Coking 101
An Introduction to Delayed Coking

Prepared By:

Jack Adams,
Adams Project Managers, Inc.
Email: APMI.Jack@Gmail.com
www.JLAdams.com

&

PROCESS
ENGINEERING ASSOCIATES, LLC
"Excellence in Applied Chemical Engineering"
Email: info@ProcessEngr.com
www.ProcessEngr.com
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 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 unloading skids or double flash towers, state-of-the-art coke drum mechanical design, and an innovative water management-recovery system. The process can handle a variety of feedstocks, such as petroleum derived residues, cracked materials, gas plant 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**
- Enhanced commercial and plant data base predictive tools
- API sludge disposal process
- Special coking heater design
- Online heater decoking
- Preferential coke oil bed and coke drum structure design
- Automated flange unloading system
- Advanced control system
- Environmentally advanced design
- Coke drum mechanical design
- Low recycle design

**Process Description**
Delayed coking is a semibatch process using alternating drums that are switched off-line for cleaning. Support facilities include staged blowdown, coke cutting and handling, and a water recovery system.

Hot residual oil is fed to the bottoms of the fractionator where it mixes with continued 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 periods, all steam and hydrocarbon vapors are directed to the blowdown systems where they are recovered. After the coke drum cooling cycle is complete, the coke is hydrodynamically cut from the drums and dropped into a pit on 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
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.
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 sidetracks 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.
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

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

- 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
Picture / Nozzle DeltaGuard
VELAN DELAYED COKER BALL VALVES

NEW RING TYPE BACKPRESSURE VALVE

DRUM A

Overhead vapor valves

Drain valves

Warm-up valves

Warm-up gas

Inlet isolation valves

4-way switch valve

Warm-up gas

Bypass valve

Quench water valves

Pump isolation valve

Flow control valve

DRUM B

Blowdown valves

Feed from heater

Heater

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

Adams Project Managers, Inc.
Interlocks

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

Adams Project Managers, Inc.
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

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
Revolutionizing Hydraulic Decoking

With more than 100 years of decoking experience through its Worthington, Pacific and GPI 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 eliminating the operator from the cutting deck. Manual shifting is accomplished automatically and remotely by water pressurization and engine rotation, normally or with other tools. In fact, there is no personnel exposure to the following dangers:

- High pressure water
- Hot spots or flame exposures
- Hydrogen sulfide (H2S) vapors
- Mechanical hazards

AutoShift Tool Benefits

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

- Improved operation safety
- Greater system automation
- Reduced cycle times
- Improved efficiency
- Lower maintenance
- Shifting flexibility in low "stick" tools
- Internal shift torquers

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 by manually shifting cutting tools. First, a pilot hole must be bored down through the top of the drum where the cutting tools are connected to the decoking tool. Then, the tool must be raised to the top of the drum where it is then reconnected to the operating motor for the combination decoking tools to charge to the required cutting pressure. Finally, the tool must be rotated and moved vertically down to the pit holes, where the decoking necessary for a successful operation begins. In the proper condition, it is not safe to maintain the full cutting pressure in this cutting tool.

The AutoShift combination decoking cutting tool eliminates these dangers and reduces cycle times by shifting remotely and autonomously to the drum. Moreover, its ability to remotely shift operating modes means that operating personnel do not need to be in the cutting deck, thereby exposing them to no gases and mechanical hazards. The time savings significantly impact the productivity capacity of the facility by eliminating the decoking-related turnover periods.

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

Experience in Motion

Adams Project Managers, Inc.
Coke Handling Crane
VIII. Coke Drum Cycle Time Comparison

COKE DRUM CYCLE
SIXTEEN HOUR COKING CYCLE

COKE DRUM CYCLE
TWELVE HOUR COKING CYCLE

LEGEND

HOURS      ACTIVITY

16         COKING
0.75       STEAMOUT TO FRACTIONATOR
0.25       STEAMOUT TO BLOWDOWN
5          QUENCH AND FILL
2          DRAINING
1          UNHEADING
3          DECOCKING
1          REHEADING AND TESTING
3.5        PREHEATING

32         TOTAL

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

