Fired Heater Detailed Instruction

Appendix A

Furnaces

Furnaces in process plants are used to supply heat to the process fluid by regulating fuel flow to the burners. In P&ID four sections should be included when it comes to furnaces.

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

1. Process Fluid Heating Section

If the furnace charge is divided between different inlets, the design should be in a way that the flow is well-distributed among inlets so that no over-heating for tubes due to flow lagging would happen. Such occurrence if happens leads to tube cocking and rupture; thus, it should be avoided.

- For fractionator charge furnaces and reboiler furnaces, a control valve with a flow controller on each stream is provided so as to keep the split flow constant. For such multi-stream pass furnaces the process fluid is partially vaporizing. However, the process fluid must be liquid phase, not vaporized, just upstream of the flow control valves, since the control valves may not properly work with vapor-liquid mixed flow.
- For ammonia, hydrogen, and methanol plants, process gas passes through catalytic tubes and the reforming reaction happens throughout the tube length.
- Symmetrical Piping Layout: Wherever it is required, it should be indicated on P&ID. In case of symmetrical piping arrangement, the distributing and collecting manifold headers should be employed at inlet and outlet of the furnace. Care should be taken in sizing and arrangement of the manifold headers to ensure uniform flow distribution.
- Convection section: The purpose of convection section is to utilize the flue gas heat coming from radiant section to heat-up process fluids or utilities like boiler feed water (BFW) for steam generation and steam superheating. it shall be noted that duty control on the hot side (flue gas) is impossible. Convection section is basic designed by licensor and detailed designed by furnace vendors based on pinch analysis, process duties, and minimum furnace efficacy.
- Auxiliary facilities: For refinery fired heater, the following connections are typical:
    1. Provision of purge steam connection on combustion chamber: LPS is used as purge steam. The number of connections depends on the volume of the combustion chamber, which is determined by furnace vendor.
    2. When liquid fuel is contemplated and convection section incorporates extended surface tubes, soot blowers(optional) are to be normally provided to cleanse outer surface of the furnace convection tubes which are likely to be fouled with soot. MPS is used for such purpose.
    3. MP Steam Connections for Emergency Blow Out (Optional): In most of the charge furnaces of crude and vacuum distillation units, MP steam is introduced to blow out the fluid remaining in the furnace tubes in an emergency case.

- Instrumentation:
  1. Pressure indicators: For normal applications, one indicator at each of inlet and outlet common headers is sufficient. In case where the flow is distributed to each stream pass by the control valve, field mounted pressure indicators should be supplied to inlet of each stream, and one indicator on the common outlet header for detecting signs of in-tube fouling/coking, where the fouling is expected. Where the pressure is an important operational variable, it should be indicated on the panel of the central control room.
  2. Temperature indicators: It is a must to install temperature elements at the outlet header and on the inlet header to monitor furnace duty. Local temperature indicator should be provided to the outlet of each stream pass for monitoring uniform heating and even flow distribution over the split streams.
  3. Tube skin temperature: For the furnaces such as crude charge furnace, vacuum charge furnace hydrotreater charge furnace and thermal cracking furnace since there is potential coking and/or fouling inside tubes, consider tube skin thermocouples on the tubes. Minimum two tube skin thermocouples should be installed on the radiant tube surface per each stream pass. Knife-edge type tube skin thermocouples should be specified. Location of the tube skin thermocouple points should be proposed by furnace vendor in detailed engineering stage. In general, the tube skin thermocouples are directly welded on the tube wall surface, on the side facing to the burner flames, at or near the highest section of the temperature profile. An alarm may be actuated for high tube skin temperature to prevent damage to tubes by overheating. The alarm is usually set at the maximum tube design temperature.

2. Fuel Supply and Burner Control Section

The firing duty of furnaces is controlled by fuel supply and burner control. Typically, the controlling parameter is the fuel supply pressure. To better control the fuel and flowrate, a restriction orifice is provided.

- Due to difference between feed NG and fuel NG, it is recommended to consider flowmeter into the design.
- In many installations of fuel oil firing, steam-atomizing oil burners are employed. When steam atomization is used, the most common control is to maintain the pressure difference constant between the steam and the fuel oil. Constant pressure control is also employed in some installations where the oil burner characteristics so require.
- Valve Arrangement around Burners:
  1. For fuel header, gate valves are used for isolation purposes.
  2. For fuel isolation before each burner, ball valves are used for tight shut-off.
  3. Glove valve is used for atomizing steam, due requirement of fine tuning of burner pressure, referring flame pattern.
  4. Due to significance of fired heaters and fast impacts of fuel pressure on the furnace firing, a set of shut-off valve should be incorporated into the design to safely shut-down the furnace.
- Instrumentation:
  1. Pressure indicators should be installed on the main header and PG on the sub-headers.

