ADVANCING PRESSURE DROP MITIGATION THROUGH COLLABORATION

Honeywell UOP's successful history of developing hydroprocessing reactor internals and Crystaphase's market-leading CatTrap® product can now be combined for refiners to take advantage of both of these technologies to extend cycle time for units which are limited by pressure drop build-up.

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INTRODUCTION

When operating hydroprocessing units, reactor pressure drop is an issue that must be accounted for and monitored.

For as long as pressure drop has been a problem for their customers, Honeywell UOP and Crystaphase have answered requests for help with the development of very successful technologies. Honeywell UOP offers mechanical solutions in the form of reactor internals and Crystaphase offers graded bed solutions in their CatTrap® product line. Now Honeywell UOP and Crystaphase are continuing their long association by offering a Pressure Drop Mitigation tray that combined with CatTrap® materials provides maximum benefit in minimum reactor space.

AUTHORS

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Ian has worked in the refining industry since 2006, starting his career at Foster Wheeler. He has worked at Honeywell UOP since 2012 and has had roles as a Technology Manager and Yield Estimator for hydrocracking.

He has a MEng in Chemical Engineering from UMIST (University of Manchester Institute of Science and Technology) and is a Chartered Chemical Engineering in the IChemE.

Austin Schneider leads Crystaphase's technology department, with responsibilities in technical service, product development, intellectual property, and customer education. He has developed and applied models for reactor filtration, catalyst poisoning, fluid distribution, and catalyst usage optimization. He has put these models to the test in the field working directly with refinery engineers, conducting on site troubleshooting reactor fouling and related issues.

Austin has worked in the refining industry since 2004, focusing on fixed bed reactor hydraulics, feed purification, and particle generation. He has an MS in Mechanical Engineering and a BS in Physics.

WHAT IS PRESSURE DROP

Particulates in reactor feed can accumulate and, if unchecked, cause problems with flow through the reactor that will be measured as increased pressure drop from inlet to outlet.

Figure 1 shows an example of unchecked particulate accumulation found inside a reactor. Filtration of all hydroprocessing unit feed streams upstream of the reactor is recommended, but this is not always sufficient to prevent pressure drop increase due to feed contaminants or unit mis-operation.

In some cases, the increased pressure drop results in shortened cycle life and negatively impacts a unit's profitability quite dramatically. For example, if pressure drop from plugging of catalyst requires a shutdown every 6-12 months in a unit that would otherwise only stop every 2 years, costs can accumulate quickly. As technologies improve and allow units to achieve longer and longer cycle lengths, some units are coming up against pressure drop constraints in 4- or 5-year cycles that were never an issue when the unit required more frequent catalyst changes.

Figure 1

HYDROPROCESSING REACTOR INTERNALS

One approach to addressing pressure drop in a reactor is the use of a mechanical solution.

Honeywell UOP has a long history of developing hydroprocessing reactor internals (HRI) to improve unit performance. HRI play a critical role in the effective utilization of reactor catalyst volume. These mechanical components for reactors can be highly beneficial pieces of equipment, improving flow through reactors with minimal impact to turnaround times – even improving turnaround maintenance times in some cases. This is especially important in the current environment of stringent product specifications, difficult feedstocks and flexible operating requirements.

UOP Uniflow™ reactor internals utilize innovative vapor-liquid tray technology to provide optimized flow distribution, allowing refiners to extract the full benefit of the catalyst system.

Table 1 shows the improvement in radial temperature spread achieved by installing Uniflow reactor internals in a five-bed hydrocracking reactor as part of a unit revamp. In this example, the customer was able to reduce their radial spread from 45°F to 4°F at the bottom of Bed 5 while operating at 32% higher feed-rate.

Hydrocracking Bed	Radial Spread (°F) New Cycle with Uniflow HRI	Radial Spread (°F) Previous Cycle
Bed 1	Top: 1 Bottom: 1	Top: 3 Bottom: 18
Bed 2	Top: 4 Bottom: 3	Top: 2 Bottom: 6
Bed 3	Top: 4 Bottom: 2	Top: 5 Bottom: 6
Bed 4	Top: 4 Bottom: 3	Top: 12 Bottom: 36
Bed 5	Top: 4 Bottom: 4	Top: 11 Bottom: 45

Table 1

The customer feedback on the Uniflow reactor internals was that “we would never have been able to operate this unit where it is today without these new internals.”

