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 catalyst at risk and negatively impacts process performance. Operating at higher than target purity leads to excess H₂ wasted to fuel. There is usually some “handle” 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 purge rate, but in reality, the low frequency of analyses and operator attention elsewhere mitigates these dynamic issues. UOP and Honeywell UOP’s comprehensive approach of optimizing single process units indepedently.

Catalytic reformer improvements. Modern H₂ production systems see a growing interest in applying process-based advanced process controls (APC) to the refinery-wide network. This is a change from the usual approach of optimizing single process units independently.

Recovering H₂. H₂ recovery opportunities include adding new purification units, modifying existing purification units so that they perform at higher suction, revamping existing purification units for higher capacity or recovery.

There are other miscellaneous improvements where UOP has found including modifing relief valves so that reactors can be operated at higher partial pressure, compressor debottlenecking and repairing significant leaks in H₂ compressors.

The following case study demonstrates a method of H₂ recovery that combines the addition of new purification PSA and membrane units with debottlenecking of the PSA units for increased capacity.

Case study—Staged exploitation of H₂ recovery opportunities. An atmospheric resid desulfurization (ARDS) facility is installed in North America with H₂ make-up for this plant coming from a steam reformer H₂ plant with a product flow of 55 MMSCFD. The H₂ plant employs a large 10-bed PSA unit that removes essentially all of the impurities, including nitrogen, from the steam reformer effluent.

As designed, the feed gas to the steam reformer was predominately natural gas, and supplemental feed was derived from the high-pressure vent and the low-pressure flash of the ARDS unit. The high-pressure vent was scrubbed of H₂S and throttled down to steam reformer feed pressure, and the low-pressure vent was compressed to match the steam reformer feed pressure. Fig. 3 shows the overall flow scheme.

To meet the increasing H₂ needs of the refinery throughout the years various revamps have taken place as summarized in the Table 1.

**Phase 2—First revamp of steam reformer PSA.** The first plant expansion was undertaken in which the target H₂ capacity was increased from 55 to 70 MMSCFD. The first capacity increase was achieved through the debottlenecking of the steam reformer and SMR PSA unit to increase the H₂ output from 55 to 65 MMSCFD. The SMR PSA debottlenecking was achieved through a process redesign and changes to the control system software with essentially no hardware modifications. This increase in capacity more than compensated for the decrease in H₂ recovery and the net result was an increase in H₂ production of 18%.

The high-pressure vent 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 two-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.

The new CCR PSA unit added an additional 50 MMSCFD of H₂ to the H₂ balance. Eventually, this unit was revamped, as discussed (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 adsorbents 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 revamps. 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. 4.