Refinery operations gain from advances in digital automation

Advances in digital automation can better enable the next generation of refinery workers to operate more efficiently, reliably and safely

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A significant number of experienced refinery personnel will retire in the next decade. With new personnel being younger and less experienced than those they are replacing, will refineries continue to operate safely, reliably and efficiently? The short answer is: "Yes, by utilising the recent advances in automation such as smart devices and accompanying embedded human centre designed systems." The younger generations are more conditioned to current digital technology, embracing all of the real-time, online information and capabilities available from these smart instruments and systems. Smart devices replace the "ear of a seasoned field operator or technician". With information about asset health and performance more readily available, refiners can achieve safer and more reliable operations than previously experienced. Asset health information can be used by maintenance for long-term condition-based maintenance on an as-needed basis, and operations can be alerted only on short-term imminent failure or abnormal operation.

The simplest analogy to represent technology advances is to look at the cellular phone. In the late 1980s, "The Brick" phone was available for about $4000. The main and only function was to make a phone call. Today, there is the Apple iPhone and other similar smart phones that are a fraction of the cost of a Brick, but with much more functionality beyond making phone calls, including many real-time applications. Many refiners still have DCS systems from the late 1980s and 1990s operating their plants. These systems are robust and control the process, but without additional features (no "apps"). Today's modern systems include additional features not found in legacy systems, such as embedded advanced process control, statistical monitoring, smart device monitoring, asset health monitoring and more. Like the iPhone, the console operator is presented with more analysed information to make better and more informed decisions, with time to take corrective action. If the console operator continues to use the modern system in exactly the same way as the older replaced system, the benefit of additional functionality and information is lost (like people using an iPhone only for the phone call capability).

Refiners' challenges

The challenge of getting skilled and experienced resources to replace seasoned personnel who are retiring is not limited just to the refining industry. Many industries are facing the same challenge with a noticeable gap in the availability of experienced staff. There are also fewer people wanting to enter the refining industry. This combination has led to changes in the way refiners operate to ensure reliable and safe operations.

In the past, a single train refinery had about 20 000 I/Os, whereas today that same refinery design can have 50 000 I/Os. This means there are greater challenges for older, well-established facilities in the US and Europe when competing with newer, modern assets in the Middle and Far East. The

refining industry is faced with both competition and opportunity from the globalisation of fuels and petrochemicals distribution across regions and countries. For example, when demand is down in one region, opportunities arise to find consumers in other markets where production and distribution costs make this economically attractive. Basically, this means that modern refiners with lower operating costs can look for additional opportunity markets beyond their own regional markets.

This leads to the need to control costs. Most people consider gasoline, diesel and other fuel products as commodities, making it difficult to extract premium pricing and additional margins from a differentiated product. The reality is that additional margins come from operating the refinery more efficiently and more reliably than other refiners.

While there are niche market opportunities to extract higher margins, overall the refining industry is a commodity market where an individual refinery has limited control over raw material costs and finished product values. Refinery net margins have historically averaged below $2/bbl. Refiners have a significant investment in fixed assets, which are expensive to maintain and subject to on-going environmental, health and safety regulations. These realities give rise to an industry focused on cost reduction without jeopardising plant reliability or safety. Top quartile refiners with high availability also tend to operate more safely.

For the refinery operator, safety and environmental compliance are at the top of every refiner's list of important concerns. Safety and environmental programmes represent a large, on-going cost to the refinery, and incidents can be extremely expensive. With hundreds of employees, many hazardous areas, and with the presence of explosive, carcinogenic and poisonous materials, refiners are extremely interested in systems that can provide early warning of pending failures and prevent unsafe or environmentally unfriendly conditions.

Unplanned shutdowns incur costs beyond lost production. Emergency shutdowns and subsequent startups put abnormal wear-and-tear demands on equipment, increase catalyst and chemical losses, produce off-spec products and require additional manpower, overtime and expedited 24-hour service. Just one unplanned shutdown in a major FCC unit can cost a large refinery over $1 million per day. Similar costs can be incurred by shutdowns in any of the refinery's key process units. Based on the *Marsh Report*, a majority of severe incidents occur during startup and shutdown (transition) and piping:

"Losses in the refinery industry have continued to increase over the last few years and the causes highlight the ageing facilities in this category. A significant number of larger losses (over $10 000 000) have been caused by piping failures or piping leaks, leading to fires and/or explosions. Several large losses due to piping failures were due to corrosion issues or using the wrong metallurgy. ...Incidents occurring during startup or shutdown continue to cause significant dollar losses." *Marsh Report - The 100 Largest Losses 1972-2001, Large Property Damage Losses in the Hydrocarbon-Chemical Industries*.

