Options for improving hydrogen network operations

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Efficiently operating a refinery hydrogen network is a challenge due to the breadth and complexity of the network. While efficient use of H₂ represents significant operating cost savings, it is a mistake to manage the network on the basis of H₂ losses alone. The effect of H₂ on processes, performance, and profit margins must be managed at the same time. Major improvements can be achieved through H₂ recovery projects, but we have also found many other opportunities to improve H₂ network operations.

Managing H₂ purity. Continuously operating at target H₂ partial pressure is a key goal. Operating a hydroprocessing unit at lower H₂ partial pressure than target catalysts at risk and negatively impacts process performance. Operating at higher than target purity leads to excess H₂ wasted to fuel. There is usually some “handful” to turn such as a bypass around PSA, mixing different purity makeup streams or adjusting purge rate, but, in reality, the low frequency of analyses and operator attention elsewhere leads to significant variation in this target variable. A further degree of optimization is available when the refiner considers changing the target with varying feed properties and charge rates.

Network topology. The mixing and matching of H₂ sources and sinks provides opportunities to increase H₂ efficiency through modification of the network topology including adding cascades, minimizing purges, mixing makeup streams of different purities.

Balancing H₂ production and consumption. Many refiners produce more H₂ than the plant can use and must burn the excess as fuel, as a margin to maintain a safety margin for the ability to provide more H₂ quickly to consumers when there is a change in operating conditions. Some refiners send this H₂ to flare. These practices are clearly inefficient and costly. The other extreme is to just let H₂ system pressure swing with supply. A 100 psig swing in a hydrocracker will swing the H₂ partial pressure in the reactor, which is also inefficient and costly. Improved operating procedures and advanced controls like anticipating demand changes and automatically adjusting H₂ plant rates can greatly mitigate these dynamic issues. UOP and Honeywell Process Solutions see a growing interest in applying process-based advanced control processes (APC) to the refinery-wide network. This is a change from the usual approach of optimizing single process units independently.

Catalytic reformer improvements. Modifying the existing catalytic reformer to increase H₂ yield can be considered. These opportunities range from small pressure drop improvements to catalytic repackaging to revamp to operation at significantly lower pressure.

Hydrogen-to-hydrocarbon plant feed. Sending H₂-containing streams to the hydrocarbon plant feed rather than fuel gas can significantly reduce the feed + fuel required in the plant.

Recovering H₂. H₂ recovery opportunities include adding new purification units, modifying existing purification units so that they perform at their full capacities, changing feed to revamp to operation at higher partial pressures, and changing to the control system software to maintain recovery already obtained from process equipment.

There are other miscellaneous improvements UOP has identified including modifying relief valves so that reactors can be operated at higher partial pressure, compressing low-pressure vent and the low-pressure flash stream at over 2,000 psig was routed to a membrane system. The H₂ product was delivered to the suction of the H₂ make-up compressor. This change added an additional 5 MMSCFD of H₂ to the refinery H₂ header.

Phase 3—A new PSA unit. Later, a continuous catalytic reforming (CCR) unit was installed and the net gas was fed to a new ten-bed PSA unit. By compressing the tail gas, it was possible to maximize the H₂ recovery in the PSA while still sending the tail gas to the refinery fuel system. This new CCR PSA unit added an additional 50 MMSCFD of H₂ to the H₂ balance. Eventually, this unit was revamped as described in Phase 5 below.

Phase 4—Second revamp of steam reformer PSA. A second revamp took place to further increase the capacity of the steam reformer and its PSA from its operation at 65 to 85 MMSCFD. This additional debottlenecking required modifications to many of the control valves and piping on the piping skid, but maintained the existing adsorber vessels and mixing tanks. The flow rates had increased by over 50% since the original design. A close working relationship between the refiner, UOP and valve vendor allowed the revamp design and hardware to be completed and ready for installation less than six months after the project was authorized. All field modifications were completed during a two-week turnaround.

Phase 5—Revamp of CCR PSA. The CCR PSA unit was later debottlenecked, as additional feed was available from the catalytic reformer. By installing additional tail gas compression and updating the PSA cycle, the unit’s H₂ production was increased to 60 MMSCFD while maintaining the design product specification.

Further increases are possible to make cycle changes similar to the types implemented in the steam reformer PSA unit. The predicted H₂ production is increased to 75 MMSCFD. This revamp will reuse the existing adsorber vessels and adsorbent, but would require changes to the existing valves and piping skid. These changes will allow the CCR PSA to produce 50% more H₂ than the original design and will maintain the H₂ recovery already obtained from the previous revamp. This revamp design will fully utilize all the tail gas compressors to their full capacities. The revamped flow scheme following Phase 5 showing current operation is shown in Fig. 6.