White paper

Efficiency and electrical integration in pipelines and refining

As energy costs rise over the long term, pipeline and refining operations are placing more emphasis on efficiency.

The oil and gas industry is home to some of the most energy intensive operations in the world. In such an environment, even small percentage gains in efficiency can produce significant dollar savings while also reducing resource consumption and emissions. In the pipeline segment of the industry, advances in pump and compressor design and the application of high pressure transmission technologies have improved pipeline efficiency. Similar advances in refining have boosted efficiency as well, but there is still room for improvement in both sectors.

Efficiency in the pipeline

Moving natural gas from source to market uses energy equivalent to 0.5% of the gas being shipped, according to Petroleum Technology Alliance Canada. That translates to over $1.1 billion per year in costs to producers. Of course not all of that energy goes to actually moving the gas—most of it is lost in the form of heat.

A 2007 IPIECA report estimates that 65-75% of energy losses in gas pipelines occur in compressor stations where even today the most advanced turbine-driven compressors achieve just 40% thermal efficiency. However, that level is still an improvement over previous designs. The IPIECA report also notes that in the case of a pipeline operating at between 15 and 30 billion cubic meters per year, high pressure technologies can be expected to yield a 20-35% reduction in energy consumption per cubic meter of gas per year. There is an additional cost savings associated with this in that fewer compressor stations are required in a high pressure system.

Despite these advances, compressors driven by gas-fired turbines still must contend with the inherent inefficiencies of converting heat into rotary motion. The alternative is to replace the turbine with an electric motor. Motors are extremely efficient—over 95% of the electrical energy coming in is converted into mechanical energy going out. They also require very little maintenance as compared to gas turbines, which has important implications for system uptime.

The efficiency of electric motors can be further enhanced by the use of variable speed drives (VSDs), which modulate motor output by varying the speed of the motor itself rather than through the use of control valves. VSD-equipped motors in a wide range of industries have been shown to use anywhere from 20% to 70% less energy than motors alone, depending on the application. The use of VSD technology also has the additional benefit of reducing mechanical stress on the motor and associated components.

Finally, motors have a smaller footprint and produce less noise and emissions than a gas turbine. VSDs reduce emissions by 50 percent, according to Oil and Gas Production Handbook by Havard Devold, and are typically less expensive than a comparable turbine-based solution.

Efficiency in the Refinery

Petroleum refining is also a highly energy-intensive business, but the vast majority of the energy used in refineries is in the form of heat. According to a US Department of Energy report, 93% of the energy used in refining operations goes to either process heating and cooling or to steam systems; only 5% is used in motor applications. The report notes that when best practices are applied, cost savings in steam systems of 10-15% are typical. But what about the 5% of energy consumed by motors?

An earlier (2004) DoE study showed that despite accounting for such a small portion of total energy use, motor applications in refineries have the largest proportional losses of any end use. Losses averaged over 50% with some motor applications in refining coming in at 80-90%. Energy losses of this magnitude often indicate a situation in which the load on the motor varies widely and frequently over time. Such instances offer the greatest opportunity for energy savings through the use of VSDs.

Another DoE report, published in 2006, broke down the refining process into specific sub-processes and examined the gap between current industry averages and a best-practice scenario. This "bandwidth" analysis produced some interesting results. Fluid catalytic cracking processes were shown to enjoy a 5% energy savings when wet gas compressors were switched from turbines to electric motors, and in alkylation, improving compressor efficiency was estimated to produce energy savings of 25-50%.

Electrical integration

It's clear that there is tremendous potential for electric motors equipped with variable speed drives in improving the energy efficiency of pipeline and refining operations. However, to maximize this opportunity, it is necessary to integrate control of process automation systems with control of power management systems.

For pipeline operations, implementing VSD-equipped motors in compressor stations is fairly simple and the business case for doing so is similarly straightforward. Terminal stations are more complex, and it is in those facilities that electrical integration becomes more important. This is predicated on open, standardized communications and system architecture.

In the past, electrical integration was achieved by hard-wired connections between electrical equipment and the process control system, but the advent of Ethernet-based communications provides a better alternative. Less wiring means fewer potential points of failure and lower cost. Similarly, proprietary systems are beginning to give way to open protocols like IEC 61850 that allow components from different manufacturers to be combined without the need for complex software interfaces.

Electrical integration bridges the gap between process instrumentation and electrical equipment, and presents operators with a unified interface to control both domains. In pipeline operations, SCADA systems are typically used along the right of way due to lower power availability. Distributed control system solutions are most effective in terminal stations and gathering points. Having a more comprehensive view of the operation allows pipeline owners to gain a better understanding of asset health, on a near real-time basis. This in turn allows potential problems to be addressed before they manifest as costly downtime.

Electrical integration also offers significant potential for efficiency savings. Industry researcher ARC estimates that "savings on the order of 10% can be achieved in many process plants by integrating power and automation." This is due in part to the increased level of visibility operators have in an integrated system, which enhances any existing energy reduction initiative.

The argument for electrical integration in refineries is conceptually the same as in pipelines, if not more compelling. The efficiency benefits are augmented even more by lower maintenance and greater reliability. For example, with maintenance, an integrated control system becomes the nexus for monitoring critical assets—whether they are part of the process or electrical systems. Operators can diagnose problems more rapidly in an integrated system because all of the relevant information, such as a plant-wide sequence of events list, is available in one place.

Expanding the use of electric motors and optimizing their performance with variable speed drives has the potential to boost energy efficiency in both pipeline and refining operations. But the positive impacts don't stop at the device level. Lower maintenance, reduced downtime, lower environmental impact—all of these accrue as well, and all of the above benefits are best realized by the integration of electrical and process systems. Unified control systems that cover both power and automation provide a new level of insight that operators can leverage to improve efficiency, reduce costs and streamline operations.

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