Issue 18
Issue 17
Issue 16
Issue 15
Archives

RSS
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# Refinery of the Future

## BP is forging ahead with a host of new technologies aimed at providing improved performance and maximum value from its worldwide refining operations, as *Malcolm Brown* learns

Some crude oils, like Arabian grades, have a relatively stable composition. Their makeup scarcely changes from one year to the next. Others, such as Russian crudes, especially those which are blends of oils from different fields, are very variable. Their composition can change from cargo to cargo. The name may be the same, but the stuff in the barrel may vary enormously.

That can leave refiners with a big headache since the composition of what goes into the refinery has a large bearing on the products that come out at the other end. Secondly, crude oils often have impacts on the fabric of the refinery itself. For instance, acidic crudes can cause corrosion. Factors like these explain why refiners conduct assays. An assay is a detailed analysis that results in a 'fingerprint' of the oil.

But assaying is a complex and time consuming business, which normally takes several weeks to complete. BP buys more than $50 billion of feedstocks a year, but can only complete about 60 assays over the same period. So purchasing decisions are often made on the basis of historical data. That may be fine where Arabian grades are concerned, but is not good enough when the company is dealing with crudes whose composition is less stable. Refiners can be left with cargoes of uncertain provenance.

'We have little recourse if what we buy isn't what we thought it would be,' says Tim Shooter, manager of BP's Refinery of the Future (RotF) programme.

RotF is a five year technology-based project aimed at making BP one of the very best refiners in the business. One of the many things it is trying to do is resolve the assay dilemma by using advanced technologies to provide almost 'instant assays'. That, at least, is the ultimate objective.

**The Refinery of the Future programme is applying new technologies to get maximum performance from BP refining operations**

The RotF programme started at the end of 2003. By the time it is completed in 2008-9, it is expected to improve BP's gross margin from the company's refining business by several hundred millions of dollars per year. The goal is to develop tools that will help refiners understand how feedstocks will behave in the refinery before they are purchased or processed, as well as help refiners maximise value and reduce maintenance risks while the feedstocks are subsequently being processed.

The programme consists of five main themes. The first is *immediate feedstock valuation*, which is about being able to

understand the qualities of a crude oil very quickly so that it can be valued appropriately. The second theme, *processing high margin feedstocks with confidence*, looks at how BP can more rigorously assess the potential impact of contaminants, like metals or acidity, in crudes. Again the objective is to correctly value the feedstocks and plan the management of the crude processing.

*Next generation logistics*, the third theme, concentrates on the physical infrastructure of refineries – the jetties and the tank farms where crudes, intermediates and products are held. Capacity for storage and product handling is always in high demand and crucial to optimising the business. *Next generation logistics* aims to ensure that this infrastructure is flexible and adaptable enough to take advantage of whatever opportunities the market throws up.

The fourth theme, *refinery wide optimisation*, involves building sophisticated process models to run the whole refinery – not just individual component parts – in the most efficient way to maximise the value of its products. The fifth and final theme, *remote plant monitoring*, is about devising clever and cost effective ways of monitoring refinery equipment, both to spot problems as quickly as possible – even to predict them before they happen – and generally just make things run more efficiently.

## Growing confidence

Shooter says that the 'holy grail' of crude evaluation, which is the centrepiece of *immediate feedstock valuation*, would be to assay every single cargo and to make the results available immediately across the company. His experts believe that crude oil analysis could ultimately be reduced from six weeks to 30 seconds. That would be to make assaying an astonishing 100,000 times faster than it is now. Even if they don't achieve this, the RotF team is certain that in aiming for it they will hugely improve assay performance.

**Click the link below to view a panel on *immediate feedstock valuation***

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Mike Hodges, who leads the *immediate feedstock valuation* team, says that they have already developed a portable micro technology-based device, about the size of an electric toaster, that can rapidly tell the operator what the yield structure of a crude oil is – that is, how much gasoline, diesel and kerosene it will produce.

Other intelligent devices that might be incorporated in the future would be able to determine the asphaltene content of crudes - the bitumen-like portion of the oil, which has few uses other than road surfacing – or tell refiners what type of sulphur their cargoes contain. Sulphur emissions are implicated in air pollution. Some sulphurs are easy to remove, others are difficult.

'At the moment, we only measure density and sulphur in each cargo,' says Hodges. 'It does not indicate how easy or difficult the sulphur is to remove. By inserting that extra bit of knowledge on how difficult it is, the information we gain can feed forward into the processing of the crude. It also feeds forward into the valuation, because more processing means greater cost, lower processing means less cost.'

The second theme of the RotF programme, *processing high margin feedstocks with confidence*, is something that will become increasingly important for refiners as the hydrocarbon resource industry matures further. The easier-to-extract and better quality crudes, which have higher values, have in the main been recovered first, so the remaining feedstocks around the world are becoming poorer in quality or contain an increasing number of contaminants. Acid crudes, which are corrosive to the metallurgy in refineries, are increasingly common. The aim of the team dealing with *processing high margin feedstocks with confidence* is to

**Click the link below to view a panel on *processing high margin feedstocks with confidence***

find ways of assessing the impact of contaminants in a more rigorous way than in the past.

