Lecture №9 Coking. Delayed Coking

Coking is a thermal cracking type of operation used to convert low grade feedstock such as straight-run and cracked residua to coke, gas, and distillates.

Two types of petroleum coking processes are presently operating:

1. delayed coking, which uses multiple coking chambers to permit continuous feed processing wherein one drum is making coke and one drum is being decoked;

2. ***fluid coking***, which is a fully continuous process where product coke can be withdrawn as a fluidized solid.

- ***Feedstock:*** Crude oil residua obtained from the vacuum distillation, deasphalter bottoms and tar sand bitumen, and cracked residua (thermal tars).
- ***Products:*** *gases, gasoline, fuel oil, gas oil and coke.* The gas oil may be the major product of a coking operation.
- **Temperature** - 480-515 *°C.*

- **Basic quality of petroleum coke:** the sulfur content, the ash content, granular composition, porosity, true density, mechanical strength, etc.

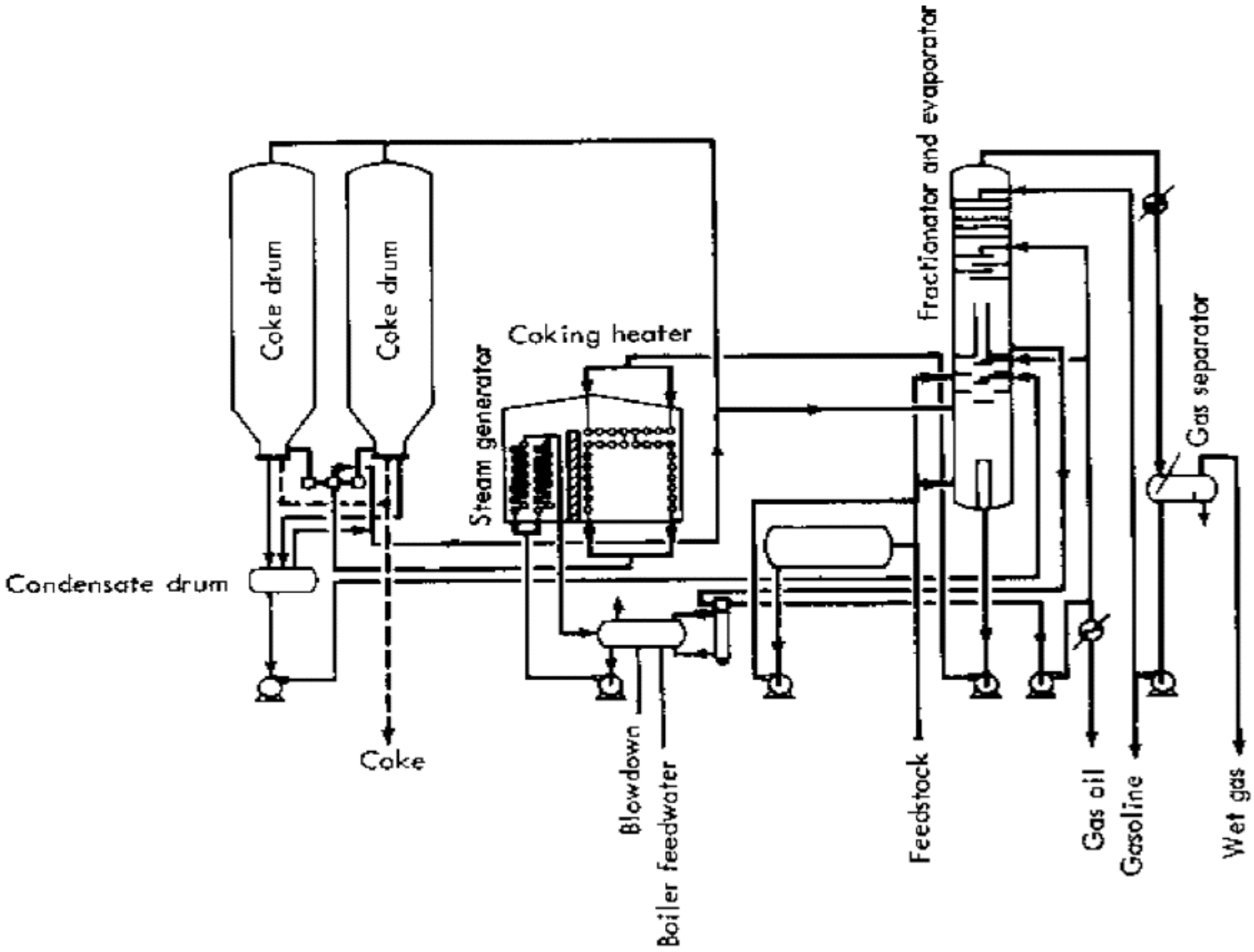
Use of the products

- The **gas oil** may be the major product of a coking operation and serves primarily as a feedstock for catalytic cracking units.
- **Calcined petroleum coke** can be used for making anodes for aluminum manufacture and a variety of carbon or graphite products such as brushes for electrical equipment.

Delayed Coking

- Delayed coking is the oldest, most widely used cooking process and has changed very little over its 60 year history. It is a semicontinuous (semi-batch) process in which the heated charge is transferred to large coking (or soaking) drums that provide the long residence time needed to allow the cracking reactions to proceed to completion.
- The process uses long reaction times in the liquid phase to convert the residue fraction of the feed to gases, distillates, and coke. The condensation reactions that give rise to the highly aromatic coke product also tend to retain sulfur, nitrogen, and metals so that the coke is enriched in these elements relative to the feed.

Delayed coking process



Description of scheme

In the process the feedstock is charged to the fractionator and subsequently charged with an amount of recycle material (usually about 10%, but as much as 25%, of the total feedstock) from the coker fractionator through a preheater and then to one of a pair of coke drums; the heater outlet temperature varies from 480 to 515°C to produce the various products. The cracked products leave the drum as overheads to the fractionator, and coke deposits form on the inner surface of the drum.

