How Today's Technology Can Help Improve Crude Unit Operation

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The reliability and operating flexibility of a refinery's crude unit has a material impact on the profitability of the entire refinery given its importance to the overall process by distributing intermediate streams as feedstock to the downstream "workhorse" conversion units that create higher-value products. Many refinery managers and operations personnel just want the crude unit to run and not cause trouble. However, it can be the source of increased energy usage, reduced productivity, lower intermediate product quality, high maintenance costs, and increased safety risks.

This is true because crude units are often among the most neglected parts of any refinery – with all the infrastructure issues of aging facilities. Today, nearly every crude unit faces major operating challenges of energy inefficiency, poor unit utilization, and asset unreliability as well as safety, health, and environmental issues.

Unexpected pump failures, accelerated coking on fired heater tubes, overhead column vapor not condensing, and unreliable measurement of high viscosity fluids are among everyday occurrences. Energy issues are often related to heat exchanger tube fouling and poor heat transfer efficiency, inability to optimize fired heaters, and inadequate temperature measurements needed to optimize crude unit operation.

The good news is that improvement is possible. In the words of one official of a large U.S. refinery, "Selective application of advanced technology can help a crude unit overcome built-in deficiencies and actually improve its performance to the point of becoming an industry top tier benchmark."

The "advanced technology" refers to Emerson's PlantWeb™ digital automation architecture and DeltaV™ digital control system, which are designed to take full advantage of digital communications protocols such as FOUNDATION™ fieldbus, HART®, DeviceNet™, and AS-i Bus. Besides the improvements in accuracy and long-term stability, modern microprocessor-based field instruments provide vastly more information about their status and condition than the simple process measurements of older instrumentation. These technologies enable more efficient operations, decreasing costs, and increasing profit levels.

Emerson calls this the Smart Refinery – a place where personnel are better informed about process performance, faulty field assets, and the root causes of existing or imminent problems. In the Smart Refinery, console operators receive information relating to critical control applications, maintenance technicians are made aware of impending maintenance needs, and the safety engineer is notified of Safety Instrumented System (SIS) issues.

Effective crude unit operations depend on achieving excellence in the areas of energy efficiency, day-after-day reliability, asset utilization, and safety. Each of these can be improved by implementing modern technologies that are often lacking in older units.

Modernization

The crude unit can be eliminated as a sore spot for the refinery and made a star performer by modernizing control systems and adopting digital field architecture. Investments in technology enable efficiency, reducing the impact of crude unit disruptions on the downstream refinery operations. Existing facilities can start small and gain experience through upgrade programs at a measured pace with benefits from early installations paying for the later stages.

Replace older legacy control systems. Modern automation technology is faster, more powerful, and with features that enable information management beyond the simple process variable, setpoint, and output. Embedded advanced process control (APC) tools are easy to use and maintain, require no additional hardware or software, and can shorten implementation schedules dramatically.

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Digital automation architecture gives refiners the ability to safely operate closer to process and equipment constraints without violating them, while monitoring the condition of many assets in real-time. Information from this smart technology helps personnel address the long-standing uncertainty as to whether observed problems are the result of instrument degradation or indeed are process problems.

For refineries with frequent crude oil switching, disturbances in crude unit operations often propagate into bigger issues downstream. It only makes sense to diminish such disturbances at their source to achieve effective and reliable operations throughout the refinery.

Managing the change from one incoming crude to another requires a regulatory control layer with the dynamic performance necessary to respond quickly and precisely to setpoint changes. Yet, the importance of the regulatory control layer is often overlooked in older systems. For example, energy consumption and material balance must be re-established following a switch to bring the intermediate products within specifications. Advanced process controls shift the burden of managing crude switching from the operator to a fractionator optimization package that minimizes the chance for human error, hastens the transition time, and mitigates crude unit disruption during switching.

It's also important to effectively use the levels in crude unit process vessels as a disturbance buffer. This may require a shift in thinking for operators to allow intermediate levels to fluctuate from 25 to 75 percent full and not try to maintain a given setpoint such as 50 percent. If disturbances are absorbed in the crude unit, the intermediate feedstocks can be processed more effectively in downstream units.

Install digital instrumentation to improve asset reliability and utilization of crude unit production equipment. Smart field devices produce a great deal of useful information that is easily accessed and stored by advanced asset management software. With the availability of near real-time information on the condition of measurement instruments, final control elements, and other assets, refiners can predict when these assets will require attention and fix them before the process is adversely affected. In addition, unnecessary maintenance is avoided on those assets that do not need immediate work. This predictive maintenance strategy keeps the unit operating and minimizes spurious process tripping. As a result, unscheduled slowdowns and shutdowns are reduced or eliminated, and the unit operates reliably within safe limits, thereby improving profitability.

Not all changes require large capital investments to get fast and long-lasting returns. For example, adding missing measurement points to aid optimization, adding "smart", microprocessor-based instruments for asset health information, and advanced process control can be implemented on key operating parameters at minimal expense to produce a significant ROI in a short time.

Benefits of Today's Technology

Without question, the application of advanced technologies can improve the performance of most crude units in today's refineries with respect to energy efficiency, reliability, utilization, and safety.

Energy Efficiency

Significant energy savings can be achieved by reducing the amount of excess combustion air to the crude and vacuum heaters. The challenge is to minimize excess combustion air while maintaining a sufficient air supply for full, safe combustion. If combustion air is not sufficient, after-burning can take place in the upper parts of the heater, resulting in higher temperatures than designed for that section. This can damage the heater tubes, tube supports, and firebox structure. In extreme cases, the fuel mixture in the firebox can become explosive.

