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Atmospheric Distillation Unit (ADU)

Petroleum crude oils contain hundreds of different hydrocarbon compounds: paraffins, naphthenes and aromatics as well as organic sulfur compounds, organic nitrogen compounds and some oxygen containing hydrocarbons such as phenols. Although crude oils generally do not contain olefins, they are formed in many of the processes used in a petroleum refinery.

The crude oil fractionator does not produce products having a single boiling point, rather, it produces fractions having boiling ranges. For example, the crude oil fractionator produces an overhead fraction called "naphtha" which becomes a gasoline component after it is further processed.

The naphtha cut, as that fraction is called, contains many different hydrocarbon compounds. Therefore it has an initial boiling point of about 35 °C and a final boiling point of about 200 °C. Each cut produced in the fractionating columns has a different boiling range.

At some distance below the overhead, the next cut is withdrawn from the side of the column and it is usually the jet fuel cut, also known as a kerosene cut. The boiling range of that cut is from an initial boiling point of about 150 °C to a final boiling point of about 270 °C, and it also contains many different hydrocarbons.

The next cut further down the tower is the diesel oil cut with a boiling range from about 180 °C to about 315 °C. The boiling ranges between any cut and the next cut overlap because the distillation separations are not perfectly sharp.

After these come the heavy fuel oil cuts and finally the bottoms product, with very wide boiling ranges. All these cuts are processed further in subsequent refining processes.

Technical Description

The crude oil charge pump feeds crude oil from storage to the ADU. The raw crude oil flows through the tube side of the heat exchanger train and is heated to 446 ^{0}F. A flow control valve controls the crude oil flow rate to the process unit. The heater is a direct-fired heater.

The crude oil exits the heater at approximately 680 0F and enters the flash zone of the crude tower. A temperature controller maintains the heater outlet temperature setpoint by adjusting the flow of fuel to the burners thereby increasing or decreasing the firing rate of the heater.

The two-phase stream enters the flash zone of the crude tower. The residuum is the liquid part of this two-phase stream and flows to the bottom of the tower. The vapor part of the stream flows upward through the tower producing the remaining diesel, kerosene and naphtha products. The diesel and kerosene is fractionated as a liquid from the crude through vaporization and condensation based on the boiling range of the different products. The trays in the tower facilitate this fractionation or separation process. The naphtha, the lightest of the products, exits the top of the tower as a vapor. A reflux of liquid naphtha through a temperature control valve is used to maintain the 176 0F temperature at the top of the tower.

The tower bottoms pump moves the 669° F residuum (also called reduced crude or residual fuel oil) from the bottom of the tower through the crude/resid exchangers and the air cooler thereby cooling the stream to a final temperature of 250 0F. The residuum level in the bottom of the tower is controlled by a level control valve. A small slip stream of hot residuum is pumped through the tube side of the diesel stripper reboiler for re-boiling diesel.

Diesel is drawn from the tower through the level control valve into the diesel stripper at 553 0F. The vessel is re-boiled to remove or strip light ends from the diesel to increase the flash point of the diesel. These light ends are returned to the tower. The remaining diesel is pumped from the bottom of the stripper through the crude/diesel exchanger and air cooler to storage at 125 0F. Flow is controlled by a flow control valve.

Kerosene is drawn from the tower through a level control valve into the kerosene stripper. An electric emersion heater provides heat to strip the light ends from the kerosene product. The light ends are returned to the tower. The kerosene is pumped from the stripper through the kerosene/crude exchanger and air cooler to storage at 100 0F. Flow is controlled by a flow control valve.
The naphtha vapor from the top of the tower is cooled to 100 0F as it flows through the overhead condenser into the reflux accumulator. Uncondensed vapor is routed to the heater and used as fuel. Naphtha is pumped from the accumulator to the tower as reflux and to storage.

A minimal volume of water is produced based on the water content (maximum

0.5% volume) of the crude oil. This water accumulates in the water boot at the bottom of the accumulator and is automatically drained using an interface level controller. The water flows to storage.

Plant Controls

The plant is equipped with two types of instrumentation control loops:

1. Process control computer instruments: Those which control a process variable from the control computer in the control room. Typical installations have included an Allen Bradley Control System. The entire process control computer instrument "Loops" are electronic-type.

2. Local control instruments: Instrument loops, which are located on the process skids, i.e., a control function which is not controlled from the process control computer. All of the local control devices are pneumatic- type.

Recorders

In addition to the process control instruments located on the process control computer, the following process variables are monitored and historically recorded on the software:

Temperature Indicators: Multi-Point Indicator – Several important process temperatures are monitored by the human-machine interface (HMI) software and hardware.

- *Motor Run Lights*: Each of the motors in the process units is equipped with a motor-run light located on the HMI. The status of any one of the motors can be determined visually in the control room by observation of these indicators. Each pump and other motor-driven equipment item which is "running" is indicated by an indicator on the HMI. The indicator is not "on" if the motor is idle.

