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Achieve refinery cost savings with real-time hydrogen monitoring

As stay-at-home orders and state mandates to shelter in place made waves around the globe in early 2020, nearly every industry was severely impacted by the COVID-19 pandemic. With more people working from home and business and personal travel slowed, the gasoline and aviation fuel industry has seen a sharp decline in demand that is worse than the post-9/11 era.

With shutdowns and reduced production at oil refineries across the globe throughout much of 2020, the oil and gas industry is struggling. It is difficult to predict when things will return to a pre-pandemic state, or if the industry is experiencing the next "new normal." It certainly looks like it will continue well into 2021. The negative impact on oil and gas may lead to an industry projection that the oil industry no doubt hopes will turn out to be untrue—that more than 1 MM oil workers will lose their jobs in 2020.

As the uncertainty caused by the COVID-19 pandemic rages on, refiners will increasingly face difficult decisions as they look to cut spending. How can the oil industry reduce spending without reducing workforce or operations? The answer may be in hydrogen (H_2).

A brief introduction to H_2. As of 2020, the majority of H_2 (approximately 95%) is produced from fossil fuels by steam reforming of natural gas, partial oxidation of methane and coal gasification. Other methods of H_2 production include biomass gasification and electrolysis of water.

H_2 is required for many essential chemical processes. As of 2019, roughly 70 MMt of H_2 are produced annually worldwide for various uses, such as oil refining, petrochemical production, ammonia and methanol production, and transportation fuel production.

One way that oil refineries can better control or even reduce costs is by accurately monitoring the levels of H_2 in a number of locations and operations throughout a refinery.

Importance of H_2 monitoring. In a typical refinery, there can be anywhere from 12 to 20 locations where H_2 measurements are critical. These locations include steam methane reforming, hydrotreating, tail gas treating, catalytic reforming, fuel gas and isomerization.

Knowing the exact amount of H_2 at these critical points throughout a plant provides a key indication of parameters that are crucial for optimizing profitability:

- **Process efficiency:** By monitoring the H_2 level at multiple points in each process in real time, refinery operators are able to ensure that they are maintaining peak process efficiency.
- **Catalyst health:** Knowing the exact condition of the catalyst based on the H_2 present means catalyst life can be extended, resulting in fewer changeovers and significant cost savings.
- **Available net and recycle H_2 (or the need for makeup H_2):** By knowing exactly how much H_2 each process is consuming or producing, refineries are able to either reuse their excess H_2 or avoid purchasing unneeded H_2.
- **Product quality:** Real-time measurement of H_2 allows refineries to detect and react to any issues immediately, avoiding costly waste and damaged equipment.
- **Recycle purity:** Maintaining the correct level of H_2 in various recycle streams not only ensures process efficiency but also helps avoid the need to purchase additional H_2.
- **Flare Btu monitoring:** With increasingly stricter EPA regulations, it is more important than ever to ensure that the amount of H_2 consumed in the flare is correct to maintain the appropriate Btu level.
- **Ethylene production:** Monitoring and reacting rapidly to changes in the feedstock are critical to maintaining proper control of downstream processes. This applies to all three stages of the ethylene production process.
- **Syngas:** As the use of synthesis gas (or syngas) is growing around the world, maintaining the ratio of H_2 to CO is the key to controlling the entire process. Avoiding delays through the use of real-time H_2 monitoring helps ensure that products like methanol and other liquid fuels are produced correctly.

Multiple ways exist to monitor H_2 at a refinery. Traditional methods of H_2 monitoring include thermal conductivity devices (TCDs) or gas chromatographs (GCs), and other established methods exist that leverage modern H_2-specific sensors. Although H_2 monitoring is critical for optimizing profitability at oil refineries, not all methods of monitoring are created equal.

Why TCDs and GCs are not ideal. Historically, H_2 has been measured using either a TCD or a GC. Although they are useful for certain applications, the shortcomings of these analyzers are well known. For example, these analyzers tend to not work well with complex or varying gas streams, may provide unreliable data in certain applications (often requiring a second analyzer to verify the results), or are expensive and difficult to use correctly.

The GC, in particular, typically requires a trained operator, unlike other analyzers that are much easier to install and use. The delayed response time, complexity and maintenance requirements, and upfront and ongoing costs also make the GC an unappealing option, especially when used only to monitor H_2 levels, as is often the case.

H_2-specific sensors. Sensing systems have emerged that can deliver real-time, H_2-specific measurements. These analyzers can deliver continuous H_2 concentration data with no cross-sensitivity to most other gases in the typical hydrocarbon processing stream, including CO and H_2S. Additionally, these sensors can reliably and accurately report real-time H_2 measurements without the added complexity and expense of using reference or carrier gas systems. The results are increased product yield, improved H_2 utilization and extended catalyst life.

With these proven H_2-specific sensors in place, many refiners have found they can easily eliminate errors caused by slow or indirect analyzers, improve overall H_2 usage to reduce costs, and ensure process optimization and better control of typical gas streams.

Achieve significant cost savings with H_2 sensors. Having H_2 measurement data available in real time allows refinery operators to make continuous adjustments that optimize H_2 usage. For example, just maintaining the correct H_2-to-hydrocarbon ratio in certain processes can save a typical refinery or petrochemical plant up to $2 MM/yr in H_2 generation and usage costs.

Similarly, big cost savings can come from making adjustments in real time that prevent coking, which can extend catalyst life by up to 6 mos. Another area where significant savings can be realized is through better control of recycle streams, potentially reducing the need to purchase expensive merchant or third-party H_2.

Many leading refineries and petrochemical plants around the world have already installed H_2-specific, real-time sensors that have delivered these benefits and cost reductions. Operators also benefit from simplifying maintenance, which both engineers and technicians appreciate. In this unprecedented time, refiners are faced with many operational and cost challenges. By having H_2 measurement available in real time, processes throughout the entire refinery can be tightly controlled for process optimization, helping reduce costs, layoffs and shutdowns. HP

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