Data operations transform fuels value

A refiner applied advanced analytics to develop techniques for processing opportunity crudes which minimise negative effects on the plant

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The petroleum industry is once again in the midst of titanic changes.[1] Declining prices, expanding sources of supply, rising regulatory requirements and, perhaps most importantly of all, a dramatic shift in markets like transportation are forcing companies across the value chain to reconsider long held assumptions about expansion, growth and customer demand.

Luckily, these new challenges are coinciding with advances in big data, Internet of Things (IoT) and predictive analytics and the ability to leverage to process opportunity crudes and be more proactive and predictive in decision making. While the upstream oil industry has been a somewhat enthusiastic adopter of digital technology, the midstream and downstream segments have been conservative and slow to adopt. That is changing with the Industrial Internet of Things (IIoT), advanced analytics and big data. Collectively, we are inundated with marketing messages that are adding confusion and false promises, resulting in a good number of projects that go awry with limited or no business value and, worse, lost opportunity costs.

But we will also see implementations that will effectively serve as a blueprint because they will demonstrate how digital technology can reduce risks and costs while improving asset utilisation, yields, integrity and, most importantly, profitability.

In fact, we already have such an example. MOL, based in Hungary, has been on a journey to reinvent its operations by better leveraging operational data already being generated by its distributed control systems (DCS) and other systems as part of its operations. In 2012, MOL leadership, in response to European competition resulting in low cracked spreads, embarked on a business transformation enabled by digital technologies.

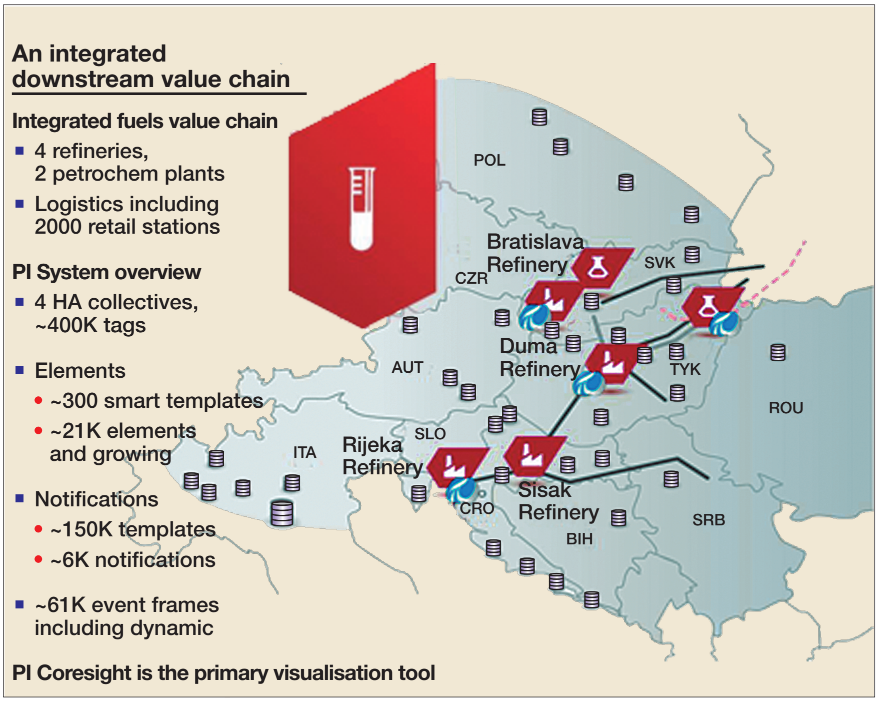

Figure 1 MOL's downstream operations and operational technology infrastructure

The results? MOL has developed techniques for processing opportunity crudes while minimising the negative consequences such as corrosion, operational issues in areas such as the cokers, and yields. Advanced corrosion analytics such as high temperature hydrogen attach (HTHA) and other forms of predictive corrosion have been implemented across multiple sites. In all, MOL estimates it increased earnings before interest, tax, depreciation and amortisation (EBITDA) by $1 billion over a five year period ending in 2016 through more aggressive data modelling and analytics.

Petroleum Economist named MOL Downstream Company of the Year in 2016[2] while the FieldComm Group gave the company its Plant of the Year Award for its Danube facility.

