Coking 101
An Introduction to Delayed Coking

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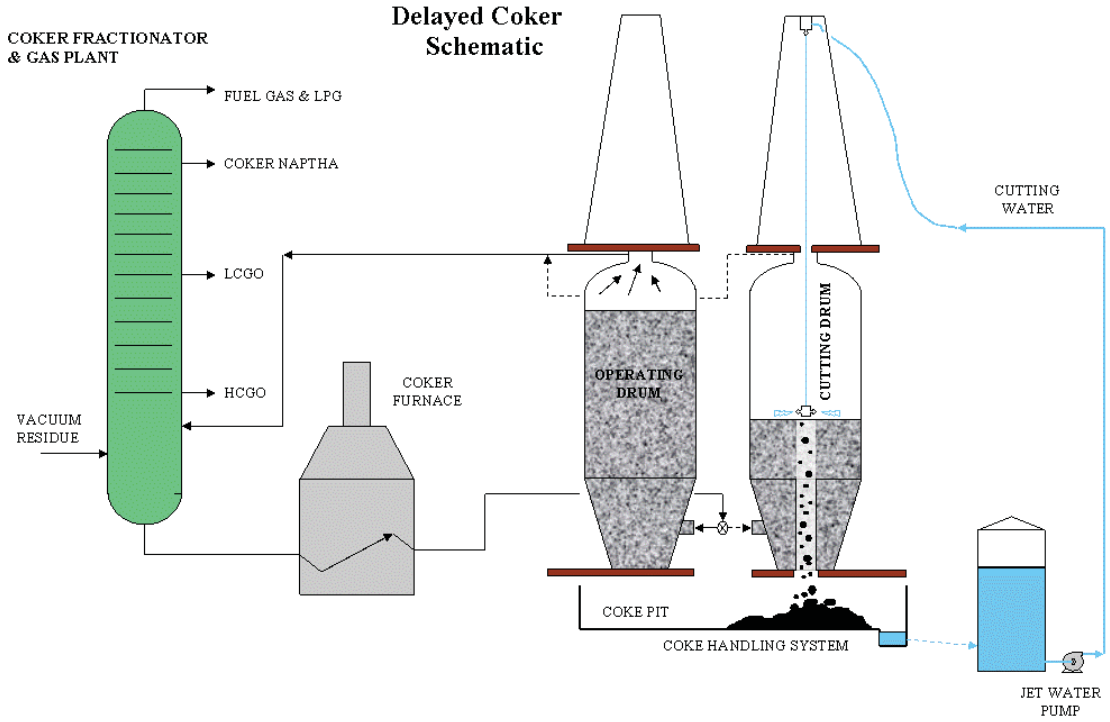
Delayed Coker Process & Systems Overview

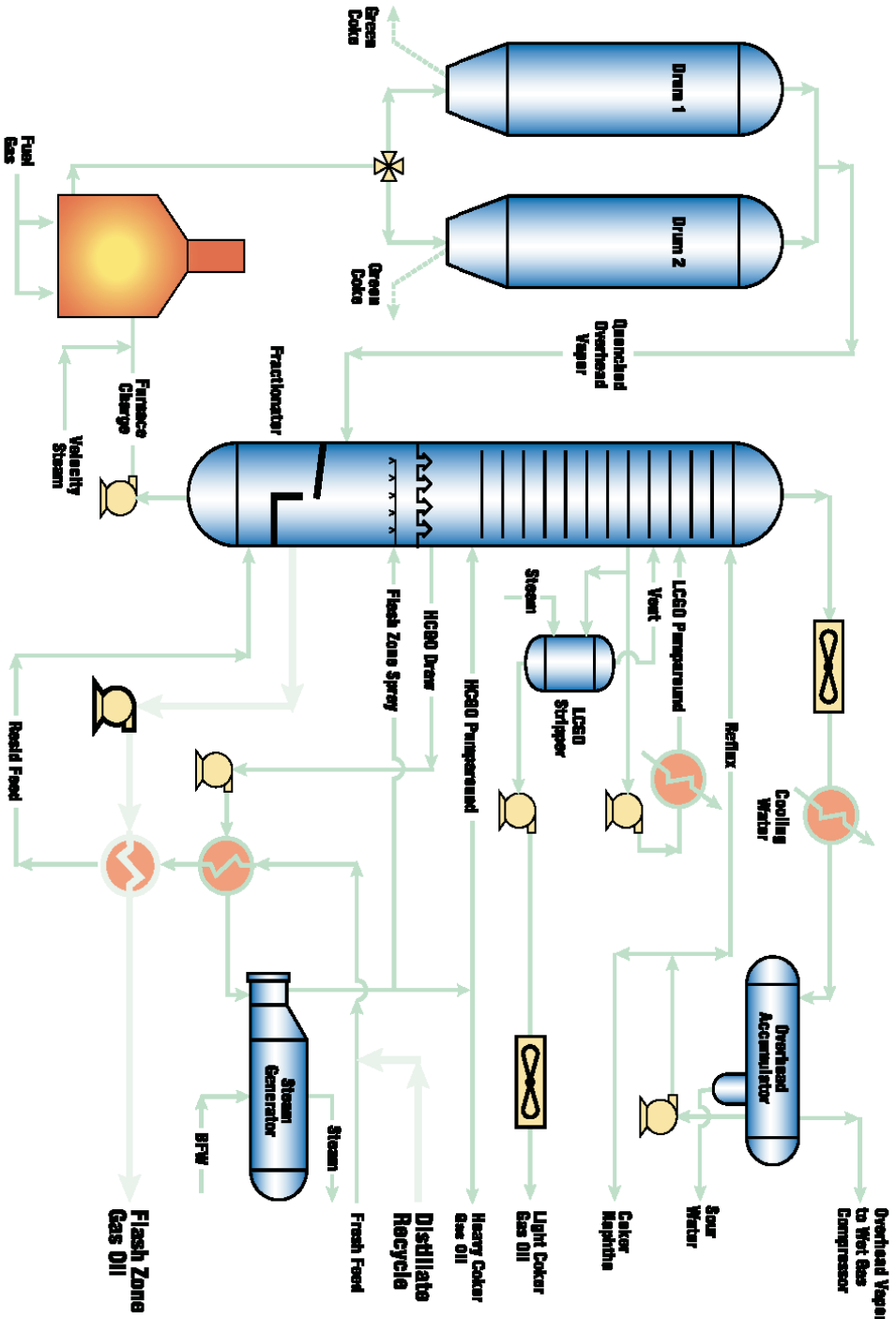
This presentation provides an overview of the delayed coking system found in modern refineries.

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



Reference: ConocoPhillips Brochure



Reference: CB&I website

Delayed Coking

Overview

Lummus Technology's proprietary delayed coking technology is one of the most cost effective routes for converting/ upgrading heavy residual stocks to more 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.

The delayed coking unit design features online computer control, automatic unheading, single or double fired heaters, state-of-the-art coke drum mechanical design, and an innovative water management/coke recovery system. The process can handle a variety of feedstocks, such as petroleum derived resids, cracked materials (pyrolysis tar and cycle oils), and liquid feedstocks derived from coal.

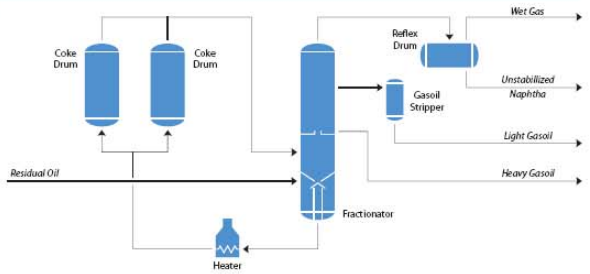
The Lummus Technology design maximizes distillate yield while achieving the specification requirements of the downstream hydroprocessing units.