UOP PRESSURE DROP MITIGATION (PDM) TRAY

UOP in cooperation with Crystaphase now offers a solution that is both a graded bed solution and a mechanical solution for refiners to mitigate pressure drop problems in reactors.

Drawing on this deep expertise in HRI, UOP has developed a Pressure Drop Mitigation (PDM) tray for hydroprocessing units whose cycle length is limited by reactor pressure drop due to the accumulation of particles plugging the catalyst bed.

Honeywell UOP's PDM tray with Crystaphase CatTrap® filtration is designed to extend time between turnarounds by effectively and efficiently trapping solid particulates. The PDM tray provides additional pressure drop mitigation for refiners processing heavier feeds, eliminating the need to skim the top catalyst bed and extending time between turnarounds.

It does not require additional catalyst bed volume as the entire tray fits within the unused space above the reactor tangent line. The design ensures that all reactor feed will flow through the tray, leaving any plugging material deposited in the CatTrap® materials before the feedstock reaches the catalyst below. The industry-leading void space of CatTrap® material offers plenty of room to trap an entire cycle's worth of particulates, thus enabling the reactor to stay online for the entire catalyst cycle.

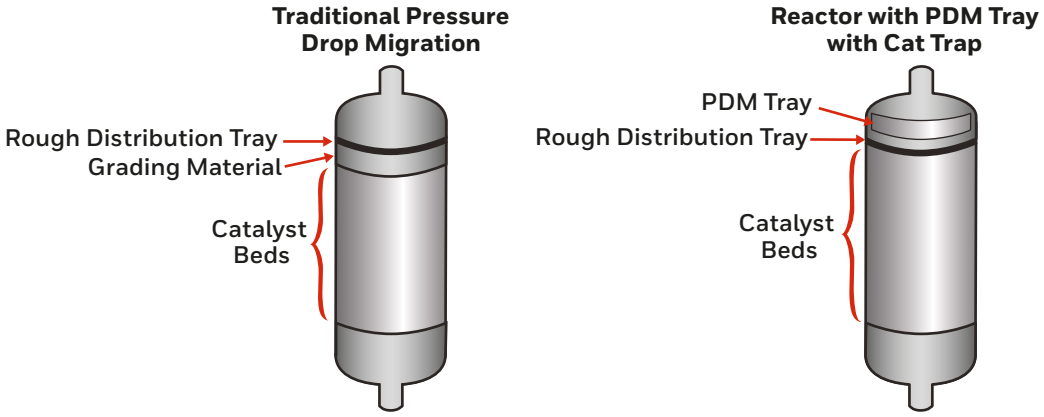

Figure 2

UOP PRESSURE DROP MITIGATION (PDM) TRAY

The tray, shown in Figure 3, consists of a perforated plate surrounded by a banding plate and liquid overflow chimneys. The bed of CatTrap® discs is contained within the tray's banding plate. A layer of grating is placed between the perforated plate and the CatTrap bed to prevent the perforations on the plate from being plugged. Liquid flows onto the tray and through the CatTrap® material where any constituents that would plug catalyst are trapped in the high-surface-area pores, and is then distributed through the perforations to the rough distribution tray below.

