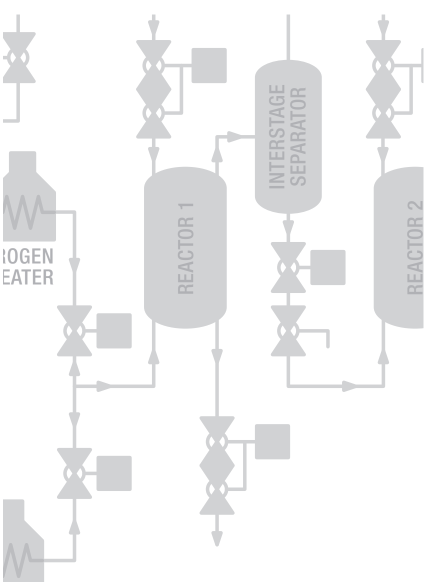
TechTalk

A comparison of ebullated bed hydrocracking vs fixed bed

Outline



Why ebullated bed experience makes a difference

Refiners have over 100 years of experience using a variety of technologies to refine the various feeds with differing chemical properties. Today, depending on the feed and chemical makeup, refiners have a choice of technologies. Two of which are fixed bed and ebullated bed hydrocrackers. Ebullated bed reactors require more exacting specifications and operational equipment because they have higher erosion from ebullated catalyst, higher operating pressures, higher temperatures and more corrosive contaminants than fixed bed units.

Reactor designs

Fixed bed reactors are the simplest type of reactor to design, and consist of catalyst particles loaded and packed into the beds. There may be issues with the feed, such as high viscosities, low thermal conductivities and irregular shape when being placed inside the reactor, or with small catalyst surface areas inside the reactor. But refiners can overcome these shortcomings with innovative designs, better feedstock flow and catalyst utilization or online catalyst removal.

Ebullating bed technology was developed to handle short comings in the fixed bed technology with regards to handling heaver and dirtier fluids. The ability to add new catalyst while the reactor continues to operate, as well as to remove the spent catalyst, allow ebulated bed reactors to continuously process vacuum

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residuum (heavier oil) streams. Hydrogen gas is also continuously added to the reactor. The beds are considered ebullated as the combination of oil, catalyst and hydrogen are continuously mixed and pumped by large ebullating bed pumps that are either located within the reactor or directly beside the reactor, depending on licensor configurations. Once the fluid is activated in the reactor, it passes to the downstream separator where effluent vapors are extracted at the top of the separator. The remaining resid is passed downstream for further processing.

Ebullated bed reactors allow for better temperature control, less temperature gradients throughout the reactor and more uniform products even with varying, heavier feedstocks, when comparied to fixed bed hydrocrackers. Unlike fixed bed units, ebullating bed units are not batched and offer higher conversion rates; all leading to lower overall cost of ownership.

Ebullated bed complexities

An ebullated bed reactor is a more difficult process than a fixed bed reactor:

- Ebullated bed defluidization can occur for various reasons, decreasing conversion rates.
- Ebullated bed separators have redundant letdown trains to ensure continuous operation, while having the ability to maintain the redundant train. Control valve trim issues include errosion and coking particulate damaging the trim, as well as plugging of the trim by foreign objects.
- Ebullated bed feedstocks contain high metals and contaminent compounds and, hence, are more corrosive. This requires facilities to use more reactive amines to counter these contaminents.
- Catalyst is highly erosive due to its ebullated nature.
- Ebullated beds operate above the autoignition temperature of the resid, which contains hydrogen. Any leak of the resid will turn into a hydrogen-fueled fire without the need for an external spark.
- Both fixed and ebullated bed have thermal fluctuations at start up and shut down.
- Though ebullated beds are designed for continuous operation, they are still limited due to coking of asphaltenes in areas (depending on plant and especially crude stock) and, hence, need to shut down for maintenance (clean outs) and repairs in these areas (turn arounds).
- Operating conditions of high temperature ebullated bed reactors tends to be 757–766° F (403–408° C), with a design temperature typically at 849–860° F (454–460° C) depending on licensor and application. These units are monitored and ideally controlled to within ±1° C inside the reactor. Only on operating excursions (upsets, high rate depressuring, operator errors) do these units go much above this temperature (large failures excluded).
- With only a couple dozen ebullated bed units operating worldwide—compared to over 200 fixed bed units—there are fewer opportunities for valve OEMs to get experience.