Advantages

Process Features	Process Benefits
Extensive commercial and pilot plant data base; predictive tools	Optimizes operating conditions and product slate
API sludge disposal process	Provides sludge disposal capability
Special coking heater design	Maximizes run length • High efficiency
Online heater decoking	Higher on-stream factor
Proprietary coke pit/pad and coke drum structure design	Reduced investment and maintenance costs
Automated flange unheading system	Enhanced operational safety • Shorter cycle time
Advanced control system	Operating cost savings
Environmentally advanced design	Reduces fugitive emissions and waste effluents
Coke drum mechanical design	Maximizes drum life for all drum sizes
Low recycle design	Maximizes distillate production

Delayed Coking

Process Flow Diagram



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 cutting and handling, and a water recovery system.

Hot residual oil is fed to the bottom 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 wet gas, unstabilized naphtha, light gasoil, heavy gasoil, and recycle.

During the coke drum steam out and cooling period, all steam and hydrocarbon vapors 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 drum and dropped into a pit or pad, where water is separated from coke and recycled.

Predictive Tools

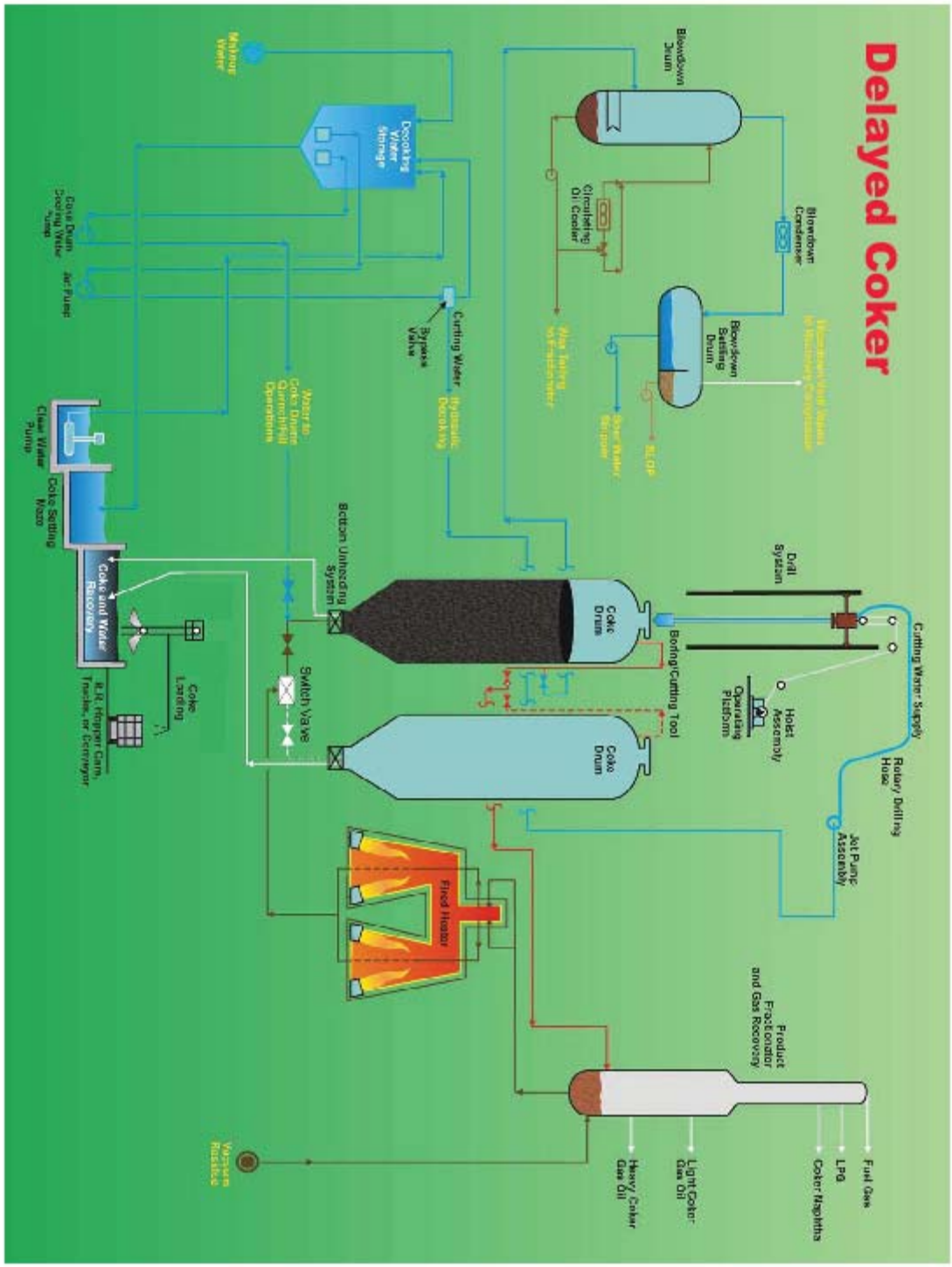
From extensive pilot plant and operating experience, Lummus Technology has developed a correlation package and computer software to predict delayed coking yields and operating conditions for a wide variety of feedstocks and product requirements. For unusual feedstocks, Lummus' pilot plant can be used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