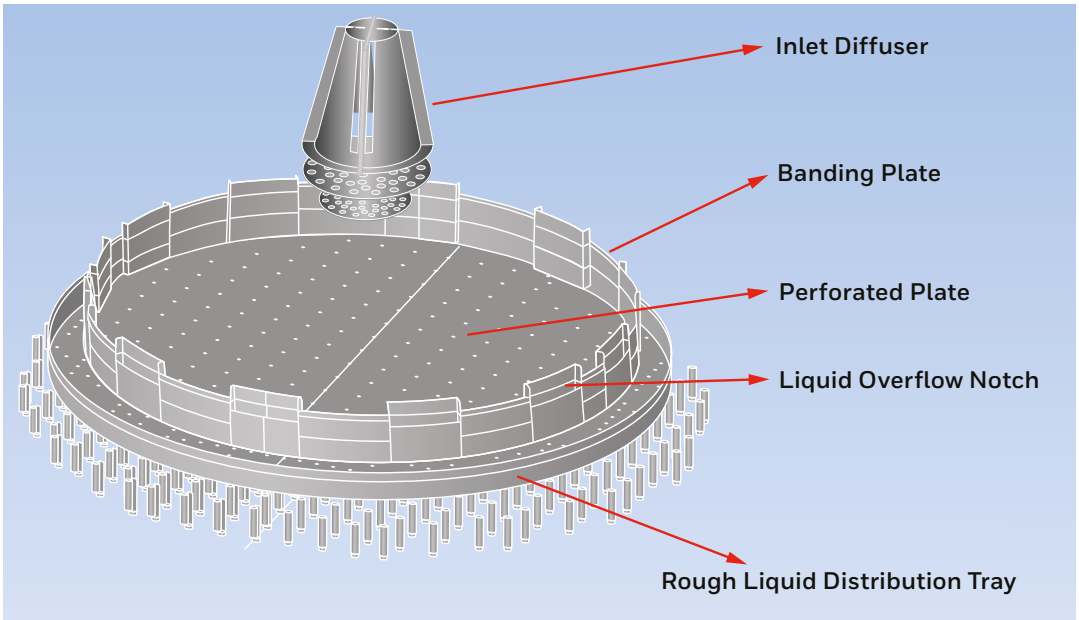

Figure 3

As is the case with all of UOP's reactor internals, the UOP PDM tray is easy to install and clean. Unlike other filtration devices, the UOP PDM tray with CatTrap® technology is designed for maintaining liquid-full operation in a wide range of liquid flows (60% to 120% of design). This is achieved through a unique design with limited open area on the perforated plate and overflow chimneys around the banding plate; benefits include the elimination of liquid channel flow and increased liquid residence time, so improved filtration efficiency. As overflow liquid at high liquid rates can only enter into the chimneys through a clearance at bottom above the perforated plate, no liquid will be bypassing the CatTrap® bed for filtration.

INTRODUCING CRYSTAPHASE

A key component of the PDM tray design is the use of Crystaphase CatTrap® products within the tray itself to provide the necessary surface area to capture particulates before they can get past the tray and start plugging catalyst below.

CatTrap® technology is well known as a leading solution used to address pressure drop in fixed-bed catalyst systems.

Crystaphase, using comprehensive sample analysis, helps refiners identify specific foulants and their characteristics. With this information, Crystaphase delivers CatTrap® technology – reticulated ceramic medallions sized to match the identified fouling particles – as an integrated system that filters with precision and efficiency.

What makes CatTrap® products unique, as pictured in Figure 4, is their ability to filter from within each disk, utilizing the high tortuosity pathways of the ceramic material itself to trap insoluable foulants, rather than in the spaces between pieces. As pieces closest to the inlet become full, as seen in Figure 4, the feedstock flows through the open spaces around them and into the empty pieces below, yielding an unmatched linear holding capacity.

