Delayed Coker Process & Systems Overview

This presentation provides an overview of the delayed coking system found in modern refineries.

I. Process Schematics (various sources)
II. Delayed Coker Feed Material
III. The Coker Fractionator unit
IV. The Coker Furnace
V. The Coke Drums
VI. Coke Drum Opening
VII. Coke Drum Cutting, Coke Handling
VIII. Coke Drum Cycle Time comparison
I. Delayed Coker Process Schematics
**Delayed Coking**

**Overview**
Lummus Technology’s proprietary delayed coking technology is one of the most cost-effective routes for converting up to 50% of heavy residual feedstocks into valuable lighter distillate products and coke.

The current design is based on several decades of continual refinement and accumulated data from over 60 commercial installations. Lummus’ delayed coking technology emphasizes high reliability and flexibility while meeting today’s more rigorous environmental and safety requirements.

**Advantages**

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<th>Process Features</th>
<th>Process Benefits</th>
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<td>Efficient cracker design</td>
<td>Optimized operating conditions and product yields</td>
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<td>API sludge disposal process</td>
<td>Provides study disposal capability</td>
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<td>Special coking heater design</td>
<td>Maximum run length - high efficiency</td>
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<td>Online heater decoking</td>
<td>High on-stream factor</td>
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<td>Proprietary coke product and coke drum structure design</td>
<td>Reduced investment and maintenance costs</td>
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<td>Automated flange unloading system</td>
<td>Enhanced operational safety - shorter cycle time</td>
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<td>Advanced control system</td>
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<td>Environmentally advanced design</td>
<td>Reduces fugitive emissions and waste effluents</td>
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<td>Coke drum mechanical design</td>
<td>Maximizes drum life for all drum sizes</td>
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<td>Low recycle design</td>
<td>Maximizes distillate production</td>
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**Process Description**
Delayed coking is a semi-batch process using alternating drums that are switched off-line after filling. Support facilities include closed blowdown, coke cooling and handling, and a water recovery system.

Hot residual oil is fed to the bottoms of the fractionator where it mixes with condensed recycle. The combined stream is heated in the furnace to initiate coke formation in the coke drums. Coke drum overhead vapor flows to the fractionator where it is separated into light gas, unconverted naphtha, light gasoil, heavy gasoil, and recycle.

During the coke drum steaming and cooling period, all steam and condensation waters are directed to the blowdown system where they are recovered. After the coke drum cooling cycle is complete, the coke is hydraulically cut from the drums and dropped into a pit or pad, where water is separated from coke and recycled.

**Predictive Tools**
From extensive pilot plant and operating experience, Lummus Technology has developed a correlation package and computer software to predict delayed coking yields and operating conditions for a wide variety of feedstocks and product requirements. For unusual feedstocks, Lummus’ pilot plant can be used to obtain design yields.

Reference: CB&I website

[www.Lummus.CBI.com](http://www.Lummus.CBI.com)
Typical Delayed Coking Unit

II. Delayed Coker Feed Material

Delayed Coker (Coker) feedstock is material from the refinery vacuum unit, which is otherwise used as road asphalt. The objective of the Coker is to process the asphalt-like material to produce higher value products, such as gasoline, diesel fuel, LPG, and petroleum coke.
III. Delayed Coker Fractionator

The Coker Fractionator receives and separates the feedstock and sour 'cracked' gas and liquids from the operating Coke Drum and Coker Furnace.

• Fuels Gas and LPG are recovered for fuel or other products.

• Naptha is recovered and sent to the other refinery units for gasoline production.

• Light Coker Gas Oil (LCGO) and Heavy Coker Gas Oil (HCGO) are sidedraws from the Fractionator and are sent to hydrotreating for processing into diesel and other products.

The Coker Gas Plant further separates the products.
The Coker Furnace heats the heavy liquid material from the bottom of the Fractionator to about 900 to 945° F. (482 to 507° C). This heating causes the heavy liquid material to "crack" or change into a combination of smaller molecule gas and liquid products. Steam is injected to minimize the cracking until it is in the Coke Drum.
The Coker typically has 2 or more Coke Drums which operate in pairs in a semi-batch mode:

• In the Operating Coke Drum, the material from the Coker Furnace, at high temperature and low pressure, is injected into the bottom of the drum and is further ‘cracked’ into (1) gaseous products which are returned to the Fractionator for product recovery and (2) into the petroleum coke that solidifies in the drum.

• The other offline drum is steamed, vented, and cooled prior to the drum being opened to atmosphere. After the drum is opened, the petroleum coke is cut from the drum using high pressure water. Petroleum coke or simply “coke” is similar to coal and is typically used for fuel in power plants.
The modern Coker has automatic deheading valves on the top and bottom coke drum flanges to allow the coke drums to be opened safely for “cutting” the coke from the drum. Historically, the flanges were opened manually.

Engineering is required to replace manual flanges with automatic deheading valves, due to the changes in orientation of the inlet nozzles and due to the size and weight of the deheading valves.