Lummus Technology
a CB&I company

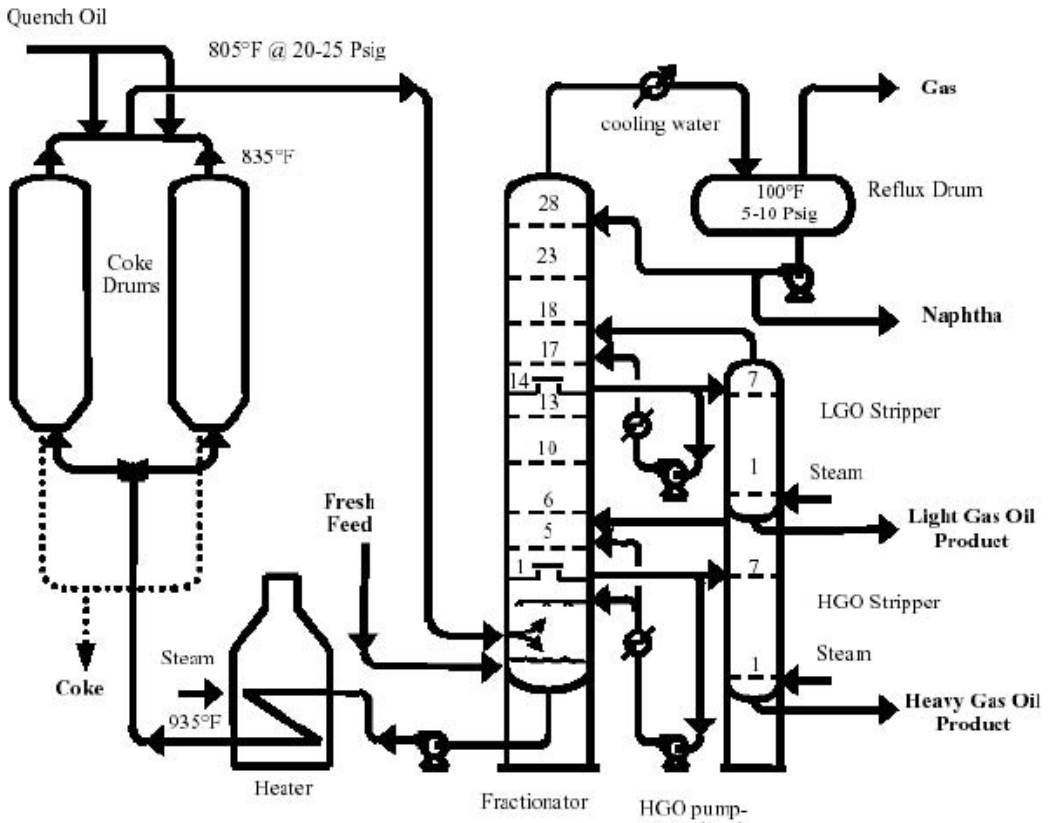
www.Lummus.CBI.com

technology | engineering | procurement | construction

Reference: Foster Wheeler Brochure



Typical Delayed Coking Unit

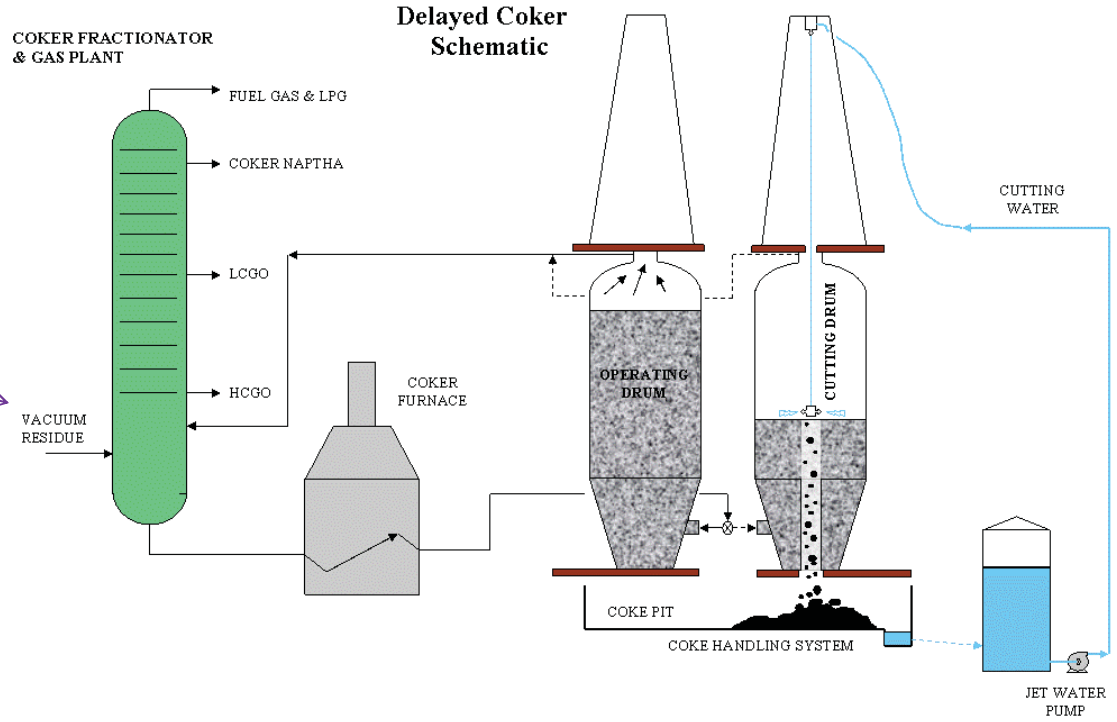


Source:
Refining Overview – Petroleum Processes & Products,
by Freeman Self, Ed Ekholm, & Keith Bowers, AIChE CD-ROM, 2000

Refining Processes course curriculum, Colorado School of Mines, taught by John L. Jechura Jr., http://inside.mines.edu/~jjechura/Refining/.

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

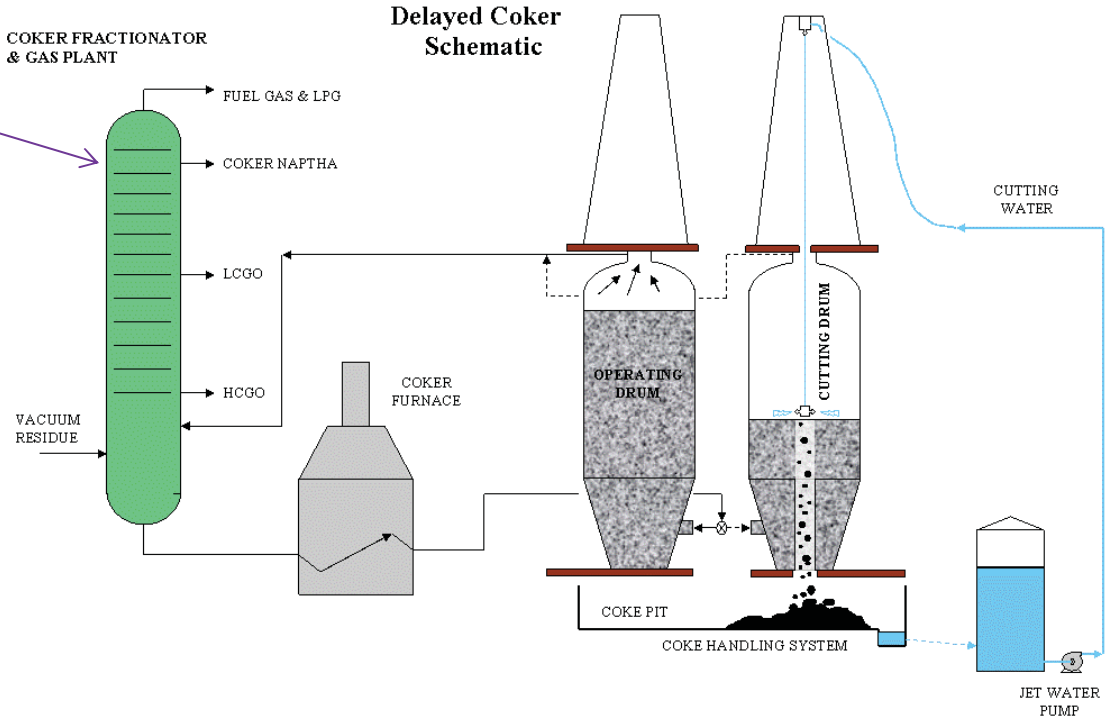
The Coker Fractionator receives and separates the feedstock and sour 'cracked' gas and liquids from the operating Coke Drum and Coker Furnace.

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

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

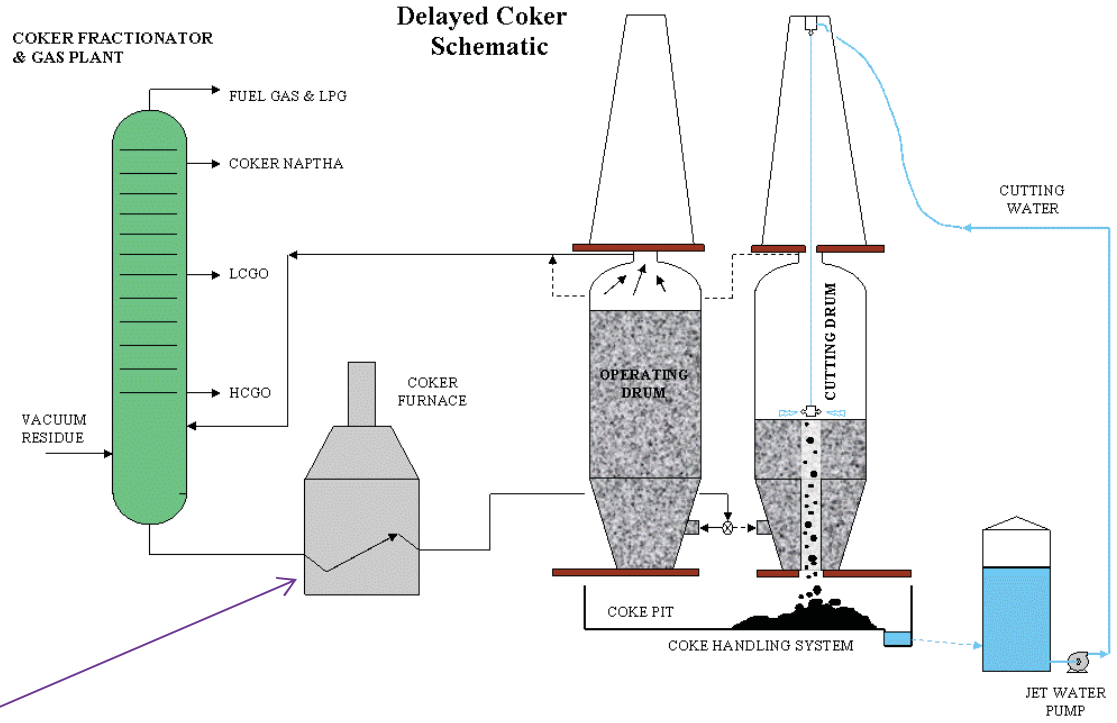
•Light Coker Gas Oil (LCGO) and Heavy Coker Gas Oil (HCGO) are sidedraws from the Fractionator and are sent to hydrotreating for processing into diesel and other products.