Background

MOL is one of Central Europe's largest downstream companies. It operates four refineries and two petrochemical plants in eight countries along with 2000 filling stations across 13 countries. To organise data across its production facilities, MOL has been using the PI System from OSIsoft since 1998. The system, which has expanded steadily,

MOL downstream OT data model based applications

Safety (PSM) and asset integrity
- Interlock governance/DCS role tracking
- Operating envelopes
- Integrity operating windows (IOWs)
- Advanced alarm management

Yields
- Crude blending control
- Yield optimisation/reporting
- Product quality
- Analyser reliability

Energy
- Energy monitoring management
- Energy KPI breakdown (6 tiers)
- Column energy efficiency dashboards
- Hydrogen, utilities and energy balances
- Flaring

Operational optimisation
- Plan vs actual analytics with future data
- NG and fuel demand gas forecasting
- Peak electrical forecasting
- Normal mode of control loops
- APC monitoring
- PI AF and Sigmafine (PI AF) used for yield accounting and material movement

CBM asset reliability
- All critical rotating equipment
- Hydrogen pressure swing absorbers

Figure 2 MOL's downstream OT data model-based applications

is divided into four high availability collectives with a combined total of approximately 400 000 'tags' or data points. More importantly, MOL utilises PI Asset framework with smart asset objects to provide a configurable, dynamic smart operational technology (OT) infrastructure. Currently, MOL has over 300 smart asset object templates 300 templates, 21 000 elements, and over 61 000 event frames for signalling the occurrence of key parameters or events (see **Figure 1**). Tibor Komroczki, who leads the Information Integration and Automation team at MOL, refers to the PI System as the MOL common language as it enables the abstraction and nomination of a diverse tag and asset naming, units of measure, and time zones. MOL generates over 80 billion data points per year.

The PI System served primarily as an operations system of record until 2010 when Komroczki led an effort for digital transformation. As a first step, MOL adopted PI Asset Framework to create a so-called 'digital twin' of different processes and equipment sets in a facility. With PI Asset Framework, all of the relevant data streams, meta data, calculations and analytics, and alerts and notifications from a process step are combined into a comprehensive, digital replica of the plant. Additionally at this time, it adopted PI Coresight, a visualisation tool for displaying and/or analysing AF models. Taken together – the smart OT infrastructure with PI Asset Framework, and PI Coresight – MOL had built a self-serve analytics and business intelligence environment where operators and engineers who traditionally used Microsoft Excel can configure their own smart asset objects, combine them like Lego blocks and create their own digital replica and experiment with potential improvements, and then execute changes across the MOL enterprise with governance.

Challenge
critical availability problems

- Hydrogen Production Plants (HPPs) are critical units in the refinery
- Pressure-swing absorbers (PSAs) are critical equipment in unit operation
- Cyclic operation: heavy load on valves (9-10 open-close hourly)
- $1.2M loss in three years due to PSA valve failures

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- UPTIME program: 97% operational availability

Figure 3 Advanced analytics can predict the impact and ripple effects of opportunity crudes

With the smart OT infrastructure in place, MOL established a foundation for higher level efficiencies because it could connect its assets relatively easily and track its performance backwards and forwards. New applications can be added rapidly. Komroczki asserts that greater control over data has enabled MOL to move from managing in a reactive sense to predictive management to management by exception as indicated by the existence of over 61 000 event frames.

Some of the achievements include improved asset integrity and safety, asset health, improved energy efficiency, increased yield, reduced hydrocarbon loss, improved environmental reporting, and reduced maintenance costs (see **Figure 2**). Another plus: MOL reduced its IT costs and reliance on outside vendors because employees were able to quickly build their own functionality on top of their infrastructure and then replicate it across foundries and, in doing so, simplifying and standardising its application and solutions portfolio. Different data streams can also be analysed in tandem so that MOL could determine the full impact (financial, maintenance, energy consumption) on changes to output.

MOL employed analytics to reduce the risk of high temperature hydrogen attacks (HTHA). By studying the relevant operational data, the company was able to pinpoint the temperature and pressure parameters that increased the risk of HTHA. They developed a smart asset HTHA application template that was deployed in six units in less than a week. Following the successful test, it was rolled out across MOL's plants in 2015 to over 50 pipe nodes.

