Growing global demand for transportation fuel continues to drive refiners toward operations that maximize hydrotreating capacity and capability either through unit debottlenecks or new unit construction. More stringent environmental regulations and the processing of cost-advantaged sour and heavy feed stocks make meeting this demand even more challenging.

IsoTherming® hydrotreating technology is a commercially proven process that provides refiners a more economical means to produce today’s transportation fuels.

The core of IsoTherming® technology, Figure 1, is the ability to provide the hydrogen necessary for the reactions using a liquid stream, rather than a recycle gas system. The reactor feed is saturated with hydrogen which eliminates the need for a recycle gas compressor. To satisfy hydrogen requirements within the reactor, additional hydrogen can be added by means of an external liquid recycle stream or inter-bed hydrogen injection.

Operating the reactor liquid-full also acts as a heat sink for the exothermic reactions. Thus, the reactor operates closer to isothermal conditions, which reduces uncontrolled cracking reactions and lowers light ends make.

Application, design objectives and hydrogen requirements dictate optimal reactor design including required number of catalyst beds and recycle ratio. With similar operating temperatures and pressures to conventional technology, IsoTherming® technology has a number of very attractive benefits to a refiner.

Applications for IsoTherming®, whether grassroots or revamp, include:
- Kerosene Hydrotreating
- Transmix Hydrotreating
- Diesel Hydrotreating
- FCC Feed Hydrotreating
- Mild Hydrocracking
- Dewaxing
- Gas-To-Liquid (GTL) Upgrading
- Heavy Oil Upgrading
ISOTHERMING®
HYDROPROCESSING TECHNOLOGY

REDUCED OPERATING EXPENSES
By eliminating the hydrogen gas compressor and its ancillary recycle loop equipment, significant maintenance and operating cost savings can be realized. In addition, IsoTherming® recovers the heat of reaction by recycling a portion of the hot hydrotreated product back to the inlet of the reactor. This direct transfer of heat to the feed in turn reduces the fired heater duty. Overall, IsoTherming® technology has consistently demonstrated a 40-60% utility savings over trickle bed technology including:

- **FUEL GAS: 30 TO 60% USAGE REDUCTION**
  - Heat of reaction absorbed by liquid recycle
  - Liquid recycle used to heat the feed
  - Lower heater firing rates in normal operation
  - Lower greenhouse gas emissions

- **POWER: 30 TO 40% USAGE REDUCTION**
  - Reactor recycle pump vs. recycle gas compressor

- **ENERGY RECOVERY: 30 TO 50% INCREASE**
  - Optimized heat integration/heat recovery allowing for steam or power generation
  - Lower maintenance costs
  - Less equipment
  - Reactor recycle pump vs. recycle gas compressor

INCREASED CATALYST LIFE
With a liquid-full reactor, IsoTherming® technology ensures the catalyst is completely wetted thus drawing the heat of reaction away from the catalyst surface and minimizing local hot spots. In addition, even liquid flow throughout the catalyst bed results in a uniform radial temperature profile. These phenomena minimize light ends generation and catalyst deactivation due to reduced coke formation.

These claims are supported commercially by several operating units that have experienced catalyst life in excess of 4 years in VGO hydrotreating service.

CAPITAL COST ADVANTAGES
IsoTherming® technology has demonstrated significant capital cost advantages, particularly in the area of refinery hydrotreating revamps and low hydrogen use applications (e.g. kerosene, transmix processing, dewaxing). While savings in excess of 30% have been seen, these are dependent upon the application under consideration, incremental capacity requirements and global economic factors.

Replacing the recycle gas compressor and ancillary equipment with a single recycle pump provides a clear advantage to IsoTherming® technology in the event of a revamp. There is no need to replace or supplement any existing recycle gas equipment. This is also a benefit when plot constraints are present for any project, whether it is a revamp or grassroots construction.

For those projects with low hydrogen consumption, the ability to supply the hydrogen through feed saturation rather than a gas recycle system inherently means fewer pieces of high pressure equipment resulting in lower capital costs.

As mentioned, IsoTherming® technology recovers the heat of reaction by recycling a portion of the hot hydrotreated product back to the inlet of the reactor. As such, the feed/effluent exchanger heat duty requirements are reduced, which contributes to the reduction in the number of pieces of high pressure equipment required when comparing to an equivalent trickle bed design.