The Coker Gas Plant further separates the products.

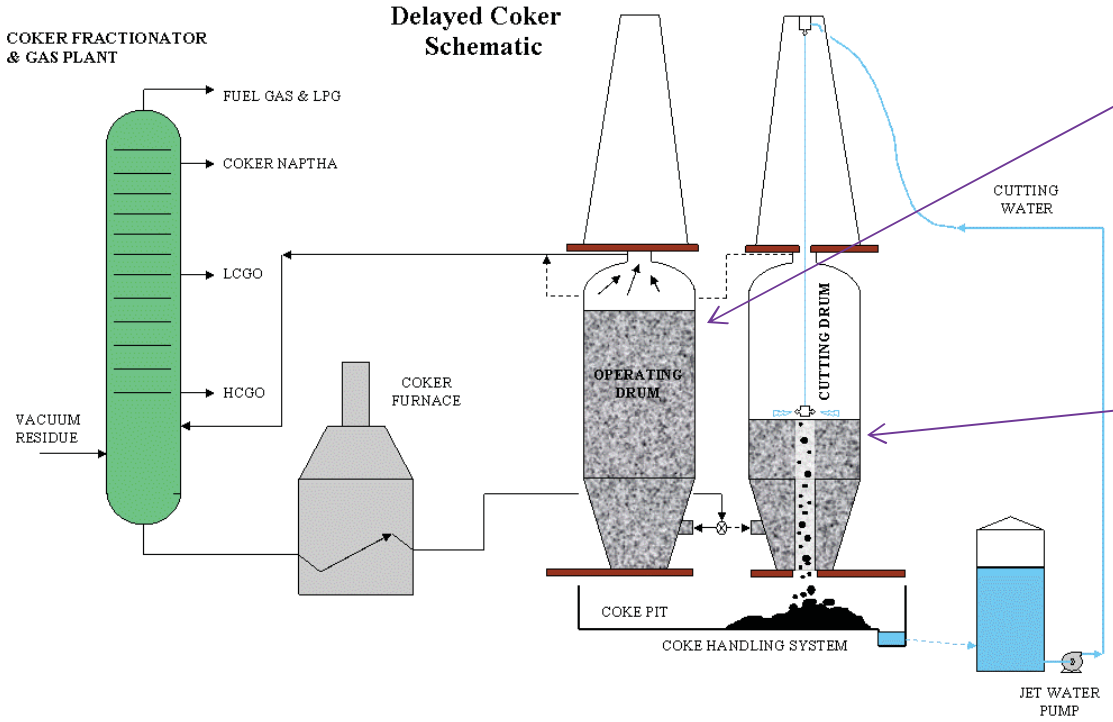


IV. Delayed Coker Furnace

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.



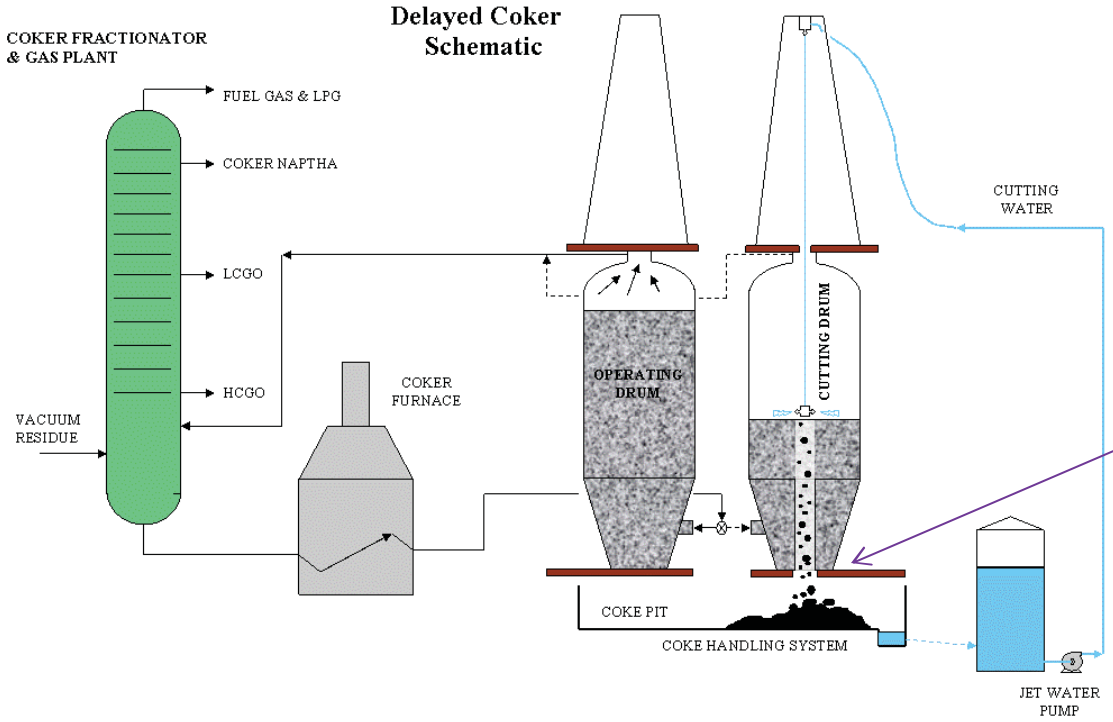
V. Delayed Coker Coke Drums



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.

VI. Coke Drum Deheading

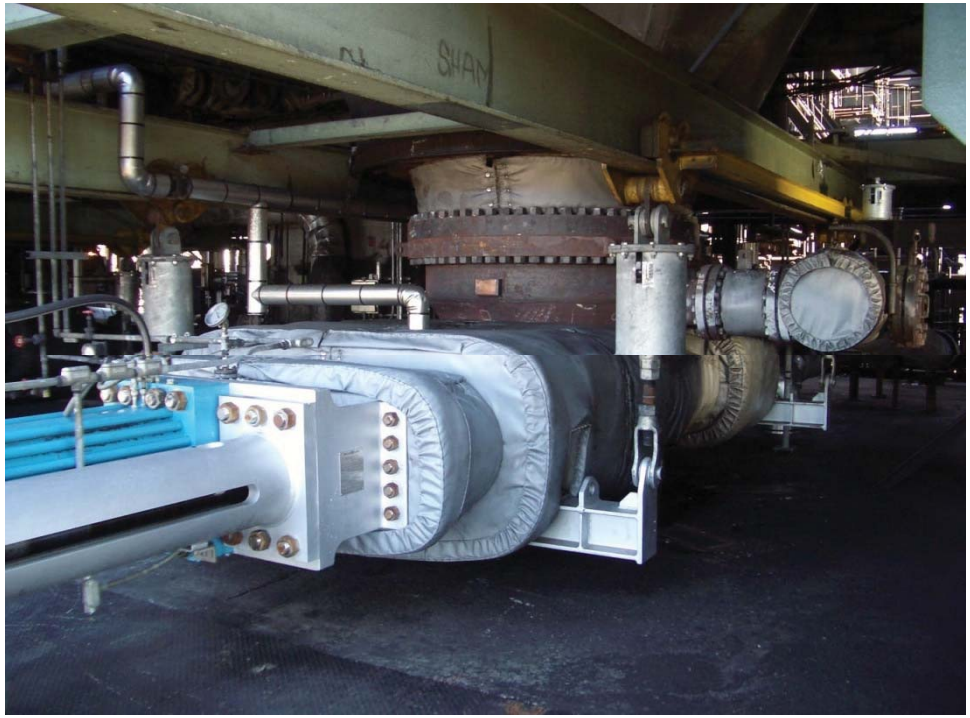


The modern Coker has automatic deheading valves on the top and bottom coke drum flanges to allow the coke drums to be opened safely for "cutting" the coke from the drum. Historically, the flanges were opened manually.