- *Local Control Instruments:* Each of the process variables which is not provided with the control instrumentation on the main HMI is set and controlled by local control instrumentation which is located on the process skids ("field control instruments"). Most of the local control functions pertain to ancillary processes or utilities in the process units. These variables do not require frequent change.

Alarms & Controls

- An alarm is a visual and audible display of changing conditions in the operation of the plant. This display calls the operators attention to the change as soon as it occurs.

- Alarm set points and annunciations are set in HMI and output to audible devices in the process area thru the field mounted programmable logic controllers (PLC).

- The visual indication of an alarm is a flashing icon on the HMI screen together with an audible signal from the alarm horn located at the topping plant.

The ADU is operated with the following controls:

- the crude feed pump is a rotary pump. The rate is controlled by an automatic flow control valve ;
- an automatic temperature controller in the control panel controls the heater outlet temperature;
- the kerosene side draw product is controlled by an automatic level controller in the control panel that controls the flow rate of the kerosene side draw by monitoring the level in the side stripper;
- the diesel side draw product is controlled by an automatic level controller in the control panel that controls the flow rate of the diesel side draw by monitoring the level in the side stripper;
- an automatic temperature controller controls the tower top temperature by controlling the reflux flow rate;
- an automatic temperature controller in the control panel controls the kerosene reboiler temperature;
- an automatic temperature controller in the control panel controls the diesel reboiler temperature;
- an automatic level controller controls the tower bottoms level by varying the flow rate of the bottoms;
- an automatic level controller controls the stripper bottoms level by varying the flow rate of the diesel and kerosene products;
- an automatic level controller controls the naphtha accumulator level by varying the flow rate of the naphtha stream; and
- for sub-zero weather, the air cooler temperature is controlled manually by opening and closing recirculation louvers.

Codes and Standards

The following prevailing standards of United States engineering design and codes are adhered to in the processing, layout and selection of the various component parts used in the fabrication and assembly of this plant:

- ASME Code Section VIII, Division 1, Pressure Vessels and Heat Exchangers;
- ANSI B31.3 Petroleum Refinery Piping;
- FM Requirements for Burner Control;
- API-RP520, Parts I and II, Design and Installation of Pressure Relieving Systems in Refineries; and
- API-500A Classification of Areas for Electrical Equipment in Petroleum Refineries (Class 1, Group D, Division 2) on the process end of the skid The heater is located at least 50 feet from the other process equipment and control room.

All process vessels are designed and fabricated in accordance with the ASME Code, Section VIII, Division 1. The tower and strippers are carbon steel, with associated trays being 316 stainless steel as required. Fabrication shops for the vessels are tested and certified by ASME, insurance companies and other regulatory agencies to perform fabrication in accordance with the ASME Code, Section VIII, Division 1. These shops are provided with a certificate having a certificate number and they are audited and re-certified every three years. Copies of the shop's certificate are available after a purchase order has been issued for the coded vessels.

The fabrication shops must use certified welders who are tested and certified in accordance with the ASME Code, Section IX.

Pressure gauges are calibrated annually in accordance with a dead weight tester.

Certified mill test reports on materials used on ASME Code vessels are provided and shipped with each vessel for the buyer's and customs use.

Sufficient surge capacity is provided in all vessels to assure stable control and allow corrective action to be taken in the event of a process upset or equipment failure. Sufficient elevation is provided for all vessels to assure adequate suction head at low liquid level for pumps.

The heater is a horizontal cabin-type with a convection section. Certified mill test reports on materials used to build the heater are provided and shipped with the heater for the buyer's and customs use. Burners can be designed to meet the needs of multiple fuel sources. The heater is built in accordance with the following codes:

- Coil: ASME Section I;
- Tubes: ASTM A-106 Grade B;
- Fittings: ANSI B16.9;
- Flanges: ANSI B16.5; and
- Burner: FM Requirements.

All piping and valves required within the process battery limits are provided, fabricated and installed to the maximum practical extent. Piping design is according to ANSI B31.3. All process piping is A-106, Grade B seamless unless otherwise specified.

Environmental Impact

The Chemex ADU will not make a significant contribution of air contamination to the atmosphere. Fugitive emissions are minimal due to the small number of flanged connections and pumps. Since these plants use air cooling, the only other effects on the local environment are the products of combustion exhausted into the air by the plant heater and the water that is brought in with the crude oil.

For each 1/10th of 1% of water in the crude feed, one barrel of distilled water will be produced for each 1,000 barrels of crude processed (1 kg per metric ton). Since the water is in equilibrium with the distillate, the water may contain up to 500 mg per liter of total organic carbon (TOC).

If a desalter is used, depending on the amount of salt in the crude, from 30 to 130 gallons per hour of brine water is discharged per 1,000 barrels of crude processed (from 0.9 to 4 liters per hour for each metric ton per day).