**FIGURE 1. ISOTHERMING® TECHNOLOGY**
**HYDROPROCESSING TECHNOLOGY**

**ISOTHERMING** requirements and global economic factors. Excess of 30% have been seen, these are dependent upon the hydroprocessing revamps and low hydrogen use applications (e.g. Iso Therming® technology has demonstrated significant capital savings in units that have experienced catalyst life in excess of 4 years in normal operation. These claims are supported commercially by several operating companies.

Uniform radial temperature profile. These phenomena minimize catalyst exposure away from the catalyst surface and minimizing local hot spots. In liquid-full reactors, Iso Therming® technology ensures the catalyst is completely wetted thus drawing the heat of reaction for steam or power generation. Overall, Iso Therming® technology has consistently demonstrated increased catalyst life for steam or power generation.

---

**INCREASED CATALYST LIFE**

- **ENERGY RECOVERY:** Three to five percent increase
- **POWER:** Three to four percent usage reduction

**REDUCED OPERATING EXPENSES**

- Reactor recycle pump vs. recycle gas compressor
- Lower maintenance costs
- Optimized heat integration/heat recovery allowing energy recovery
- Lower greenhouse gas emissions
- Lower heater firing rates in normal operation
- Liquid recycle used to heat the feed
- Heat of reaction absorbed by liquid recycle

Elimination of the recycle gas compressor and associated treating equipment also removes a large amount of high pressure equipment from the hydroprocessing unit. Not only does this result in a substantial plot space reduction, but also provides a significant reduction in overall unit hydrogen inventory. Since the hydrogen content in liquid full catalyst beds is limited by solubility, it eliminates any potential of reactor runaway. Therefore, IsoTherming® reactors are inherently safer than conventional trickle bed reactors.

**CONFIGURATION FLEXIBILITY**

For refiners contemplating a revamp of existing hydrotreating assets, IsoTherming® offers the option of utilizing an IsoTherming® reactor system as a pretreatment unit. If there is an existing hydrotreater, the IsoTherming® hydrotreating technology can be installed as a simple pretreat unit ahead of the existing hydrotreater, Figure 2.

The pretreat configuration can be installed at a fraction of the cost of competing low sulfur technologies. The IsoTherming® pretreat reactors do most of the hydrodesulfurization, leaving less work for the existing conventional reactor, which now operates in a polishing mode. Any mass transfer limitation of the conventional trickle bed reactor is no longer a constraint because the IsoTherming® reactors have already transferred the bulk of the hydrogen to the oil. Because of this, catalyst deactivation due to coking in the conventional reactor is drastically reduced. For existing low pressure units, a higher pressure IsoTherming® loop can be installed maximizing the use of existing assets and minimizing overall costs.

**REDUCED LIGHT ENDS MAKE**

The lower temperature rise across the IsoTherming® reactor and liquid-full beds allow the refiner to achieve their desired product specification while minimizing undesired cracking reactions. This reduces the yield of light ends that have limited value within many refineries.

In addition, the reduced cracking reactions decrease hydrogen consumption for the same product specification. The degree of improvement, of course, will vary depending on a number of factors (feedstock, service, operating conditions and catalyst to name a few). For highly unsaturated feedstocks such as light cycle oil (LCO) or coker gas oil (CGO), the low temperature rise across the IsoTherming® reactor system provides a particular advantage not only due to decreased uncontrolled cracking, but allows for effective treatment of hard to remove nitrogen compounds without sulfur recombination.

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**FIGURE 2. ISOTHERMING® REVAMPED DHDS UNIT**

![IsoTherming® Revamped DHDS Unit Diagram](image)

RED = NEW EQUIPMENT

- Blended feed
- IsoTherming® Reactor
- Existing Trickle Bed
- Recycle Gas Compressor
- Lean Amine
- Rich Amine
- Hot Separator
- Naphtha
- Diesel
- Steam
- Make-Up Hydrogen
- Stripper Off Gas
- Diesel

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**FIGURE ONE. ISOTHERMING® TECHNOLOGY**
### IsoTherming® Technology Licensing Activity to Date

<table>
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<th>Licensee</th>
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### WorldWide Sales and Support

For more information, please contact:
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