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



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

Reference: "Automation and Improved Safety of the Delayed Coking Process using Modern Delayed Coking De-Heading Technology"
By: Ruben Lah, VP / CTO
Curtiss-Wright Oil and Gas Systems Division

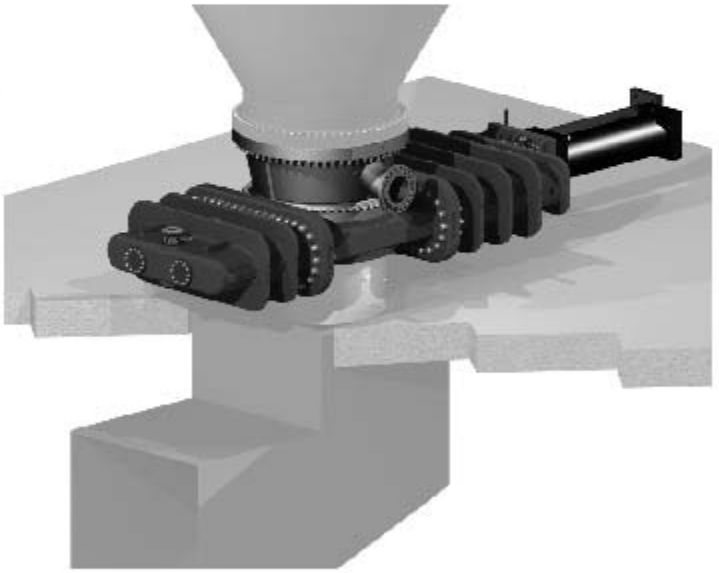
DELTAGUARD

DeltaValve®

Current Technology Advantages

Safe Unheading

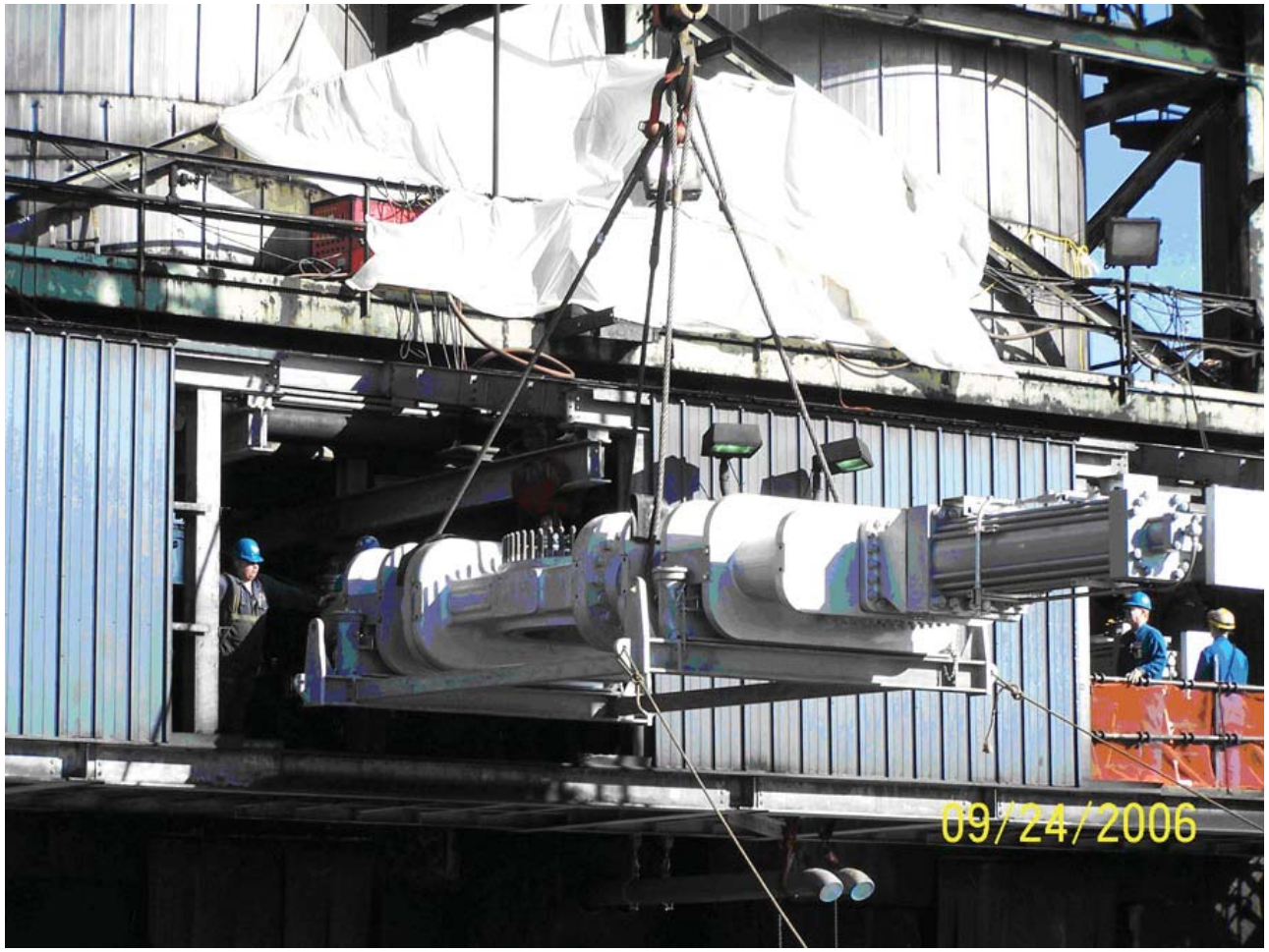
- Totally enclosed system from the top of the coke-drum to the drain pit, rail car or sluice way
- Eliminate exposure risk to personnel, equipment, and the unheading deck
- Remotely operated from control room
- All safety interlocks incorporated
- Isolation of a tarry drum
- Isolation or control of a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