The majority of the sulfur originally in the feedstock remains in the coke. A pair of coke drums are used so that while one drum is on stream the other is being cleaned, allowing continuous processing; the drum operation cycle is typically 48 h.

The temperature in the coke drum ranges from 415 to 450°C, at pressures from 103 to 620 kPa.

- Coke removal at present is a daily routine performed by means of water jet under the pressure of 140 atm. At first, a hole is drilled from top to bottom in coke cake in the drum. Then, a rotating rod is lowered to the hole, which makes water jet swing. High pressure breaks the coke cake into pieces that fall from the lower part of the tower into cars carrying them to a warehouse. The drums normally operate in the 48-hours cycle: during 24 hours the drum is filled with coke, while switching over, cooling down and removal of coke take about 22 hours, during which the other drum is filled with coke.

Obviously, the feedstock heater and the coke drums are the most critical parts of the delayed coking process. The function of the heater or furnace is to preheat the charge quickly to the required temperature to avoid preliminary decomposition.

The function of the coke drum is to provide the residence time required for the coking reactions to proceed to completion and to accumulate the coke.

- Coker naphthas have boiling ranges up to 220°C, are olefinic, and must be upgraded by hydrogen processing for removal of olefins and sulfur. They are then used conventionally for reforming to gasoline or as chemical feedstocks.
- Middle distillates, boiling in the range of 220-360°C), are also hydrogen treated for improved storage stability, sulfur removal, and nitrogen reduction. They can then be used for either diesel or burner fuels or thermally processed to lower boiling naphtha.
- The gas oil boiling up to about 510 °C endpoint can be charged to a fluid catalytic cracking unit immediately or after hydrogen upgrading when low sulfur is a requirement.

Influence of Operating Parameters

- **An increase in the coking temperature**
- (1) decreases coke production,
- (2) increases liquid yield,
- (3) increases gas oil endpoint.
- **Increasing pressure and/or recycle ratio**
- (1) increases gas yield,
- (2) increases coke yield,
- (3) decreases liquid yield,
- (4) decreases the gas oil endpoint.