# Good operating techniques improve coker yield, increase gas-oil production

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Methods to reduce the production of low-valued sponge coke and increase the volume of hydrocracker and fluid catalytic cracker unit (FCCU) plant feeds are of high interest to refiners. Following are some ideas of the author and representatives of ten major refineries on the subject.

The observations were presented at an experience exchange last May in New Orleans.

**Coke drum temperature.** The hotter the coke drum, the harder the coke. Hard coke means low weight percent volatile combustible matter (VCM).

By keeping a coke drum hot, the 1,000° F. boiling range gas oil is vaporized out of the coke. Heavy gas oil left in the coke thermally degrades to gas, coke, and distillates, or even worse, stays in the coke in the form of VCM.

For every increase of 10° F., the production of heavy gas oil and distillate increases by 1.1 vol % on fresh feed. The proper place to monitor the coke-drum temperatures is in the coke-drum overhead vapor line, upstream of the vapor-line quench injection point.

The beneficial effects of raising the coke drum temperature are greatest at the end of the coking cycle. This is the reason for increasing the coking-heater outlet temperature by 5-10° F. the last 2 hr before switching.

**Steam-out to fractionator.** Using 4,000-5,000 lb/hr of coke-drum quench steam for an hour on a 20,000 b/sd coker, while the drum is still lined-up to the fractionator, may recover an extra 100 b/sd of distillates.

Operators who are abbreviating this "small-steam" step due to fractionator flooding problems or reduced cycles, often count on recovering the residual gas oil and distillates in the coke drum steam-out quench blowdown scrubber.

In practice, this is somewhat of an illusion. The recovered hydrocarbons are partially lost to atmospheric evaporation, or settle to the bottom of water-recovery ponds during the subsequent slop processing. Few coke-drum quench vapor-scrubbing systems operate nearly as efficiently in recovering distillates and gas oil as do coker fractionating towers.

Table 1

### Rules of thumb for delayed cokers

1. Each 8 psi reduction in coke drum pressure reduces coke yield on feed* by 1.0 wt %.
2. Each 8 psi reduction in coke drum pressure increases liquid yields by 1.3 vol % on feed.
3. Each 10° F. increase in coke drum vapor line temperature decreases coke yield by 0.8 % on feed.
4. Each 10° F. increase in coke drum vapor line temperature increases gas and distillate by 1.1 vol % on feed.
5. Each decrease of 1 wt % VCM requires an increase of [illegible] in coke drum vapor line temperature.
6. Reducing recycle by [illegible] on feed reduces coke yields by [illegible] on feed.
7. Reducing the virgin gas oil content of coker feed by 10% reduces coke yield by [illegible] on feed.
8. Reducing coke yield by 1.0 wt % on feed raises liquid yields by [illegible] vol % on feed.
9. Decreasing cycle time by 6 hr increases coke VCM by 1.0 wt %.

*The term feed refers to fresh resid.

Careful application of distributive computer control has been used to inhibit fractionator flooding and to control the flow of steam during the drum-quench period of the coking cycle. Unfortunately, the number of "not yet completed" computer control projects (none are ever aborted) exceeds the success stories.

**Light distillate recycle.** Employed as a method to enhance coke drum operation over 20 years ago, recycling kerosine and diesel boiling range coker distillate reduces both coke yield and the coke's VCM. For example, the operator of a unit processing 20,000 b/sd of resid, initiated a recycle of 2,500 b/sd of a light distillate and saw the coke make decline by several percent on feed.

**Steam injection.** Most refiners begin injection of steam to the full coke drum prior to completing the switch. Some start the steam flow before breaking down the Wilson-Synder valve.

One delayed coking operator, capacity permitting, uses steam injection to the coke drum during most of the coking cycle. The consequent reduction in the coke drum hydrocarbon partial pressure reportedly reduced coke make enough to pay for the steam consumed ten times over.

**Drum pressure reduction.** The oldest and best known method to minimize coke yield from a barrel of resid is to reduce the coke-drum pressure. Although the May meeting in New Orleans produced no uniformity of opinion on quantifying this (or any other) parameter, the average of the opinions was that:

*Each 8 psi reduction in drum pressure increased liquid yields by 1.3 vol % and cut coke yield by 1 wt % of fresh resid feed.*

It definately appears as if the significance of this correlation has not been related to the first line supervisors operating delayed cokers. Almost 50% of the delayed cokers visited by the author are routinely operating coke drums with partially plugged overhead vapor lines.

The coke-drum overhead vapor lines are cleaned only when the drum operating pressure is starting to approach the relief valve pop pressure. Only when coking capacity is bottlenecked by coke-drum back pressure are the overhead vapor lines "run" (i.e., cleaned with the air operating knockers, turbines, or by hydroblasting) to remove the layered coke deposits inside the vapor lines.

The experience of most operators is that vapor line coke deposits occur principally upstream of the vapor valves; that is, in the section of piping that can be cleaned during the cyclic switching of the coke drums. Some operators clean these overhead lines several times a month.

Often, the decoking crew employed in unheading a coke drum is assigned to "run" the overhead vapor lines during their idle time during the coke cutting portion of the drum cycle.

It is common to see the coke drum pressure drop by 5-8 psi after cleaning. Not only is this an inexpensive method to boost gas oil production, but by maintaining a low pressure

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difference between the coke drum and the fractionator, the tendency to "foamover" a drum during switching is greatly reduced.