CURTISS WRIGHT

DELTAGUARD®

DeltaValve®



Picture / Nozzle DeltaGuard

DELTAGUARD®

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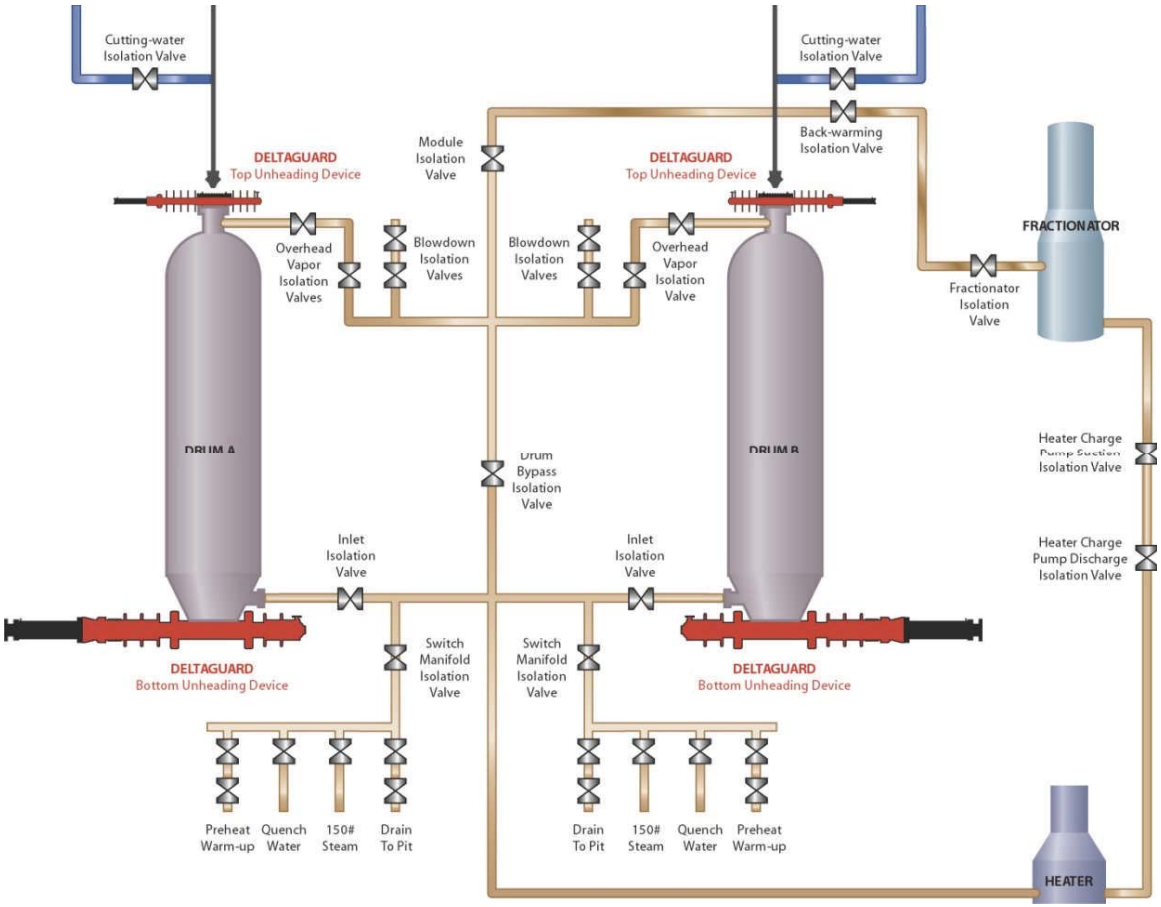
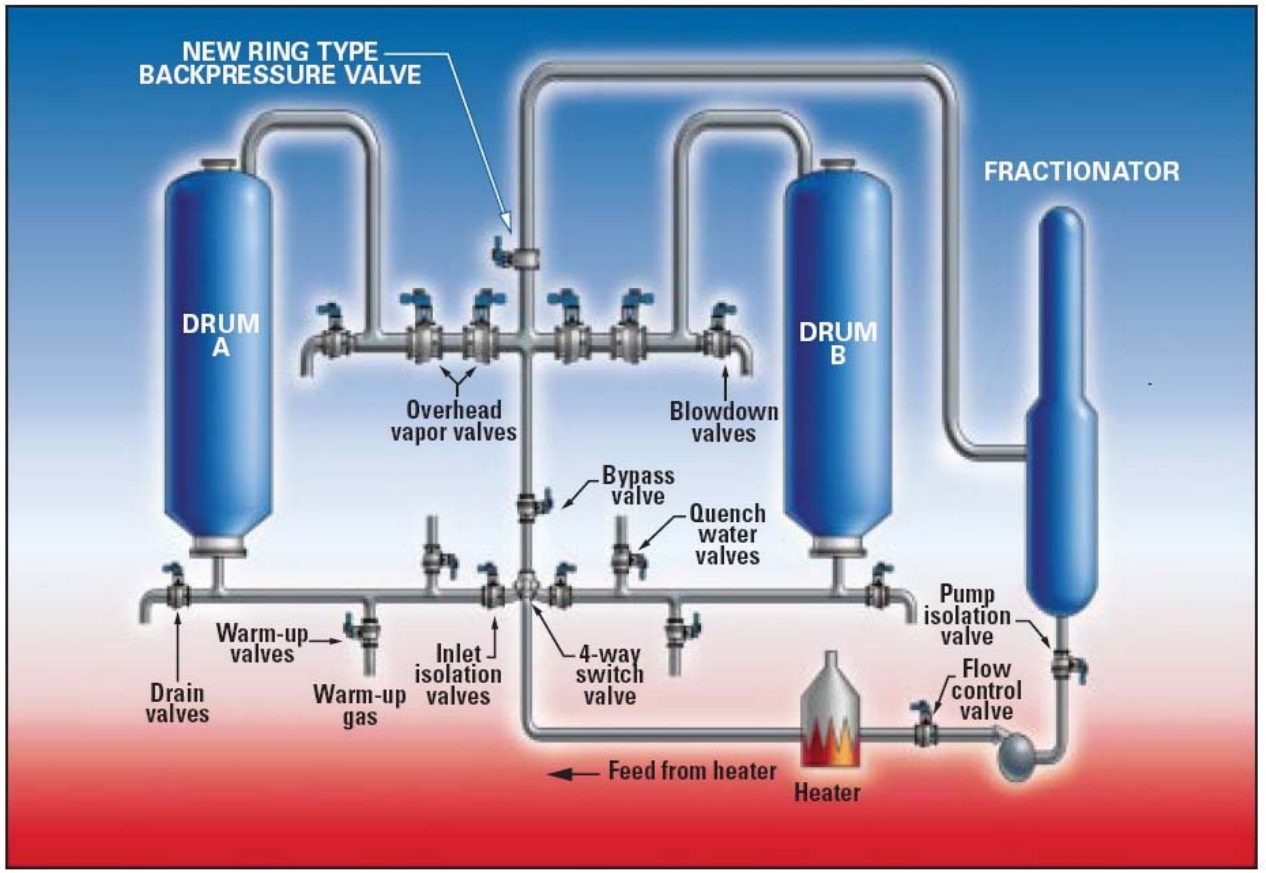
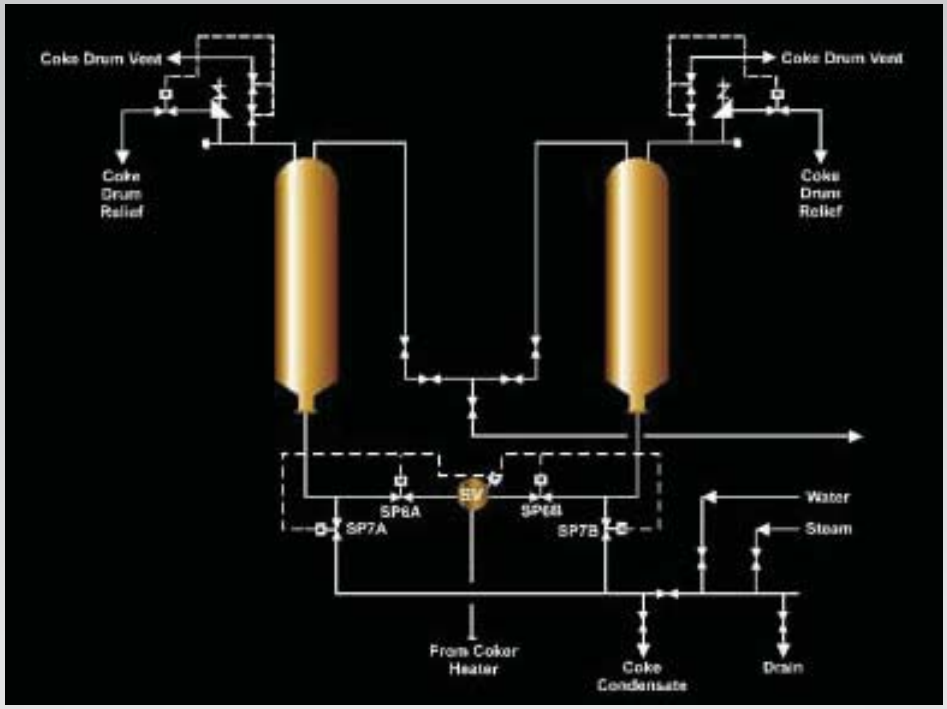


