

UOP Polybed™ Pressure Swing Adsorption (PSA) Systems

PSA systems for hydrogen recovery and purification from refinery off-gas

Introduction

The continuing need for refiners to produce clean fuels and realize more valuable products per barrel of crude oil requires more hydrotreating and hydrocracking, which in turn increases the demand for hydrogen.

To meet this increasing hydrogen demand, refiners have three options:

- Import hydrogen from outside suppliers
- Produce hydrogen on-site
- Recover hydrogen from refinery off-gases

Extraction and purification of hydrogen from off-gas streams can be an economical option to enable refiners to meet part or all of the hydrogen demand. Many projects have obtained the benefits of recovering hydrogen that would otherwise go to the fuel gas header, or to the flare.

A Polybed PSA system in the refinery:

- Turns low-value refinery off gases into a high-value hydrogen source
- Makes hydrogen available at a purity greater than 99.9 vol% at essentially PSA feed pressure
- Directly benefits hydroprocessing units
 - With high purity hydrogen make-up, the hydrogen partial pressure in the reactors can be increased, which extends the catalyst life and turnaround times.
 - High purity hydrogen make-up introduces fewer inerts into the hydroprocessor, requiring less purging, which minimizes hydrogen losses.
 - High purity hydrogen reduces the investment and operating costs of hydroprocessing units due to the lower operating pressure.

Higher Hydrogen Purity Results In Longer Catalyst Life

H ₂ Makeup Gas Purity, vol%	H ₂ Recycle Gas Purity, vol%	Relative Catalyst Cycle Length, %
99+	96	100
97	88	80
95	80	62



Maximize your profits by recovering and purifying the hydrogen from refinery off-gas streams.

Process Description

The catalytic reforming unit provides the primary off-gas source for hydrogen in the refinery. Off-gases from hydrotreaters, hydrocrackers, and isomerization units represent viable secondary sources. The hydrogen concentration from the individual streams ranges from 30 to 90 vol%.

One or a mixture of these streams enters the Polybed PSA system, typically directly from the source with minimal pre-treatment. The PSA system adsorbs the impurities in a fixed-bed adsorber at a feed (high) pressure. The impurities desorb from the bed upon “swinging” the adsorber from the feed to the tail gas (low) pressure, and by using a high-purity purge. The adsorbent does not adsorb the hydrogen.

The PSA system also produces a low-pressure off-gas stream, the tail gas. It contains all of the impurities present in the feed gas and some of the hydrogen used for regeneration of the adsorbent. The tail gas is usually sent to the fuel gas header.

Hydrogen Management Analysis

The Polybed PSA system provides a means for refiners to meet their hydrogen needs. As a way to determine the optimum use of hydrogen throughout the whole refinery network, UOP provides Hydrogen Management Analysis as a tool for strategic process decisions.

UOP's methodology uses a variety of tools including hydrogen pinch analysis and hydrogen purification process models to establish minimum hydrogen requirements. We also rely on detailed hydroprocessing process models and refinery-wide LP economic models to optimize the use of hydrogen.

By considering the impact of hydrogen on process performance (yield, throughput, product quality, catalyst life) and, therefore, refinery gross margin, profitability improvements far in excess of what is achievable through hydrogen minimization alone can be realized.

This analysis can benefit any type of refinery — hydrogen long or hydrogen short — but is especially important where refinery operation is currently constrained by hydrogen availability, or before the design basis is set for new hydroprocessing or hydrogen purification systems.

Commercial Experience

UOP invented and developed Polybed PSA technology over 45 years ago. UOP has delivered over 900 PSA systems worldwide, processing over 40 different types of feedstock.

UOP was the first to commercialize PSA technology for refinery off-gas service. UOP has provided 235 PSA systems for refinery off-gas service with hydrogen production capacities ranging from 1 to more than 157 MMSCFD (1,000 - 173,000 Nm³/hr).

Polybed PSA systems can purify a feed consisting of a mixture of refinery off-gases and other hydrogen-containing gases such as off-gases from the ethylene plant or a steam reformer. This provides attractive economics since only a single purification unit is needed.

UOP Provides:

- Unparalleled international experience in project development, engineering, fabrication, and technical support
- Flexibility in project execution
- PSA systems optimized to customer requirements
- Worldwide sourcing to meet local requirements
- Fixed pricing for accurate forecasting of project expenses
- Shop fabricated skid-mounted systems for fast on-site installation and short start-ups
- PSA systems integrated with catalytic reformers and hydroprocessors to optimize product yields for maximum profitability
- Proprietary UOP adsorbents that enable higher hydrogen recovery and that have commercially demonstrated the highest lives of any adsorbents in refinery off-gas service
- Automatic operation that minimizes manpower requirements
- Superior quality control resulting in long-term safe, reliable operation
- Greater than 99.8% on-stream factor from the rigorous design and selection of the valves and control systems
- Maximum reliability for hydrogen production due to the control system that automatically adjusts to maintain production, even during upset conditions
- Lower capital cost due to adsorbent efficiency, process design and control philosophy
- Products and services with ISO-9001 certification
- On-going technical support after plant startup
- Revamp services to enable existing equipment to meet your future needs

For more information

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