Comparison Chart – Fixed Bed vs Ebullated Bed

Key Aspect	Fixed Bed	Ebullated Bed
Catalyst	Batch process	Continuous addition and spent catalyst removal
Reactor Operating Temperature	725 – 750° F (385 – 399° C)	757 – 766° F (403 – 408° C)
Design Pressure	2500 – 2700 psi (172 – 186 bar)	2900 – 3200 psi (200 – 221 bar)
Contaminants Processing	Lower content of metals and sulfur compounds. Less corrosive. Milder amines.	Higher content of metals and sulfur compounds. More corrosive. More reactive amines.
Coking	Lower content level of resins and asphaltenes. Lower coking rates.	Higher content level of resins and asphaltenes. Higher coking rates
Unit Quantity – Worldwide	200+	25+
Pressure Letdown	No redundancy	Redundancy required for long-term unit reliability / up-time / operation
Hydrogen Consumption (scf/bbl)	1,000 – 4,000	1,500 – 10,000
Conversion Rate	50 – 60%	65 – 85%

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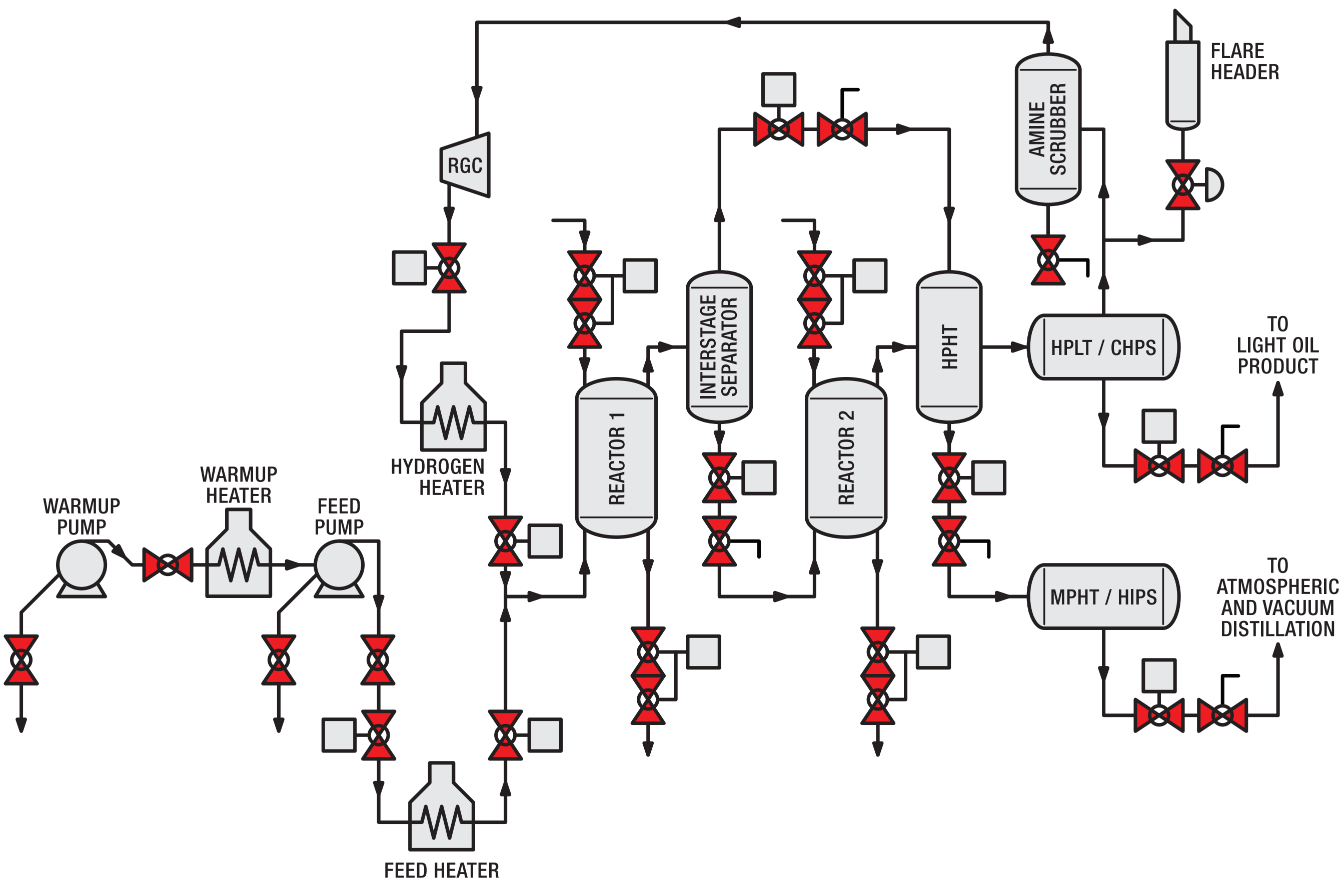
There is no substitute for experience with ebullated bed projects.

Conclusion

Ebullated bed technologies require that the engineering, services and supply companies have knowledge of the pitfalls and lessons learned from other ebullated projects to avoid the disastrous and costly consequences resulting in lost production, unplanned shutdowns, and safety incidences. High pressure, high temperature, abrasion, corrosion and coking all present individual challenges on any ebullated bed project over those of a fixed bed design. Engineering designs must consider how all process ingredients can be present while continuing to meet the production requirements of the unit. Fixed bed, delayed coker and fluidized catalytic cracking project experience will only give part of the picture.