Utilising advances from digital automation

Operations and engineering personnel represent a large fixed-cost component in a refinery's operating budget. Any opportunity to improve the efficiency and effectiveness of refinery staff can be translated into economic benefits by increasing the value of the activities they perform. Timely information that helps identify sub-optimal process control on critical loops is the key to augmenting the performance of operations and engineering. Modern systems with statistical monitoring can report on control loops with high variability or excessive alarms. What used to go unnoticed in the past is now front and centre to get attention.

Easy availability of process and historical data through the continuous historian, integrated with Microsoft Office and Internet access tools, saves engineers' and managers' time and effort. Troubleshooting operating problems can be completed quickly, and more timely decisions can be made that save the company money. Internet tools allow specialists located anywhere in the world access to plant data and displays, to aid in problem solving and analysis. Key

performance indicators, equipment alerts, status information and quality data are available in real-time for display and alerting the appropriate personnel of impending problems before they happen. These tools allow refineries to accomplish more with less by maximising their entire staff's productivity.

In addition, modern systems with simulation capabilities allow frequent training on infrequent events like startup, shutdown and emergency situations. This ensures operators are familiar with the required actions to take should an emergency situation occur. This also helps familiarise new employees with operations prior to taking on a live role in the refinery.

Utilising modern digital automation can address the challenges and opportunities for cost reduction. For example, field instruments that are equipped with smart diagnostics can alert key maintenance, operations or safety personnel about asset problems in real-time before they fail or cause abnormal operation. The key benefit is time to act on the information since the asset health information detects problems long before the process sees the effects. The diagnostics can identify the root cause of the troubled asset, so maintenance can effectively correct the problem. In addition, this same root cause predictive diagnostic capability can be utilised to identify and plan for a smarter turnaround by repairing only the assets requiring work.

Efficient use of maintenance resources, both for on-going maintenance and turnarounds, is an area that can often be improved through the use of modern technologies. Process and control equipment deteriorates over time and eventually needs attention. Heat exchangers, compressors and turbines foul over time, becoming less efficient and increasing production costs. Without maintenance, instruments tend to drift, control valves wear and process dynamics change, decreasing the overall effectiveness of the control system. The question of when to pull a piece of equipment for repair is a complex issue that should be based on its performance history, the operation performance cost of degradation, the cost of repair and the risk and consequence of a failure. In a cost-cutting environment, the appeal of delaying maintenance activities must be weighed against the increased risk of unplanned shutdowns and the cost of operating below peak equipment performance.

Maintenance costs can be reduced by improving the efficiency of the maintenance staff, reducing the frequency of unplanned shutdowns and reducing unnecessary maintenance work. Studies have shown that more than 60% of a typical instrument technician's trips to the field result in either no action or a minor configuration adjustment that could be done from their office with smart instruments (see Figure 1).

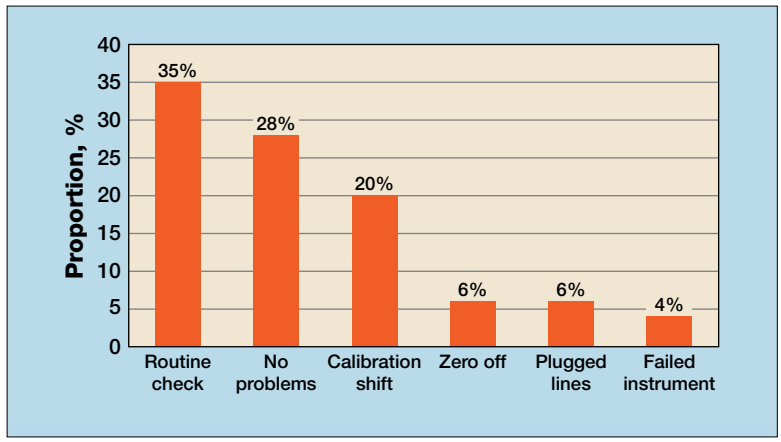

Figure 1 Advanced process control optimises distillation columns, enabling significant energy savings

Refiner feedback estimated a manpower saving of 1.6 hours per instrument, per year, by automating instrumentation work practices and reducing trips to the field. For a large refinery with over 10 000 process inputs, a digital solution could save 16 000 hours per year, for instrument and valve maintenance. This provides the opportunity to create a predictive maintenance culture that acts on alerts and root cause information in real-time, rather than reactive. At the 2010 NPRA Reliability and Maintenance Conference, a Gulf Coast refiner indicated that reactive maintenance cost their facility 50% more than planned maintenance. Their focus was to reduce the number of incidences of reactive maintenance.