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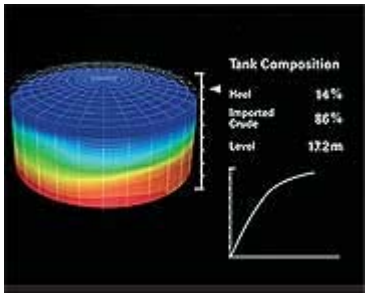
A key element in that will be risk-based modelling, which involves quantifying the potential effects of the contaminants in crude. BP is developing computer-based models which can account for these effects and is factoring the risks into the prices its traders are prepared to pay for crudes. It is about better understanding what is in the crudes so that, for example, one can predict corrosion and mitigate it.

One aspect of refining that is sometimes overlooked are the logistics assets, for example the locations where crudes are offloaded from sea-going tankers and pumped into holding tanks to await processing. *Next generation logistics* is about having a very flexible logistics infrastructure so that you never have to turn a cargo away. 'The worst imaginable situation is having the ability to process a crude but not being able to get it into the system because of problems or lack of capacity at jetties or in the tank farm,' says Shooter.

'We need to be able to determine quickly the physical line-ups currently in place – that is, the liquids route between the tanks, which is changed to handle different products by using a network of valves. We also need to know the inventory capacity, which changes from day to day and must take account of different tank sizes, as we move the contents around to accommodate new cargoes arriving while keeping different products separate without contamination. Optimising the inventory is about understanding all of this and knowing what the demand for the outgoing products will be.'

*Next generation logistics* is not about completely re-designing things for the next refinery BP might be building, says Joachim Voelkening, leader of the *Next generation logistics* team. 'It is not about new infrastructure on a greenfield site. It's based on the existing assets we have, what we can do with the existing hardware. Some of the projects we're currently executing are focused on improving the flexibility or the capabilities of the hardware – the tank farms, pipelines, jetties and blending facilities. Others focus on developing new tools to control the hardware, like optimisation models with better software.'

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## Bigger picture

Refineries are clearly very complex operating plants, consisting of many separate but interlinked processes. Refiners are familiar with using control systems and process simulations to run individual units in the refinery. The *refinery wide optimisation* initiative within RotF broadens that, to examine how the entire refinery, rather than just its component parts, can be run optimally, says Linda Murphy, leader of *refinery wide optimisation*.

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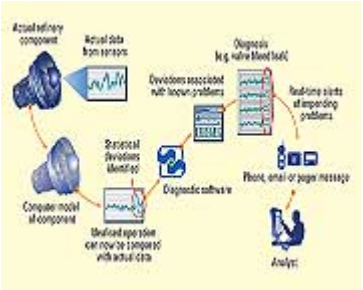
'We are developing a sophisticated full-refinery model that includes detailed models of each refining unit and can be applied to improve the optimisation of the refinery far better than the current tools that we have.'

A start has been made at BP's Kwinana refinery in Western Australia. 'Kwinana developed refinery-wide modelling in-house and has had good, measurable success with it,' adds Murphy. 'We've captured that technology and are working to improve it before rolling it out throughout the refining sector.'

The final theme, *remote plant monitoring* is primarily about getting access to and using data that historically have not been available to refiners, often because obtaining the data was not cost effective. For example, most equipment failures can be predicted if enough measurements are collected and monitored, with techniques to trigger alerts if certain combinations of parameter

values occur. Until now, adding instruments to make such measurements – say the temperatures in the pre-heat train where crudes are heated up before going into a separator – has been disproportionately expensive.

Now new technologies are being developed which can make measurements at a fraction of the cost, for example 'motes' (*Frontiers*, April 2004).

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'Motes are simple wireless sensing devices – they don't need to be directly wired into other control systems around the plant, making them very attractive,' says Zaid Rawi, project leader for *remote plant monitoring*.

'It is now possible to obtain data where previously it was too expensive, especially in retrofit situations on older plants. The sort of information gathered in this way may not necessarily be important for controlling the plant day-to-day, but can be very useful in helping to detect potential problems. For example, a heat exchanger often has a few key operating parameters monitored, but not enough to be able to compute its heat transfer coefficient. So on an older plant you're missing information to work out if the heat exchanger is fouling up or not. If you can attach these relatively cheap mote sensors around the plant, suddenly you are able to monitor all the key variables you need to keep a much closer eye on that heat exchanger and give you early warning of problems.'

The sorts of data collected by motes and other information gathering technology can be turned into something really useful by what is called 'predictive analytics', adds Rawi. 'This involves first principles computer models or empirical models running side by side with the plant to let you compare the two and see if there are any differences in the actual behaviour of the plant from how it should be performing.'

Some of the technologies involved in the RotF programme, like the portable assaying tools that may be developed, are, or will be, very high-tech. Others, like motes, can be relatively simple but still very effective. It is the combination of them all, and the application of innovative thinking, that will ultimately determine just how far gross margin improvement can be pushed. But, whatever the bottom-line improvement, the RotF project will change forever the way BP refines crude oils from around the world.

'The intent, ultimately,' concludes Shooter, 'is to understand in much greater detail the physical attributes of the hydrocarbons we are handling in our refineries, and the impact of those hydrocarbons as they are processed. That way BP will ensure it is maximising the value from converting crude oil into finished products.'



back to top