The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Cracking oil is not a funny business

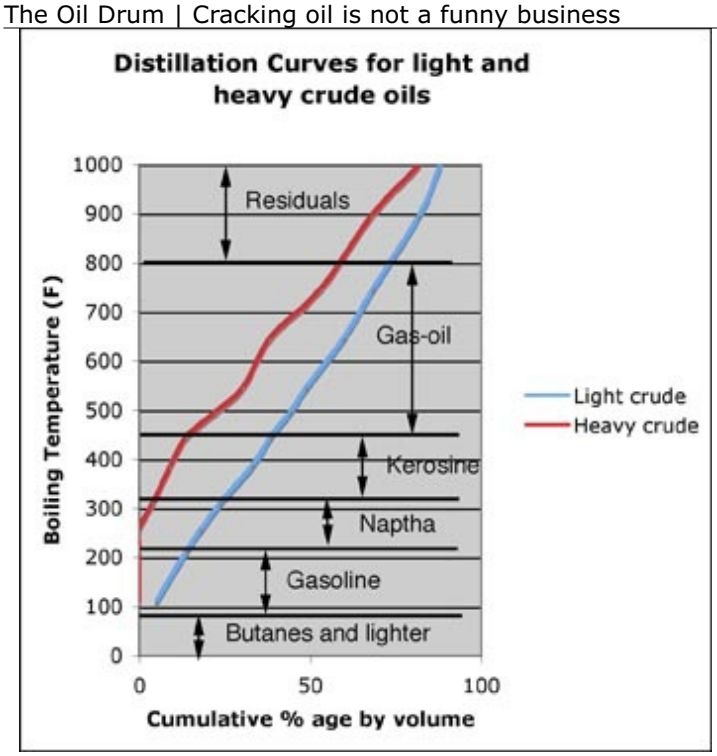
Posted by Heading Out on March 26, 2006 - 1:54pm
Topic: Supply/Production
Tags: cat cracking, crude oil, refineries, tech talk [list all tags]

A couple of weeks ago I pointed out that the crude oil that comes out of the ground is not made up of a single hydrocarbon, but rather is a mix of different hydrocarbons that have to be separated. And oils from different parts of the world are formed as different combinations of these. Today I would like to go a little further and talk about distillation curves, and because the world supply is changing to heavier crudes then go on to explain a little bit about cracking.

For those new to the site this is where, on weekends, I often post a small technical talk, explaining some of the aspects of the fossil fuel business, so as to help understanding of some of the topics on the site. There are now two main topic themes developed, those relating to oil, and those to coal. Since this talk relates to oil, at the end I will post the list of topics that relate. It is a very simple explanation, because of space, and those who wish to ask or expound a bit more are invited to do so through the comments.

When you first get a sample of a new oil, then you will gradually heat it to known temperature levels, generally following a standard method. As the sample is heated, the lighter fractions boil off, and by plotting the volumes emitted within known temperature ranges, a basic sense of the make-up of that particular oil can be achieved.

For example, of one looks at the blue line in the following graph, this shows a typical light oil composition, and might well yield, on passing through the first distillation column of a refinery, the sort of separation that I showed in the plot last time.



However, as folks are pointed out, we are seeing less of these light oils on the market, and increasingly we must use heavier crudes. To make the point consider the red line in the same graph.

You can see that there is no fraction boiled off until the temperature has passed 250 deg. Which means that, in its untreated state, there is no natural gasoline in the oil. Likely it was too close to the surface and those fractions evaporated away over the millennia (as is the case with the heavy oils in Alberta for eg, though this example is from somewhere else). So how do we change this mix into something more useful?

The answer, not only for this crude, but also for the heavier fractions of the light crude, since in both cases we would like to end up with about 45% gasoline, requires that we crack (or split) the higher carbon molecules into lighter or lower carbon ones. For example say we have a molecule of Cetane (16 carbon & 34 hydrogen atoms or C16H34) if we heat this to a high enough temperature, then we can break it down into some Octane (C8H18), some Hexane (C6H12) and some Ethylene (C2H4). But, obviously, what we would like to do is to control what it is that we break these heavier molecules into, and how much of each we produce.

And so we get into the world of Cracking Oil. After the crude oil has been separated into the different fractions, the gas-oil fraction is then fed to a second heating process, where the fluid is brought back up to a high temperature (perhaps around 735 deg C 1400 deg F) and mixed with a finely powdered catalyst (hence the "cat"). Steam is also added to help with the movement of the mix, and the combined mix is fed up a pipe (called a riser) into a tank and as it flows up and into the tank the gas-oil breaks down into the lower carbon molecules. This happens very quickly, so that by the time the mix is in the tank, the heavy molecules have broken down, and so can be drawn off. However the catalyst has first to be removed, which happens by passing the flow through cyclones that spins the flow and separates the heavy catalyst, which is collected and fed down a pipe back to be reclaimed and re-used. It needs to be processed since, in part, the process is not perfect and carbon will be deposited on the particles of catalyst, blocking its action. (It can be burned off - providing some of the heat for the process). The catalyst can then be re-used. One operation might use the catalyst at a flow rate of some 55 tons/minute.

The hydrocarbons that flow out of the cracking process are then separated into different fractions, depending on the season more gasoline or distillate might be desired, but the process might yield about 8% coke, 55% gasoline, and 12% light gas oil with about 10% of the flow being a sufficiently heavy product that it is sent back to be run through the process again. Light gas oil becomes diesel and furnace fuel oil. The lighter gas products are usually sent to alkylation or reforming where the lighter molecules can be combined to give products that can be blended into gasoline. (I got this wrong in last week's post).

Different crudes have different mixes of hydrocarbons, and will need different sizes of processing sections that convert these different fractions to usable and desirable products. Refineries havee been built to usually handle only a given range of crudes, and thus have to be considerably modified if that mix should change. Sometimes the crude can be even heavier, the sands in Alberta contain an oil which is more conventionally called a bitumen, since it has less volatile material that the heavy oil example I used. That oil must therefore go through an additional step to produce the lighter synthetic oil that can then be distilled and cracked more conventionally. Some of the new processes involved in mining and processing the ore are described in a pdf file by Herron. There are also contaminants such as sulfur which can be found in the oil. If the content is higher than 2.5% then the oil is called "sour"; this sulfur must be removed, and while at one time it was used as fuel in the refinery that has been stopped and now it is recovered. That also requires a treatment circuit that must be installed if the mix to the refinery changes.

There is a pdf from BAH here that explains the impact that some of these changes in supply may have.

This is part of an ongoing weekend series on technical aspects of oilwell (and natural gas) drilling. Previous posts can be found at::
the drill

using mud

the derrick

the casing

pressure control

completing the well

flow to the well

working with carbonates

spacing your well

directional drilling 1

directional drilling 2

types of offshore drilling rigs

coalbed methane

workover rigs

Hydrofracing a well

well logging

seismic surveying

gravimetric surveying

carbon dioxide EOR

refinery distillation

As ever, if this is not clear, or if there is disagreement then please feel free to post, and I will try and respond.