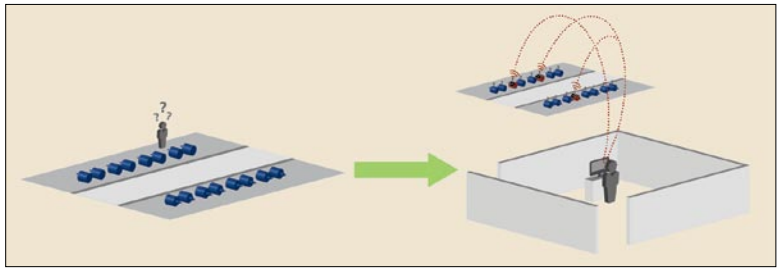

Figure 2 Online monitoring tools help prevent unplanned shutdowns and reduce time-consuming operator rounds

Embedded APC

In the 1990s, many refiners took advantage of advanced process control (APC). However, APC tended to be expensive and complex to set up, understand and maintain. The end result was many refiners turned off APC within two years of implementation.

Advanced control is still a desired functionality for refiners because it helps address energy cost savings by improving the efficiency of fired heaters and boilers (supply) and distillations columns (demand). While turned on, it also has the added benefit of consistent, high-performance operation across operating shifts, no matter who the console operator is.

Reducing process variability directly impacts a refinery's bottom line in terms of energy efficiency, capacity and quality. Modern digital automation can automatically identify high variability in key control loops to ensure visibility to both operators and operations engineers. Properly tuned and performing control loops can extend catalyst life and improve yield and quality, which directly benefit the bottom-line revenues.

APC applications reduce energy costs by further stabilising the process and pushing closer to actual equipment constraints and quality specifications. Modern, embedded APC applications are built with these standard tools that allow fast execution so distillation columns can be operated at minimum reflux, compressor recycles lowered, heater excess air reduced, catalyst losses minimised, heat recovery maximised and so on, all impacting the total energy consumed by the refinery. Using APC technology, refiners can be assured that the control system only utilises the right amount of energy needed to economically recover the most valuable products.

Manual checked measurements

As was mentioned early in this article, older refinery designs had a limited I/O count, only that which was required to operate the refinery safely. However, many process and asset health measurements that are not online are captured through manual measurements on a daily, weekly, monthly or longer period of time basis, depending on the expected mean time between failures. Only those assets deemed critical enough to have online monitoring provided continuous information to operations and/or maintenance.

Manual measurements do not always prevent asset failure and they can also create a potential safety hazard. Some examples where additional danger is introduced are:

- Manually dipping a tank to confirm the level
- Collecting pump data from a pump within an alkylation unit
- Taking temperature measurements on the crude unit preheat exchanger train
- Climbing ladders while holding onto a clipboard.

On the example of the crude unit heat exchangers, many bundles have empty thermowells in between tube bundles. For someone to manually check the temperature, they would need to get on a ladder and take the measurement around hot exchangers. Many people also use a heat gun, but this can create errors in the data collected, potentially leading to incorrect decisions, such as to pull and clean for the upcoming turnaround.

One recent solution has been the use of wireless to capture missing process and asset health measurements. On average, a refiner has hundreds of process pumps with only about 10% monitoring online. The remaining pumps are checked manually, typically once per month. This has been found to be insufficient in preventing pump failures and the potential safety and environmental incident associated with unscheduled shutdowns. For example, one refiner sends a technician out each morning to look for problems; a better approach would be to have the information available in the morning that identified the pumps requiring attention and

then to send maintenance to service them. Wireless asset health measurements enable planned maintenance that results in higher reliability.

Online vibration monitoring determines whether a pump or motor needs maintenance. These tools have demonstrated how modern maintenance tools and methodologies can be used in a predictive manner to save both time and money during a turnaround without sacrificing reliability or safety.

Online monitoring tools and automatic alerts can help prevent unplanned shutdowns and their associated costs (see Figure 2). Certainly, not all of the causes of unplanned shutdowns can be addressed by process control and automation systems, but faulty measurements, malfunctioning instruments, operator error and equipment failure are some of the common problems that smart field devices address. The online monitoring tools provide the opportunity for a refiner to create a more predictive maintenance culture that acts on information in real-time to prevent shutdowns or safety incidents, rather than the traditional reactive or preventive maintenance culture.

Conclusion

Advances in digital automation can augment the next generation of refinery staff to operate more efficiently, reliably and safely. The younger generations are more conditioned to current digital technology, thus embracing all of the real-time, online information and capabilities from smart instruments and modern systems. Additional measurements, and the benefit of time to act on the early detection of wear or abnormal operation, are the keys to ensuring refineries can operate even better than they did in the past.

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