Advanced analytics potentially can be applied in a wide variety of ways: energy modelling optimisation; the impact and ripple effects of opportunity crudes in areas of corrosion, fouling, and efficiencies; the economic gains to be achieved through opportunity crude processing; better understanding of advanced control; and preventative and prescriptive maintenance (see **Figure 3**).

Machine learning

Once MOL had the smart OT infrastructure across its value chain with associated IIoT analytics, focus was turned to machine learning and "big data analytics". MOL has become one of the first, if not the first, large refiner to adopt Microsoft Azure machine learning in a production environment (see **Figure 4**). Microsoft Azure works in conjunction with the PI System: operational data is uploaded to the cloud and then analysed across Microsoft's cloud infrastructure.

MOL has developed Azure machine learning to predict the impact of sulphur levels in variable feedstocks in their various desulphurisation units. MOL had been using offline models for analysing sulphur. Not only did using offline models increase time, it also increased the potential for error. MOL estimated it was losing $600 000 per year across four units because of its inability to adjust unit parameters to optimise sulphur content in the products. MOL eliminated the losses thanks to better forecasting and continues to roll out the technology across its infrastructure. As with its other improvements, MOL was able to leverage its previous technology investments: the new application layered on top of what it had already implemented.

Following these successes, MOL turned to improving the performance of its delayed coking units. By using opportunity crudes, MOL estimated that it could gain $6 million for each 1% gain in DCU yield. Gains in DCU yields with variable feed from opportunity crudes, however, also increased the risk of steam explosions during the hydrocutting step.

Azure analytics combined with continual data feeds from the PI System enabled MOL to thread the needle. DCU yields were increased by 2%, yielding an estimated gain of $12 for each unit per year. At the same time, steam explosions went down by 75%. Machine learning enabled the ability to achieve two seemingly contradictory goals at the same time. The company has now positioned machine learning for its four DCU units across its enterprise to take full advantage of opportunity crudes.

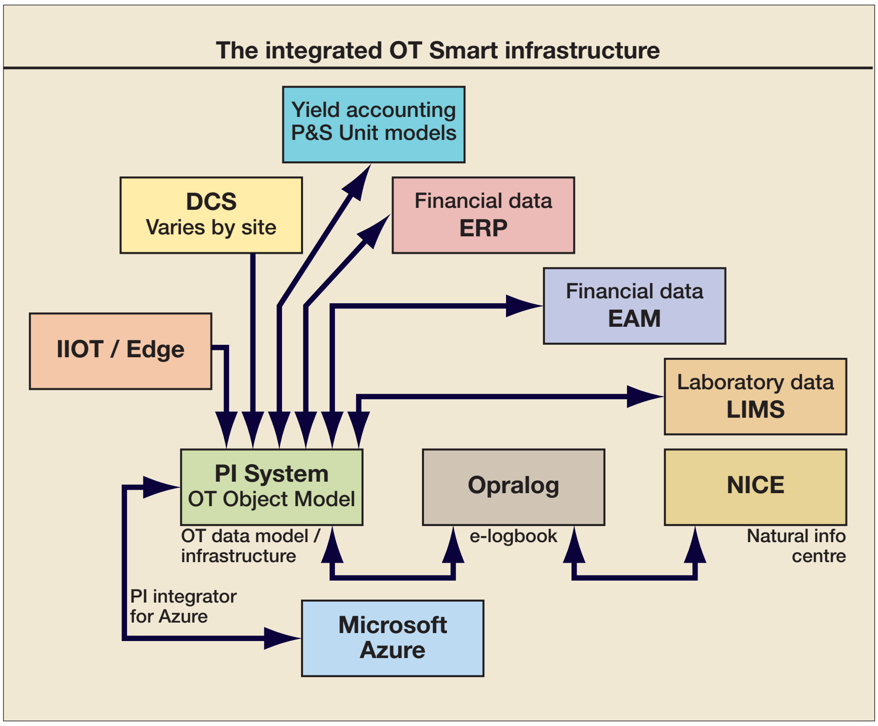

Figure 4 MOL adopted Microsoft Azure machine learning for a production environment

On-premise vs cloud? No: on-premise plus cloud

While data gets transferred and stored in the cloud with machine learning analytics, cloud systems typically will not replace on-premise storage systems. Real-time control and insight are required for operational efficiency as well as safety. Transferring data to the cloud invariably increases latency: data simply has to move far further before it can be used. It also increases risk because a disruption in the network can lead directly to disruptions in operations costing millions in downtime. (Anyone who has worked with offshore upstream companies is likely familiar with the risks of satellite links.)