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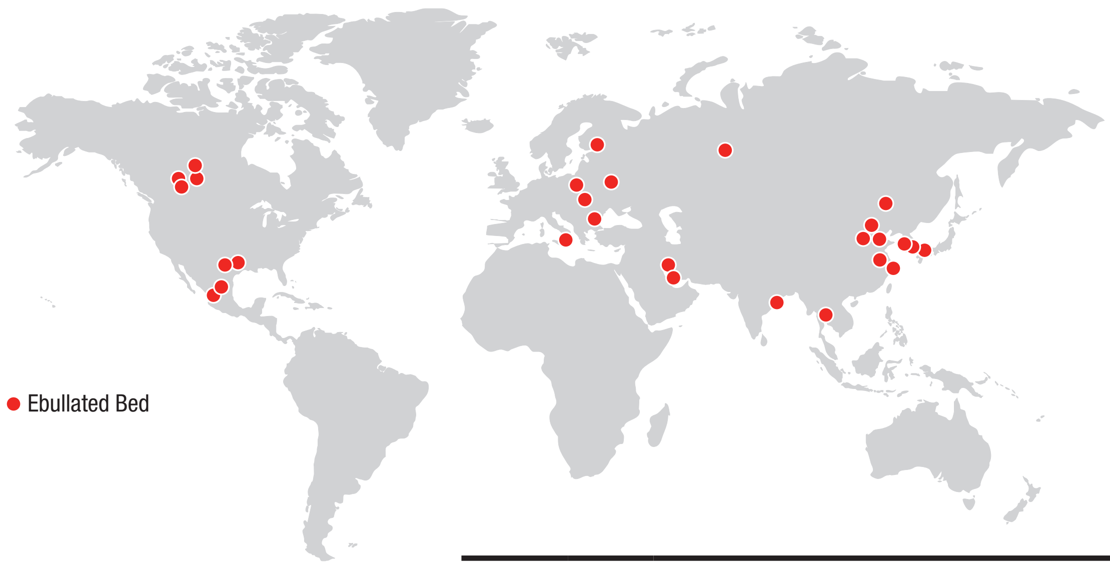

25+
ACTIVE OPERATIONS

40+
YEARS OF INNOVATION

15+
PROVEN APPLICATIONS

10,000+
VALVES INSTALLED

MOGAS ebullated bed experience
With only a limited number of ebullated bed hydrocracking units in existence globally, finding a valve manufacturer that understands the process could be nearly as arduous as the process itself.

For over 40 years, MOGAS has worked in concert with all major licensors of this technology to develop coatings and valve designs that can withstand this demanding process with outstanding reliability for a unit's entire planned production run. Our experience, performance record and dedication to continuous improvement have made MOGAS the preferred vendor for this unique process technology.

This is why MOGAS is the only manufacturer with valves installed in EVERY ebullated bed unit worldwide — totaling well over 10,000 valves.

Ebullated Bed Hydrocracking Experience — Partial List

Location	Qty	Sizes (in)	Description
China	1259	1–18	MOGAS was selected to supply over 1,000 critical valves to this first-of-a-kind installation based on our quality manufacturing processes and knowledge of severe service ball valves. This included applications such as high pressure letdown isolation, catalyst isolation and many high cycle, thermal shock applications.
Canada	84	2–8	Initially, the severe service block valve order was awarded to a competitor—but nine months after start-up, the unit was brought down due to mechanical failures and fires. MOGAS was contacted and provided two C-Series valves with a 14-day delivery to restart the unit. Customer then purchased all new critical service valves from MOGAS.
Bulgaria	320	0.75–20	All Tier 1 and Tier 2 severe service valves were awarded to MOGAS because end user, licensor and EPC felt the risk was too great to go with a less experienced valve company.
USA	131	1–8	Initially, MOGAS and a competitor supplied severe service valves for their unit. After years of service and parts problems from other valves, they began to replace those valves with MOGAS C-Series valves. Customer now uses MOGAS as a standard in all high-pressure applications.
Mexico	520	0.5–12	Due to the past performance of MOGAS, customer ordered more than 500 critical severe service valves from MOGAS. Since startup in 1997, only 10% of the original 520 valves have required maintenance of any kind.
USA	212	1–20	MOGAS supplied single ball, bi-directional valves to replace original plug valves. A competitor's valve design began leaking and locking up, causing the plant to shut down, and leading to replacement of millions of dollars worth of valves. During a March 2007 walkdown, a MOGAS valve was found that had been installed in 1984, and was still performing to expectations. In 2007–2008, over 60 high and low pressure valves had been purchased from MOGAS to replace various competitors' valves.
Thailand	155	2–24	Supplier of Choice agreement. MOGAS provided technical assistance to customer and EPC to ensure smooth startup and operation for licensor.
India	299	1–16	Strong licensor recommendation and customer consultation was key on this ebullated bed unit. Included five modules for letdown stations.