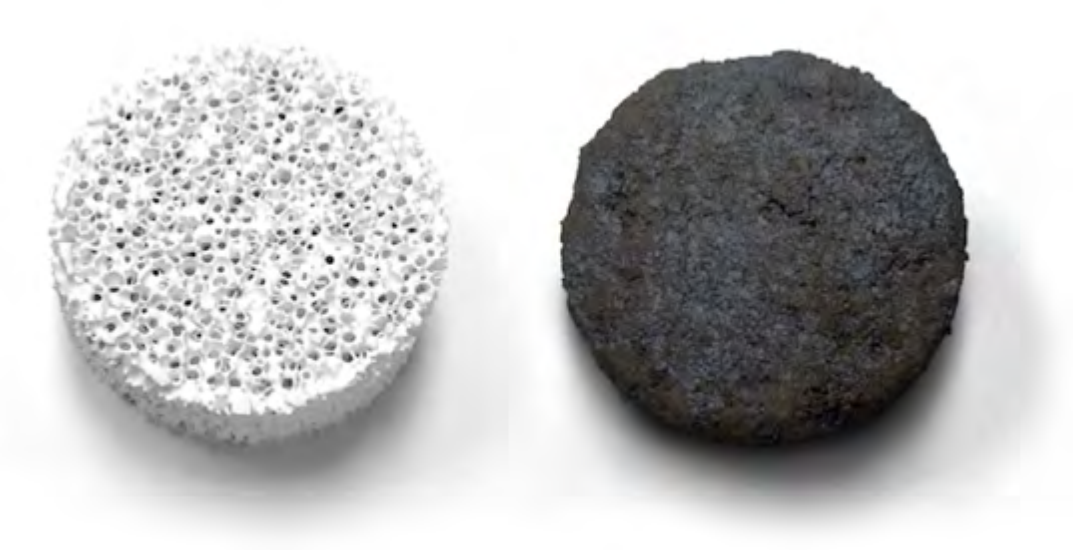

Figure 4

PRESSURE DROP MITIGATION CUSTOMER EXAMPLE 1

One refiner faced pressure drop trouble in a naphtha unit that was dramatically helped by using CatTrap® technology.

Straight-run naphtha is usually low in foulants, so these units do not typically face pressure drop challenges. However, this unit needed to shut down earlier and earlier due to pressure drop, with production cycles dropping from 331 days on oil to 257 days, and then to 197 days.

The refiner called on Crystaphase for help. They accepted the recommendation to replace 180 cubic feet of conventional wagon wheels and rings with a custom CatTrap® solution that used only 159 cubic feet. The result was a production cycle that more than doubled in length compared to prior cycles (see Figure 5). According to estimates, the full impact of increasing production cycle length to 716 days with CatTrap® technology was nearly $4 million.

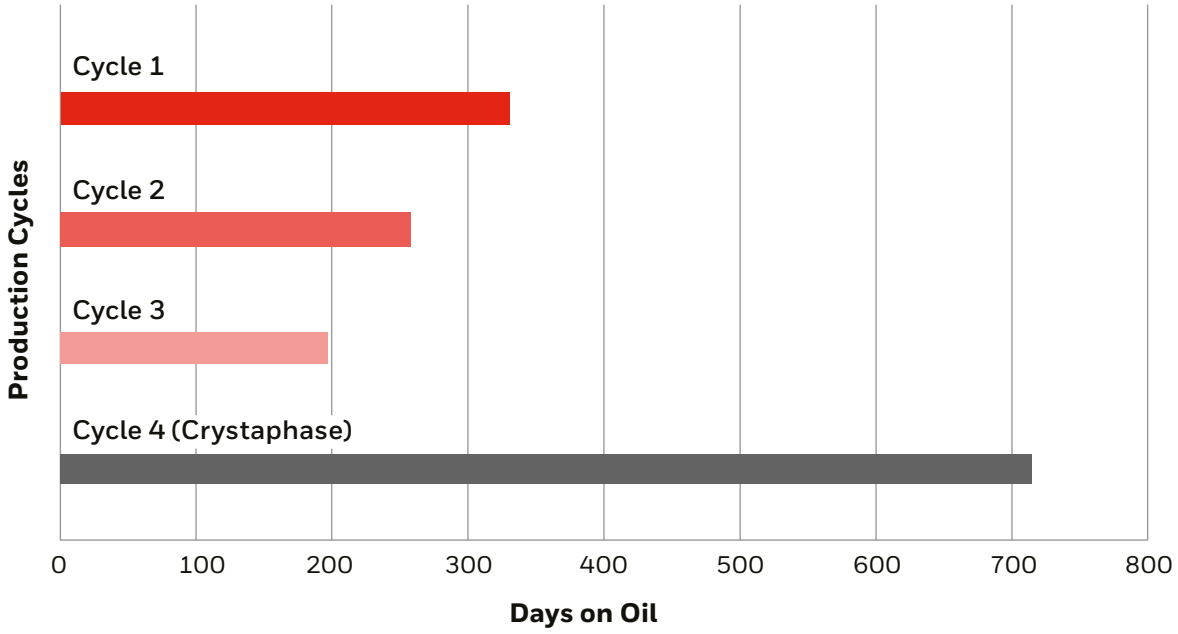

Figure 5

PRESSURE DROP MITIGATION CUSTOMER EXAMPLE 2

CatTrap® technology provided a clear advantage for a refiner running three reactors in parallel trains on their hydrocracker unit.