Instead, these systems complement each other. Companies are opting to maintain on-premise systems and transfer data, or summaries of data, on an as-needed basis, preferably during hours of low network traffic.

A substantial part of the success revolved around the use of integrators that effectively automate the translation process of bringing OT data to IT-based analytics systems. Using a CAST (clean, augment, shape, transmit) methodology, MOL was able to avoid the data prep and 'data janitor' problem that can take up to 80% of the time of projects. Other companies in similar heavy industries have experienced similar results: Cemex, the large cement manufacturer, has reduced the amount of time required for preparing and gathering data across 70 plants for its reports from over 700 hours to less than one through CAST automation.

The financial bottom line

One of the more compelling features of MOL's transformation, and likely a phenomenon others will experience, is that the changes are additive. Once the foundation for digital transformation is in place, additional applications can be added on top of the now existing digital infrastructure. As a result, incremental improvements can accelerate savings, rather than result in ever shrinking marginal gains.

Over the four year period running from 2011 and 2014, for instance, MOL estimates that its digital transformation programme accounted for an additional $500 million in EBITDA. During the next two years, however, MOL added an additional $500 million to EBITDA, bringing the total over five years to $1 billion. An equivalent amount of savings was achieved in roughly half the time.

While the curve may change over time, one can expect that savings will compound. Each new improvement potentially will cost less than the ones that went before it because MOL can leverage all of the previous advances. Improvements made in the first year should also continue to grow as additional data is continually fed back into the system to achieve Kaizen-style gains.

Next steps

MOL continues to mine for ways to apply analytics to its business. In 2017, it wants to increase white product yield by 2.5% through increased conversion and more efficient crude processing. To increase its buffer against market swings, it will additionally improve the diesel to mogas ratio from 2.4 to 2.8. Flare gas recovery and hydrocarbon loss management initiatives, tracked through continuous improvements to monitoring and tracking systems, are under way.

Lessons learned

What did MOL and other leading companies do differently in applying IIoT? There are five lessons:

1. Do not forget that it is about delivering business value and not applying IIoT and advanced analytics for technology's sake. MOL has seen technology as a means to an end, not the other way around.
2. Start the journey by creating a foundation for data. By creating a digital infrastructure MOL gave itself a scalable, coherent infrastructure. It created both a virtual model of its plant through AF and a means to implement and measure those results in reality. The infrastructure approach also made it far easier to develop new functionalities because the same basic foundation could be used for multiple functionalities.

In the end, MOL created what one could call an 'OT chart of accounts' where all OT data gets aggregated across a portfolio similar to the financial or 'IT chart of accounts' which structure has been mandated by regulations.

3. Just do it. It is a journey of continuous improvement. Search for improvements that can be implemented now and add others as time goes on. Separating problems can allow plant managers to resolve individual problems more quickly as well as document progress for upper management.
4. Determine where analytics are performed. Calculations such as exchanger and pump efficiencies, energy utilisation, and yields or advanced CBM can and should be done in the OT infrastructure closer to the assets. Performing OT analytics in the OT data infrastructure will also enable the migration of analytics to the edge over time. Meanwhile, more extensive analytics that might require thousands of servers and multiple data streams are better suited for the cloud. One way to think of the difference is that analytics for individual plants or processes are best conducted in OT while enterprise-wide analytics are most suited for the cloud.
5. Bridge OT and IT through Automation. This can be accelerated by the use of an integration layer that CASTs operational data so that it can be consumed in unstructured IT systems. These data integrators effectively automate data preparation and translation.

IIoT, advanced analytics and big data are here and growing, make no mistake. They will dramatically transform our largest and oldest industries. If you approach their implementation and use strategically with the approach presented above, you will increase the probability of value sustainable attainment from your IIoT, advanced analytics, and big data initiatives.

References

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