Reforming reformate octane measurement

Jim Kelly, ABB Bomem, Canada, describes the benefits of turnkey reformate octane analysis.

Catalytic reforming continues to have a significant impact on refinery profitability as it is still the key source of much of the high octane blendstock and hydrogen produced in the refining industry. Despite ever tightening legislation governing the aromatics content of gasoline, emphasis on catalytic reforming is likely to increase as demand grows substantially for hydrogen used in the production of low sulfur fuels.

Depending on the specific refinery configuration, regional legislation or seasonal demand, the operator will be required to optimise the reforming unit in many different ways. These operating targets may include limiting aromatics content of gasoline, increasing hydrogen production, increasing reformate yield or increasing aromatics production for petrochemical use. In addition, each unit has its own equipment limitations, leading to a unique optimisation scenario for the individual refinery. Despite the presence of unique local demands and constraints, the universally recognised primary control variable in reforming operations is reformate research octane number (RON). RON characterises unit severity and impacts on a whole range of other unit parameters that include product yield patterns, reactor temperatures, catalyst deactivation and product composition.

Traditional approaches to severity control

Reforming units provide significant advanced control opportunities because of the high value attached to reformate octane and hydrogen, expensive operating costs and complex multivariable process interactions. The primary control loop, in almost all cases, maximises feed throughput while honouring the minimum octane target to maximise octane-barrels for the unit. This is achieved while maintaining heater, coking rate and hydraulic constraints to obtain the maximum unit profitability. Severity control is provided by feedback from a measured or inferred octane, that in turn adjusts the weighted average inlet temperatures (WAIT).

Conventional RON measurement

Reformate RON is therefore a key measurement in any catalytic reformer control scheme and is usually obtained by one of the following methods:

- Inferred models: an online RON model can be constructed as a function of operating variables that can include feedrate, operating temperatures and feed PONA analysis. The RON model is usually updated online, based upon periodic lab analysis of the reformate itself.
- Lab analysis: in the absence of inferred online property models, many unit operators carry out offline sampling and analysis for RON measurement. This usually involves analysing routine or test run reformate samples on the octane engine of the refinery laboratory.
- Traditional online NIR analysers: in the early 1990s, refiners started to implement near infrared (NIR) analysers on catalytic reformers for rapid online RON measurement. This technology promised to solve many of the problems associated with traditional laboratory engine analyses. The improvement in analytical speed and data quality would allow improved control, leading to tighter approaches to operating targets. In addition, the technique was capable of multi-stream and multi-property application.

However, for the catalytic reformer operator, there are a number of problems associated with these conventional methods of RON measurement.

What are the issues?

- Inferred-octane models: inferred models commonly require large data sets to describe the operating range of the process and properties of interest. This data collection is time-consuming and, even after implementation, the model may require frequent maintenance and intervention to adapt the training set to current operating scenarios. In addition, laboratory octane engine analysis is still necessary, as the model requires periodic updates using real lab data.
- Laboratory octane engine analysis: RON measurement via laboratory engine analysis can be imprecise and too slow for optimum control when sampling time and the test itself are taken into account. Also, the analysis is only carried out once or twice a day, which is too infrequent for optimum control purposes. Making process decisions on the basis of engine results is therefore difficult for the process engineer, since precise, timely information is seldom available.
- Traditional online NIR-octane analysers: many NIR implementations on catalytic reformers have failed to deliver pre-project expectations and benefits for a number of reasons. Similar to the problems associated with inferred property models, the traditional NIR analyser requires a large number of local calibration samples, to allow refinery-specific prediction models to be built before the system can be implemented. Furthermore, the analyser commonly requires frequent model updates to allow the current operating envelope to be calibrated into the original prediction database. Lastly, after hardware maintenance, many spectrometers require re-calibration as instrument responses have changed and the...
original calibration set is not immediately applicable after service intervention.

**How can the operator of a catalytic reforming unit obtain fast, precise RON measurement and avoid the problems highlighted above?**

The CatReformir from ABB Bomem is a proven solution to the traditional difficulties associated with reformate RON measurement. It is the only NIR analyser providing turnkey reformate RON measurement to the refining industry. More detail is provided in the opposite panel.

**What other reformate properties can be measured?**

The turnkey RON capability can be supplemented by other valuable reformate quality parameters. The real time availability of benzene and aromatics content allows the operator to modify unit operation to meet either legislated fuel quality or petrochemical product targets. Knowledge of reformate RVP permits stabiliser column control.