**Recycle ratio.** Refiners who are charging heavy coker gas oil to an FCCU via a cat feed hydrotreater, typically reflux gas oil below the trap-out pan to control ASTM end-point (about 900° F.) and Conradson carbon (not more than 0.2%).

Both of these parameters are a function of the contacting efficiency, as well as the liquid rate across the wash trays.

There is a reasonable probability (although none of the attendees in New Orleans reported doing so) that installation of a structured-type packing wash section below the heavy gas oil trap-out pan would cut the internal reflux rate required to control gas-oil production Concarbon and endpoint. Such a reduction in reflux would, in turn, minimize the coking heater through-put ratio (TPR) where:

$$\text{TPR} = \frac{\text{Coking heater feed}}{\text{Fresh resid feed}}$$

Reducing TPR from 1.20 to 1.10 reduces coke production by approximately 1.2 wt % based on fresh resid feed.

Use of a structured-type packing is quite common in the wash sections of vacuum towers, cracking units, and visbreaker fractionators Certainly, structured packing has a substantially greater potential to enhance the contacting efficiency within a limited tower vertical space, than do valve trays, bubble cap trays splash baffles. or show decks

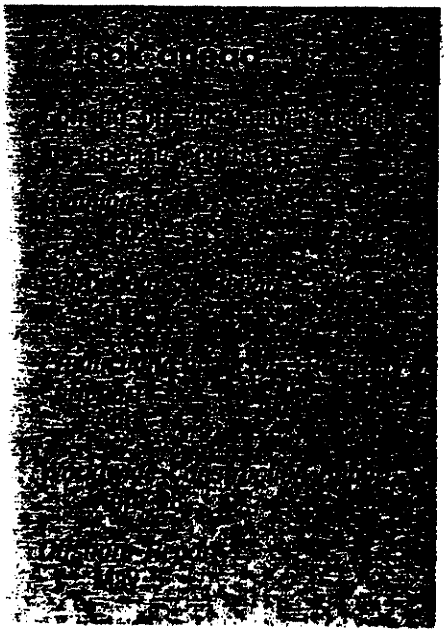
**Vacuum reduction.** Experiments have shown that reducing the volume of coker fresh feed by 10% through enhanced removal of heavy virgin gas oil in the upstream vacuum tower, will reduce sponge coke yield by 1.5 wt % on fresh resid coker feed. Although, this factor alone respresents big dollar savings, it is only the tip of the iceberg.

More importantly, the thermal degradation of the uncracked virgin gas oil as it passes through the hot coke drum reduces the "K" value, due to dehydration reactions, of the coker gas oil. As the "K" value of gas oil represents, to a great degree, its value as an FCCU feedstock, thermally degrading cat feed in a coker is a significant economic waste.

Several attendees at the New Orleans meeting had implemented, or initiated, projects to enhance vacuum reduction of resid by retrofitting their vacuum systems with ejectors mounted immediately downstream of their vacuum towers. These new ejectors were sized for several thousand pounds per hour of steam, which is designed to be injected in the vacuum heater coils as velocity steam. Use of steam in this manner suppresses temperature peaking in the vacuum heater tubes, as well as reducing the critical hydrocarbon partial pressure in the vacuum tower flash zone.

**Drum insulation.** There are a host of superficially extraneous factors which tend to be overlooked in minimizing coke yields. Some mentioned during the May meeting were:

- Deteriorated coke drum insulation—Water from the coke-cutting operation gets underneath the drum weatherproofing and degrades the insulation integrity. Not only is energy lost, but the cooler drums retain 1,000° F. gas oil in the green coke product.



- Tray flooding due to ammonia sulfide sublimation—High nitrogen content crude oils promote plugging of the tray decks at the top of the coker fractionator with ammonia salts. The trays then flood prematurely with a resulting increase of several psi in back pressure against the coke drum. Periodic, on-stream water washing corrects this problem. Residues produced from the heavy oil extracted from tar sands seem especially susceptible to this problem, possibly due to the nitrogen content of these residues.
- Overhead condenser fin fan external fouling—Coke fines and road dust accumulating around the outside of the cooling fins reduce air flow and heat transfer in the tube bundle. On one unit, this increased the vapor load to the wet gas compressor to such an extent that the compressor suction pressure rose to 8 psig from 3 psig.

The coke drum pressure also increased to 31 psig from 28 psig, with a concurrent and unnecessary escalation in coke yield. This situation was easily corrected by an external, on-stream water wash of the fin-fan tube bundle by the operating crew.

- Slop processing—Depending on how cold refinery slops are preheated and charged to the fractionator, they may induce excessive internal reflux, which in turn increases the TPR, resulting in increased coke and light gas make.

**Beware of shot coke.** The residues from crudes containing a high percentage of asphaltines will tend to form shot coke when processed in a delayed coker. It appears as if successful methods to reduce coke yields (with the probable exception of reduced pressure) will enhance the tendency to produce shot coke.

Minimizing the salt content and the exposure of hot coker feed to oxidation has been suggested as a method to partially inhibit the formation of shot coke. On one, six-drum coker, a clear trend was noticed favoring the formation of sponge coke on the lowest pressure pair of coke drums, while the pair of drums operating at an 8 psi higher pressure (due to a partially coked vapor line) was producing shot coke mixed with sponge coke.

Both sets of drums were charged from a common feed drum with comparable vapor line temperatures.

Table 1 summarizes a few rules-of-thumb for predicting the effect on coking yields of various parameters. While directionally correct, the actual quantitative relationships tabulated should be used with care. •

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