VELAN DELAYED COKER BALL VALVES



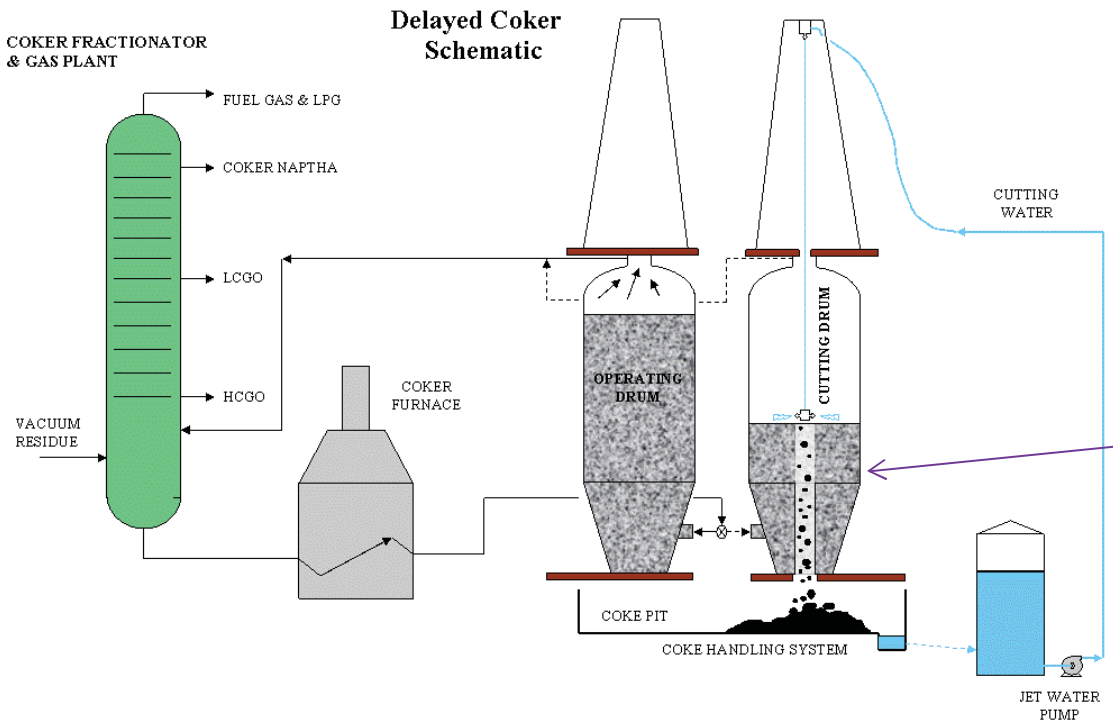
All full bore, ideal for process de-bottlenecking, can be fully interlocked for operating safety.

Interlocks



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

VII. Coke Drum Cutting, Coke Handling

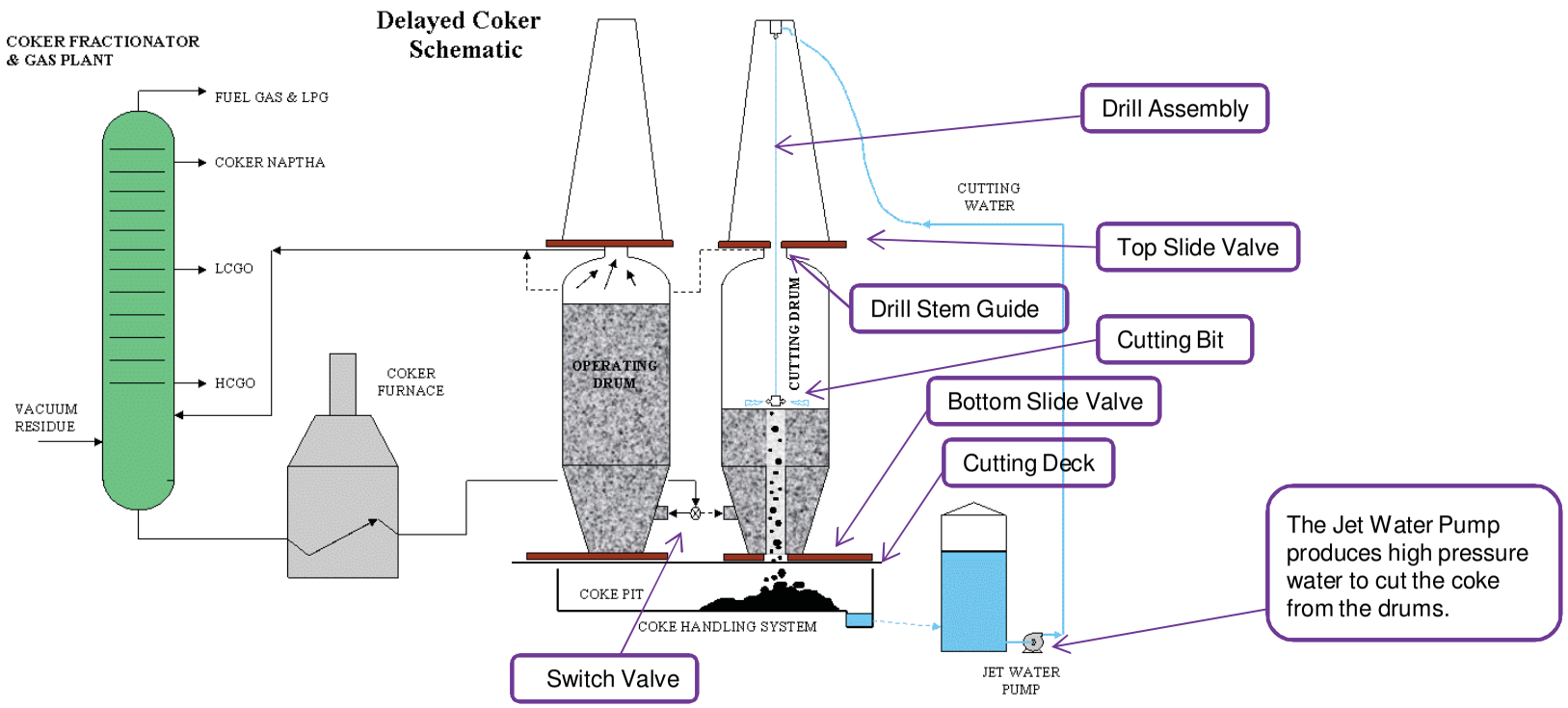


As the coke is 'cut' by the high pressure water nozzle, the coke and water flow onto a Coke Pad or into the Coke Pit, where the water is separated and recycled back to the cutting water system.

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

Additional schematics and images follow show various components of the system.