Several images are shown in the following slides showing the automated slide valves. Schematics also following showing key valves in the system and safety interlocks which are common and allow the opening of one Coke Drum while having the other one in operation at the same time.
Before DeltaGuard

By: Ruben Lah, VP / CTO
Curtiss-Wright Oil and Gas Systems Division

Safe Unheading
• Totally enclosed system from the top of the coke-drum to the drain pit, rail car or sluice way
• Eliminate exposure risk to personnel, equipment, and the unheading deck
• Remotely operated from control room
• All safety interlocks incorporated
• Isolation of a tarry drum
• Isolation or control of a drum dump
Current Technology Advantages

Safe Unheading
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Pic / Nozzle DeltaGuard
VELAN DELAYED COKER BALL VALVES

NEW RING TYPE BACKPRESSURE VALVE

DRUM A

Overhead vapor valves

Bypass valve

Warm-up valves

Drain valves

Warm-up gas

Inlet isolation valves

4-way switch valve

Feed from heater

Heater

DRUM B

Blowdown valves

Quench water valves

Pump isolation valve

Flow control valve

FRACTIONATOR

All full bore, ideal for process de-bottlenecking, can be fully interlocked for operating safety.
Interlocks

Reference: “Shot Coke: Design & Operations”
By John D. Elliott, Foster Wheeler USA Corporation

Adams Project Managers, Inc.
As the coke is 'cut' by the high pressure water nozzle, the coke and water flow onto a Coke Pad or into the Coke Pit, where the water is separated and recycled back to the cutting water system.

Coke is moved from the pit by either a bridge crane or a front end loader for shipment.

Additional schematics and images follow to show various components of the system.
VII. Coke Drum Cutting

The Jet Water Pump produces high pressure water to cut the coke from the drums.
Figure 2 - Delayed Coker Unit
Coke Drums and Hydroblast Systems
FLOWSERVE AutoShift Cutting Tool

Revolutionizing Hydraulic Decoking

With more than 100 years of decoking experience through to Wilmington, Pacific and GP heritage brands, Flowserve is the undisputed global leader in hydraulic decoking systems. It has powered many significant advancements in hydraulic decoking and has transformed it into an increasingly safe, efficient and automated process. Now, with its new AutoShift combination decoking tool, Flowserve is poised to revolutionize the industry.

The patented AutoShift combination decoking tool makes remote operation feasible by removing the plunger from the cutting deck. Mode shifting is accomplished automatically and remotely by water injection or pressurization, not manually as with other tools. As such, there is no personnel exposure to the following dangers:

- High pressure water
- Exposed hot surfaces
- Hydrogen sulfide (H2S) vapors
- Mechanical hazards

AutoShift Tool Benefits

The AutoShift combination decoking cutting tool provides numerous benefits to hydraulic decoking operations, including:

- Improved operator safety
- Greater system automation
- Reduced cycle time
- Improved efficiency
- Simplified maintenance
- Shifting flexibility to the "Rock" tools
- Manual shift feature

Hydraulic Decoking Made Safer

With the patented AutoShift combination decoking tool, hydraulic decoking is automated, simplified and most importantly, safe.

Traditional combination cutting tools require extensive handling to manually shift cutting modes. First, a plunger must be hand-drawn from the top of the drum through the collected cutting downward-oriented elements of the decoking tool. Then, the tool must be inclined to the top of the drum where either the entire tool or the operating mode of the combination decoking tool is changed to use side-oriented cutting mode. Finally, the tool must be rotated and moved vertically downward in the vessel body, where the side-oriented elements cut the balance of the coke and flush it out the upper section of the drum.

Removal of the cutting tool from the drum, to another vessel or tool or to change in cutting mode, is a cumbersome and hazardous operation. Taking this tool out of the vessel can be very dangerous if the proper control system is not in place to terminate the bad cutting processes in the cutting tool.

The AutoShift combination decoking cutting tool eliminates these dangers and reduces cycle times by shifting modes automatically and remotely in the vessel. Moreover, its ability to remotely shift operating modes means that operating personnel do not need to be in the cutting deck, reducing exposure to hot surfaces and mechanical hazards. This feature provides a significant improvement in overall safety.

Adams Project Managers, Inc.

**PROCESS ENGINEERING ASSOCIATES, LLC**

"Excellence in Applied Chemical Engineering"
Coke Handling Crane
VIII. Coke Drum Cycle Time Comparison

Reference: “DELAYED COKER REVAMPS: REALIZATION OF OBJECTIVES “
AM-04-69 – By John D. Elliott, Foster Wheeler USA Corporation

Adams Project Managers, Inc.
Additional Reading on Delayed Coking

We hope this very basic presentation has been informative. Additional suggested reading materials are listed below and provide more detail on the subject of delayed coking. We hope you will contact the APMI/PROCESS Team when a coker revamp study is needed.


Adams Project Managers, Inc.