Measurements of oxygen and carbon monoxide/combustibles from the flue gas composition analyzers located in the radiant section of the heater firebox indicate when there is enough combustion air for safe operations. Smart analyzers with health monitoring capabilities support console operator confidence in the accuracy of flue gas measurements. As a result, fuel-to-air ratios can be optimized safely by trimming costly excess combustion air to the heater.

Advanced process controls can be employed to optimize the heater operation for maximum energy efficiency. Modern digital process control systems with embedded APC functionality allow for faster implementation, easier maintenance, and greater uptime than traditional methods of implementing APC.

Optimum energy efficiency typically requires more measurements than provided for in the design of most crude units. For example, temperature measurements around each heat exchanger bundle are often acquired manually only when preparing for an upcoming turnaround to determine which exchangers need to be cleaned. Today's wireless technology makes it easy and cost effective to add measurement points to obtain the missing measurements needed to monitor heat exchanger performance.

Another important area for consideration is the transfer of heat from hot downstream products to preheat incoming crude, because heat exchanger tube fouling negatively impacts the effectiveness of the heat transfer. A ten percent decrease in heat transfer efficiency in the preheat exchanger train will require a commensurate increase of energy for the crude heater. Further reductions in crude preheat exchanger performance will cause the crude heater to reach its firing limit, making it necessary to reduce the throughput of crude oil.

SmartProcess™ heater optimization combines advanced regulatory and combustion control modules to operate at maximum efficiency within a safe operating envelope. This application package can increase energy efficiency in the crude unit, where heating costs are among the highest of any operating unit.

Reliability
The asset failures that cause many process slowdowns or total shutdowns can be greatly reduced through the use of the diagnostics produced by smart field instrumentation and digital valve controllers. This data is easily accessed by advanced asset management software and presented for use by refinery personnel. When one of the monitored devices begins operating outside its normal parameters, an alarm is raised, indicating that point needs to be evaluated. In addition, detailed information on every asset on the control network is maintained in a database for use in various routine maintenance tasks including loop checkout, configuration, calibration, troubleshooting, and accurate documentation of maintenance performed.

Most non-critical rotating machinery is monitored periodically by technicians using vibration data analyzers along pre-established routes to develop a view of the operating condition of motors, pumps, fans, compressors, turbines, and the like. Those assets that are most likely to fail can be identified by changes in vibration levels due to poor shaft alignment, worn bearings, loose or broken foundation mounts, cracked impeller, or cavitation. Critical machinery can be monitored continuously online using permanently installed sensors. For essential assets not currently wired, wireless vibration transmitters are available today to significantly reduce the cost barriers to continuous monitoring. Even second- and third-tier rotating assets can be continuously monitored, enabling maintenance personnel to identify and act on developing problems.

These advanced monitoring and analysis technologies are capable of raising alarms if field assets develop symptoms of failure, so corrective action can be taken to prevent a shutdown and potential safety or environmental incidents. It is also possible to determine which repairs can be delayed until a scheduled maintenance period or other appropriate time. This is the essence of cost-effective predictive maintenance – a most important factor for increased equipment reliability and greater unit utilization.

Utilization
Smart digital technology not only provides accurate measurements of process conditions such as vibration, temperature, flow, pressure, and desalter interface levels, it also gives refinery personnel insight into the health of the field assets. Root cause information enables people to be well prepared before they ever go into the field. Maintenance based on field-generated information is the least costly type of maintenance and contributes substantially to maximum utilization of refinery assets.

The SmartProcess fractionator optimization package can be applied to improve crude unit yields and flexibility, especially with smart field devices capable of responding rapidly to setpoint changes. Such devices also aid in detecting the onset of fractionator flooding so that operators can take appropriate actions in a timely manner. These solutions serve to improve crude and vacuum unit utilization and reduce excess energy consumption.

Safety
Safer operating conditions can be achieved through modern automation functions and features, including operator training simulation, smart instrument health monitoring, and smart safety logic solvers with automated partial stroke testing of safety shutdown valves. Training simulations provide console operators with realistic scenarios to practice infrequent events like startup, shutdown, or sudden emergencies. With deeper knowledge and more familiarity with standard operating procedures, operators are able to react immediately, properly, and confidently when required by an infrequent but rapidly evolving situation.

The diagnostic capabilities of smart instruments can also improve both the availability and reliability of safety instrumented systems (SIS). These diagnostics give refinery managers confidence that the SIS function is performing properly. They also help avoid unnecessary shutdowns by indicating when maintenance is required (as described above).

Partial stroke testing of safety shutdown valves verifies the capability of valves to move upon demand while minimizing operating disturbances to operations. However, verification of movement does not guarantee a safety shutdown valve will stroke fully when required. Safety shutdown valves that may not actually move for years could have a build-up of precipitated salts, scale, or corrosion on the valve stem preventing full travel when needed. Documented comprehensive partial stroke testing provides both verification of movement and how much the valve is capable of traveling – a valuable tool for safety instrumented system life cycle management.

Summary

Nearly all crude and vacuum units present an opportunity for improvement. Modern process control systems with embedded APC functionality continuously monitor loop performance, identify issues, and proactively address loop-tuning issues. Digital instrumentation generates a vast amount of information that can be used to drive automatic alerts, predictive maintenance, diagnostic data archives, and environmental reports. This diagnostic technology greatly reduces the amount of time required for tasks like configuration, loop checkout and commissioning, instrument calibration, and troubleshooting compared to analog instrumentation connected to conventional control systems.

More information on how today's technology meets the everyday challenges of crude unit operation is available at **www.SmartRefinery.com.** The authors are also available via email: at **SmartRefinery@Emerson.com.**

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