VII. Coke Drum Cutting



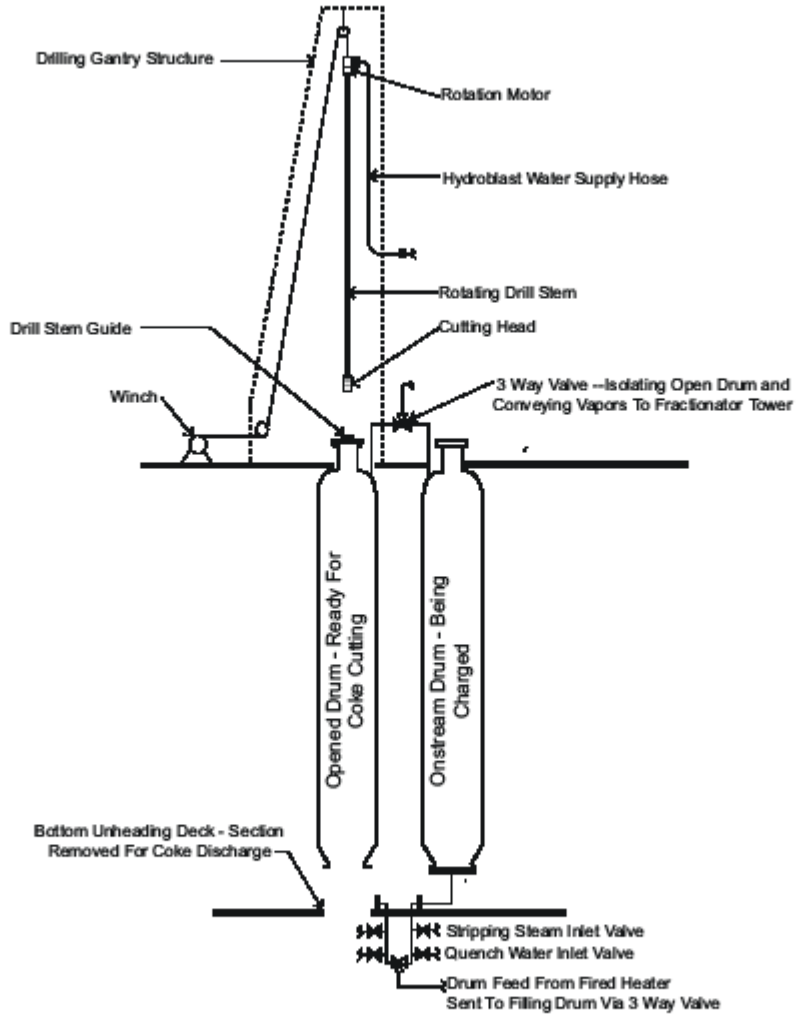


Figure 2 - Delayed Coker Unit

Coke Drums and Hydroblast Systems

FLOWSERVE AutoShift Cutting Tool

FLOWSERVE

AutoShift™ Combination Decoking Cutting Tool

Flowserve has pioneered many significant advancements in hydraulic decoking and has transformed it into an increasingly safe, efficient and automated process.

Revolutionizing Hydraulic Decoking

With more than 100 years of decoking experience through its Worthington, Pacific and IDP heritage brands, Flowserve is the undisputed global leader in hydraulic decoking systems. It has pioneered 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 operator from the cutting deck. Mode shifting is accomplished automatically and remotely by water pressurization and depressurization, not manually as with other tools. As such, there is no personnel exposure to the following dangers:

- High pressure water
- Hot spots or steam eruptions
- Hydrogen sulfide (H_2S) 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 times
- Improved efficiency
- Easier maintenance
- Shifting flexibility to free "stuck" tools
- Manual shift feature

Patented AutoShift Decoking Tool

Experience In Motion

FLOWSERVE

Hydraulic Decoking Made Safer

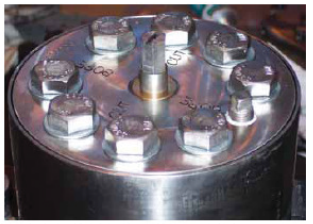
With the patented* AutoShift combination decoking cutting tool, hydraulic decoking is automated, simplified and, most importantly, safer.

Traditional combination cutting tools require extensive handling to manually shift cutting modes. First, a pilot hole must be bored downward from the top of the drum through the coke bed using downward oriented nozzles of the decoking tool. Then, the tool must be raised 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 nozzles. Finally, the tool must be rotated and moved vertically downward in the pilot hole, where the side-oriented nozzles cut the balance of the coke and flush it out the open bottom of the drum.

Removal of the cutting tool from the drum, to either change it out or to change its cutting mode, is a cumbersome and hazardous operation. Raising the tool out of the vessel can be very dangerous if the proper control system is not in place to terminate the fluid cutting pressure to the cutting tool.

The AutoShift combination decoking cutting tool eliminates these dangers and reduces cycle times by shifting modes automatically and remotely in the drum. Moreover, its ability to remotely shift operating modes means that operating personnel do not need to be on the cutting deck, risking exposure to hot gasses and mechanical hazards. The time savings positively impact the production capacity of the refinery by returning the decoked vessel to service quicker.

Decoking tool assembly with AutoShift



AutoShift cartridge with center manual shift extension

* U.S. Patent No. 6,644,567 and select international equivalents

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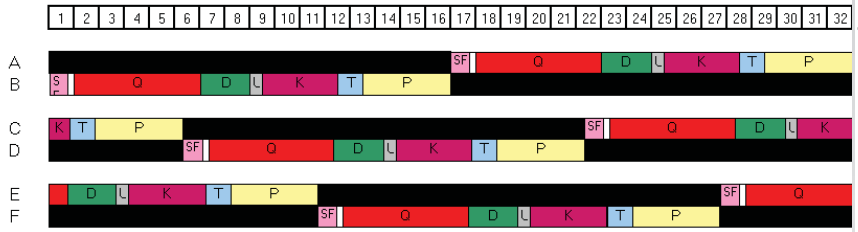
Coke Handling Crane

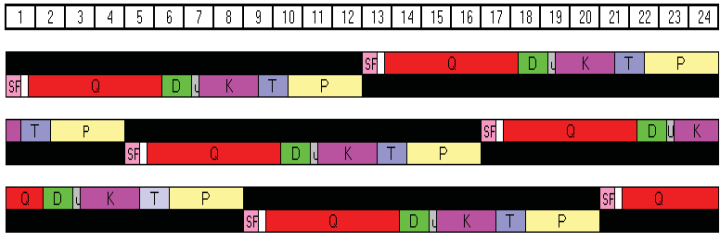
VIII. Coke Drum Cycle Time Comparison

COKE DRUM CYCLE
SIXTEEN HOUR COKING CYCLE



LEGEND	HOURS	ACTIVITY
	16	COKING
SF	0.75	STEAMOUT TO FRACTIONATOR
	0.25	STEAMOUT TO BLOWDOWN
Q	5	QUENCH AND FILL
D	2	DRAINING
U	1	UNHEADING
K	3	DECOKING
T	1	REHEADING AND TESTING
P	3.5	PREHEATING
	32	TOTAL

COKE DRUM CYCLE
TWELVE HOUR COKING CYCLE



LEGEND	HOURS	ACTIVITY
	12	COKING
SF	0.5	STEAMOUT TO FRACTIONATOR
	0.25	STEAMOUT TO BLOWDOWN
Q	4.5	QUENCH AND FILL
D	1	DRAINING
U	0.25	UNHEADING
K	2	DECOKING
T	1	REHEADING AND TESTING
P	2.5	PREHEATING
	24	TOTAL

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

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.

Tutorial: Delayed Coking Fundamentals, http://www.coking.com/DECOKTUT.pdf, by Paul J. Ellis and Christopher A. Paul of the Great Lakes Carbon Corporation. Presented at the 1998 AIChE Spring National Meeting in New Orleans, LA.

Delayed Coking, http://inside.mines.edu/~jjechura/Refining/06_Delayed_Coking.pdf, by Colorado School of Mines.

Petroleum Coke Petrography, http://mccoy.lib.siu.edu/projects/crelling2/atlas/PetroleumCoke/pettut.html, web page by Prof. John C. Crelling, Coal Research Center and Department of Geology, Southern Illinois University Carbondale.