In spite of having installed 5-micron feed filters in the unit, 1,000-micron particles were plugging the catalyst bed and causing temperature excursion issues as well as increased pressure drop. In this instance, side reactions in the heating train were causing unexpected particle generation that could not be addressed with feed filters.

The refiner wanted to compare a CatTrap® system with the existing configuration.

Figure 6 shows the pressure drop in all three reactors before and after being skimmed and reloaded. The reactors that were loaded with Crystaphase CatTrap® products (reactors 1 and 3) saw longer cycle length, increased activity, and higher throughput as well as reduced risk of temperature excursion. CatTrap® products were selected for all three reactors following this comparison.

"Since then, we've loaded Crystaphase in the top of the hydrocracker reactors in every cycle. No similar issue has been encountered." – Hydroprocessing Specialist, Major Southeast Texas Refinery

Pressure Drop Comparison of Three Reactors

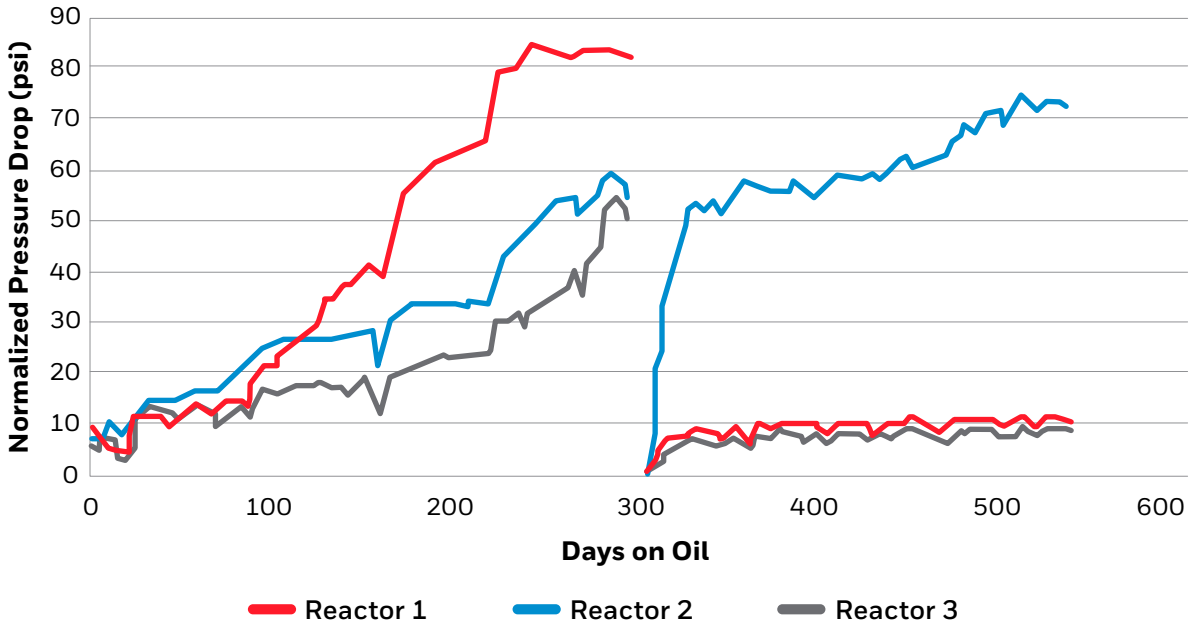

Figure 6

CONCLUSION

This new pressure drop solution offers multiple benefits because it combines excellent technologies that perform even better together.

Honeywell UOP is an established leader with reactor internals, Crystaphase is an established leader with particulate traps.

The alliance between these two companies in offering the UOP PDM tray with Crystaphase CatTrap® filtration technology is an opportunity for refiners to access the combined benefits of both mechanical and graded bed pressure drop technology in the unused space at the top of a reactor.

With the combination of these two technologies, refiners can process heavier feeds, operate for longer, eliminate inter-cycle skimming and extend time between turnarounds.

For More Information

For more information, please contact your UOP representative or visit us online at www.uop.com.

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