The universal turnkey RON model is supplemented by ABB Bomem Starter Models, which contain extensive sample databases for MON, aromatics, RVP, and benzene. For specific refinery use, the starter models only require fine-tuning using local client supplied reference data. 10 samples provide adequate local reformate characteristics to create complete models for these other properties.

**What other streams can be characterised?**

Reformer feed

The influence of feed composition on catalytic reforming operations is significant. Refiner feed quality varies for many reasons:

- Ever changing crude feeds impact straight run naphtha quality.
- Imported 'opportunity' naphthas are processed from varying sources.
- Naphthas from cracking or coking processes vary due to processing changes, and their impact is significant even at low feeds.
- Cut points within naphtha splitters vary as the overall reform-
ing/isom complex is optimised.

Feed naphthas are commonly defined by hydrocarbon family (P,N,A) and distillation characteristics. The distillation characteristics are important as light feeds result in higher reactor temperatures, shorter run lengths and more benzene in the product. Higher end points usually result in accelerated catalyst coking while naphthenic feeds give much higher yield than paraffinic feeds.

The operator can optimise the significant effects of feed quality changes by adding feed analysis capability to the base CatReform product. This includes additional sampling capability for the process analyser and models for paraffins, naphthenes, aromatics and distillation characteristics of reformer feed. The analysis of both reformer feed and product can be achieved on one instrument with each stream available on a two minute cycle.

Isomerate
Many refiners process full range naphtha in a combined reforming/isomerisation complex. The operations of these two units are closely tied and optimisation is usually carried out considering both units as part of a single operating complex. By adjusting naphtha fractionation, the refiner can increase overall throughput of the complex and increase reformate or hydrogen yields. The maximum octane-barrels can be achieved by an overall optimisation approach to the naphtha complex. These different operating scenarios are ideally implemented by rapid online characterisation of reformate and isomerate.

The operator can optimise the overall naphtha complex by adding isomerate analysis capability to the base CatReform product. This includes additional sampling capability for the process analyser and models for RON and MON. ABB Bomem has an extensive sample database for RON and MON of isomerate. The models are close to being universal and only require fine tuning locally with approximately 10 samples. The analyses of both reformate and isomerate can be achieved on one instrument with each stream available on a two minute cycle.

What are the benefits?
Real time, turnkey RON analysis allows the operator of a Catalytic Reformer to:

- Maximise octane-barrels by optimum real time severity control.
- Optimise run lengths of semi-regenerative units by tighter severity control.
- Minimise RON variation and reduce operating costs by tighter WAIT control.
- Reach optimum Tₚ₀ faster with rapid RON measurement.
- Manage feed supply interruptions affecting severity.
- Maintain product RON throughout the coking cycle.
- Evaluate catalyst performance at vendor test conditions.
- Track product quality during bed changeovers for cyclic reformers.
- Optimise hydrogen production by tight severity control.
- Track product quality during contaminant breakthroughs and process upsets.
- Provide feed-forward reformate octane data to the refinery blender.
- Optimise reformer/isomer complex to maximise profitability.
- Optmise product quality during varying seasonal demands.
- Optimise product quality during crude swings and opportunity feed processing.
- Maximise overall refinery octane barrels for multiple reformer operation.
- Optimise the petrochemical/refinery interface for chemical feedstock reformers.

Catalytic reforming continues to have a significant impact on refinery profitability despite ever tightening legislation governing the aromatics content of gasoline. Real time, turnkey RON measurement can significantly assist the operator in meeting the production and legislative demands placed upon the catalytic reformer in this complex operating environment.
The only NIR analyzer providing turnkey reformate RON measurement.

Introducing ABB Bomem’s CatReform\textsuperscript{ir}: the hassle-free solution you simply plug in and turn on.
Reformate RON measurement is important in any catalytic reforming operation. The problem is that conventional methods have limitations. Problem solved.

ABB Bomem’s CatReform\textsuperscript{ir} provides fast, accurate on-line reformate RON measurement – without the need for local calibration. Validated with 6,000 reformate samples collected across multiple refineries, CatReform\textsuperscript{ir} is the only NIR analyzer that can offer a hassle-free, turnkey approach. CatReform\textsuperscript{ir} is the proven solution with the versatility to extend measurement properties to include MON, aromatics, RVP, benzene and more, including other streams such as reformer feed and isomerate.

With the predominant NIR technology position in the global petroleum refining market, ABB Bomem has already installed over 160 projects in partnership with many of the world’s pre-eminent refiners. Optimize your catalytic reforming operations with CatReform\textsuperscript{ir} and turn conventional problems into turnkey solutions.