the individual burners should be monitored closely.

Burners could be located on the top otherwise known as top-fired burners, on the side otherwise known as side-fired burners.

3. Combustion Air Supply Section

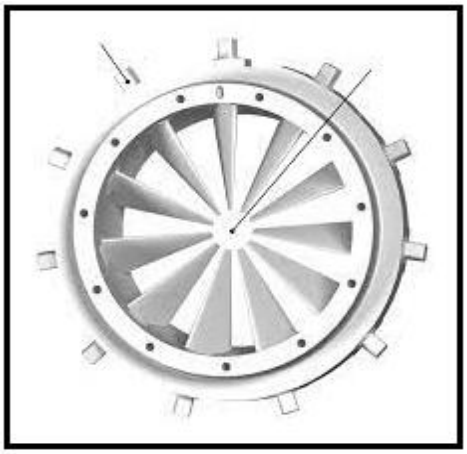
- Filters are simply used to prevent ingress of any particles. There are two types of filters, stand-alone like what you see in the picture, or integrated type which takes the air between chambers in. The method seems theoretically more efficient.
- In some designs forced fan or combustion air blower might be used. In some designs the air with natural draft comes in. For combustion air blower, in recent designs both drivers and turbines are selected as the drivers. They are connected via a clutch and functions like this that during normal operation the turbine takes the control and drives the fan but when the turbine goes into state of the trip, the motor takes the control and drive the turbine. Remember to reach the objective and being always to prevent the trip of fan, the motor should always be in a state of “free run”; simply the term “free run” means the motor shaft keeps turning but there is no load on it.
- APH or air preheater is used to preheat the air temperature from atmospheric temperature to a temperature above 100-150 C to increase combustion efficiency.
- Air bypass is used specially during start-up as a means to control air temperature and as a result the stack outlet temperature.
- Finally, the air is mixed with the fuel to be combusted and produces heat flow.

4. Convection section

This is the part where the flue gas exchanges heat with some heat exchangers inside the duct and thus, the energy is managed. You have already become familiar with two of these heat exchangers like air-preheater or feed-preheater.

The flue gas temperature shall be around 150C to avoid sulfuric acid dew point. Also notice a damper is installed on the duct to avoid overpressure inside the fired heater.

The pressure inside the fired heater is controlled by means of ID and FD Fan, which are manipulated by turbines speed and IGVs [Inlet Guide Vane]. Here is the picture of IGV to give you better perspective.



The drought pressure is the most important parameter which should be checked continuously by control operators. The drought pressure should always be kept within a range, typically -20mmWG < P < +5mmWG. The reason it should be kept above -20mmWG, is that the lower pressure damages the refractories. In a simple way, it dispositions the refractories and bricks. The reason why it should be kept below +5mmWG, is that the combustion stream with above pressure might find a way to the atmosphere and injure site operators.

As stated, the drought pressure is controlled by means of fan which is driven by a motor alone or a turbine alone or combined motor and turbine. For now, we suppose the fan is driven by a motor alone. Also, the amount of air which should be taken out is controlled by rectangular openings. The openings are controlled by inlet guide vane or IGV. When the IGV closes the amount of flow going to stack reduces and as a result there would be more combustion stream behind closed door! Which finally leads to increase in pressure. When the IGV opens the amount of flow going to stack increases and as a result there would be less combustion stream behind closed door! which finally leads to decrease in pressure. The conclusion is that IGV acts as pressure control valve or PV.

Stack

Stacks are used to discharge the flue gas to the atmosphere. Their inner surface is lined with refractories. Here is the procedure for stack diameter calculation.

$$V = \frac{m'}{\rho g \left(\frac{\pi D^2}{4}\right)} > 9\ m/s$$

Example 1: For the following conditions:

Temperature = 161 C

Pressure = 0 mmWG

Flow = 469314 kg/hr. = 130 kg/s

Gas density = 0.75

D = 4300 mm