2. Temperature indicators should be installed on the main header.

- A fuel gas knock-out drum shall be installed in individual furnace areas, if fuel gas has potential to condense in the fuel gas line from its supply system to the furnace. The fuel gas knock-out drum is not indicated in the attached P&ID for the furnace firing section.
- Steam trace should usually be applied to the fuel gas line from the fuel gas knock out drum to burners. The provision of steam trace on the fuel gas line routed to the knock out drum should basically be determined according to the fuel gas composition.

3.Combustion Air Supply Section

There are four systems regarding combustion air supply and flue gas discharge. Regardless any type of the following four systems, it should be noted that refinery process furnaces operate with a negative pressure (draft) in the fire box.

Notes:

- Design and operation

1. Natural Draft system
   Combustion air is supplied by means of draft force produced by stack. This system does not employ any machinery for delivering combustion air to the burners or discharging combustion flue gas into atmosphere.
2. Forced Draft System
   Forced draft fan (FDF) is installed to deliver combustion air to the burners. No machinery is employed for discharging the flue gas.
3. Induced Draft System
   Induced draft fan (IDF) is provided in the flue gas discharging system. Combustion air is sucked into the heater through burners by the ID fan.
4. Balanced Draft System
   Both FD and ID fans are provided to supply the combustion air and to discharge the flue gas. Installation of a combustion air preheater (APH) is one of the most common methods to attain high fuel efficiency. Balanced draft system with both FD and ID fans is usually required to supply combustion air and to discharge combustion flue gas, overcoming the pressure losses across the APH on both air and flue gas sides. As to whether the air preheater system should be provided, economical studies are generally required.

- Control system

1. Combustion Air Flow Control (Forced and Balanced Draft Systems Only)
   Where the FD fan is installed, an air flow control damper is normally provided at the suction of the fan with an air flow meter (a fabricated venturi is usually employed).The damper and the flow meter should be installed on the fan suction side, if applicable, due to energy saving of its driver. If the fan serves several heaters commonly, the control damper and the flow meter must be installed on the air supply duct to each furnace, on the fan discharge side.

2. Fire Box Pressure Control (Induced and Balanced Draft Systems Only)
   Where the induced draft fan is provided, pressure in the radiant section is maintained by automatic action of the control damper provided at suction of the ID fan. During operation, a negative pressure of at least 2 mmH_2O is to be maintained in the furnace.
3. Fans/APH By-Pass
   In installations with forced draft fans, induced draft fans, air preheaters, or a combination of these, loss of combustion air because of fan failure will require shut-down unless the furnace is equipped for alternate operation on natural draft or positive fire box pressure.
4. ID Fan & APH By-Pass (By-Pass on Flue Gas Side)
   With the stack designed to provide sufficient draft to continue operation, shut-down is not required by by-passing the ID fan and the air preheater in the event of ID fan failure. A quick open emergency damper is provided in the by-pass duct. This by-pass system is usually requested by the client when the APH system is installed. The bypass damper is controlled by the firebox pressure controller.
5. Combustion Air By-Pass on APH
   In installations with air preheaters, a by-pass duct with a manually operating damper is normally required on the air side, as well. The by-pass damper is used to adjust temperature of the flue gas leaving the air preheater in order to avoid dew formation on the APH heat transfer surfaces.

- Pressure Instruments
  Local pressure indicators should be provided at the following locations:

1. Discharges of the FD and ID fans, for their performance check
2. Pressure drop of the air preheater on the flue gas side
3. Suction pressure of the ID fan
4. Draft measurements in the furnace:
5. Floor (burner) level
6. Top of the firebox (or inlet of the convection section)
7. Outlet of the convection section (or base of the stack)
8. A pressure switch for the High-High pressure in the furnace should be provided at top of the radiant section.
9. A panel mounted pressure indicator should be required for the combustion air supply duct to the burners.

- Temperature Instruments
  Local temperature indicators should be required for the combustion air leaving the air preheater, for checking the APH performance.
  Panel mounted temperature indicators should be provided for the following:
  1. Combustion air to the burners (after joining the by-passed air flow)
  2. Flue gas leaving the radiant section (or entering the convection section)
  3. Flue gas leaving the convection section (or entering the APH)
  4. Flue gas leaving the APH

- Analyzer and Sample Connections

1. Maintaining the air/fuel ratio properly is important for safe furnace operation. Since the percentage of oxygen in the flue gases is a function of excess air, an oxygen analyzer should be provided at the outlet of the fire box (or the radiant section) for combustion management.
2. Other flue gas sample connections and/or on-line analyzers shall be provided as per the statutory requirements on atmospheric emissions (such as NOx, SO_2 and particulates).