



FCC SLURRY Oil Filtration with Mott HyPulse[®] LSI Filters

FCC SLURRY OIL FILTRATION WITH MOTT HYPULSE[®] LSI FILTERS

Mott Corporation has installed the two largest HyPulse LSI filter systems in two major refineries for removing FCC catalyst fines from slurry oil. The first system has operated successfully for ten years and is a testament to the unique features and operating characteristics of this advanced filtration system design. Its proven performance led to the purchase of a second system by the same customer. Each installation is a triple vessel system designed to provide continuous operation at capacities in excess of 10,000 BPD. The systems are totally automatic, and continue to provide a high degree of reliable high efficiency particle separation.



HyPulse[®] Filter System Operational Update

The Mott HyPulse filter system installation described in this paper has recently completed ten years of continuous operation without a need for extraordinary maintenance. During that time the filter has met all of the refinery product and processing requirements.

In the first year of operation, the refinery process subjected the filters to high pressure drops and flow conditions beyond the normal design conditions, and these conditions have had no detrimental effect on the life of the filter cycle or the mechanical components. The robust mechanical design is able to withstand severe operating conditions that are sometimes part of refinery processing.

The benefits to the refinery were greater than originally expected. Removal of the catalyst fines not only improved the oil product, it also improved downstream operating units by preventing fouling and reducing maintenance. This success prompted the customer to purchase an essentially identical system for a second refinery.

Mott has expanded its installed base of HyPulse LSI Filters for FCC slurry oil service to four continents. Several customers have placed repeat orders for multiple systems.

Mott Corporation of Farmington, Connecticut has been manufacturing porous metal products for over 45 years. Mott's Process Systems Division makes porous metal filter elements in various alloys and installs them in the HyPulse[®] line of filters. Mott has an installed base of hundreds of HyPulse filters in successful liquid/solid and gas/solid applications.

In the mid 1980s, as the petroleum refining industry began to express serious interest in removing catalyst particles from FCC slurry oil, Mott began testing the use of porous metal filters for this application. The slurry oil process requires the filter to withstand rigorous service conditions and the benefits of an all-metal filter are obvious. Mott demonstrated how successful the HyPulse LSI filter could be in this application through both laboratory tests and on-site pilot scale evaluations. Mott's installed systems demonstrate the scalability of HyPulse LSI filters to handle high flow rates and solids capacities.

Several refineries became aware of the benefits of an efficient catalyst removal system. A key goal for removing the catalyst particulate was, and remains to be, upgrading of product fuel oils or upgrading to provide feedstock for production of carbon black high-grade coke, or other products. Removing the catalyst fines also reduced the wear of downstream components due to the abrasive nature of the particles. More recently, there has been added emphasis on removing the catalyst fines to prevent settling and sludge formation in slurry oil storage tanks in addition to concerns over the hazardous waste classification of catalyst-containing tank sediments.

Since 1990, Mott has delivered HyPulse LSI Filters and Systems to more than 25 refinery sites located in the US, Europe, China, and Africa. Systems operate reliably over multiple cycles with consistent cycle lengths and long filter element lifetime. Operating systems continue to utilize filter elements originally provided with the system.



HyPulse LSI Filter Description

Mott's HyPulse LSI filters are backwashable metal filters that contain tubular porous metal elements installed in a tubesheet at the bottom of a vessel. During operation, the feed slurry containing suspended solids is introduced to the filter below the tubesheet and flows through the inside of the filter elements. Solids collect on inside surface of the elements as filtrate passes through the elements to the outside surface. See Figure 1 below.

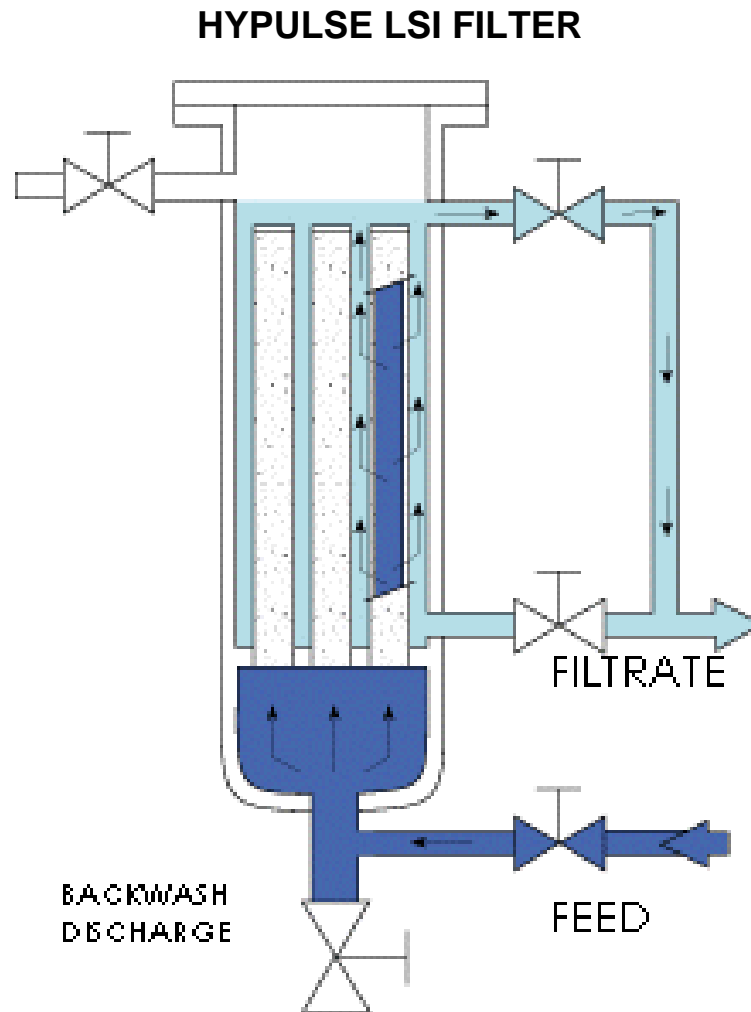


Figure 1

The accumulation of solids on the inside surface of the filter elements is followed by backflushing to remove the solids as highly concentrated slurry. This process is as simple as flushing a slurry through a pipe.

The benefits of this configuration and operation are many:

- Elements can be packed closer together in a smaller housing.
- Solids are retained on the inside surface of the filter elements under hydraulic control as slurries are in pipes.
- There is no interference with adjacent elements on cake formation.
- Solids retained in the elements are immobile and fluids can be exchanged for maximum product recovery and backwash effectiveness.
- Higher pressure drops can be accommodated which result in longer filter cycles and higher filter throughput efficiency.
- Scale-up from pilot testing or smaller filters is readily determined.
- High flow rates and solids loadings can be accommodated without complex hydraulic calculations affecting solids deposition and fluid flow patterns.
- Simple outside-in backwash eliminates the strain and stress on adjacent elements during the backwash, resulting in a stronger, more reliable mechanical installation.

Materials of Construction

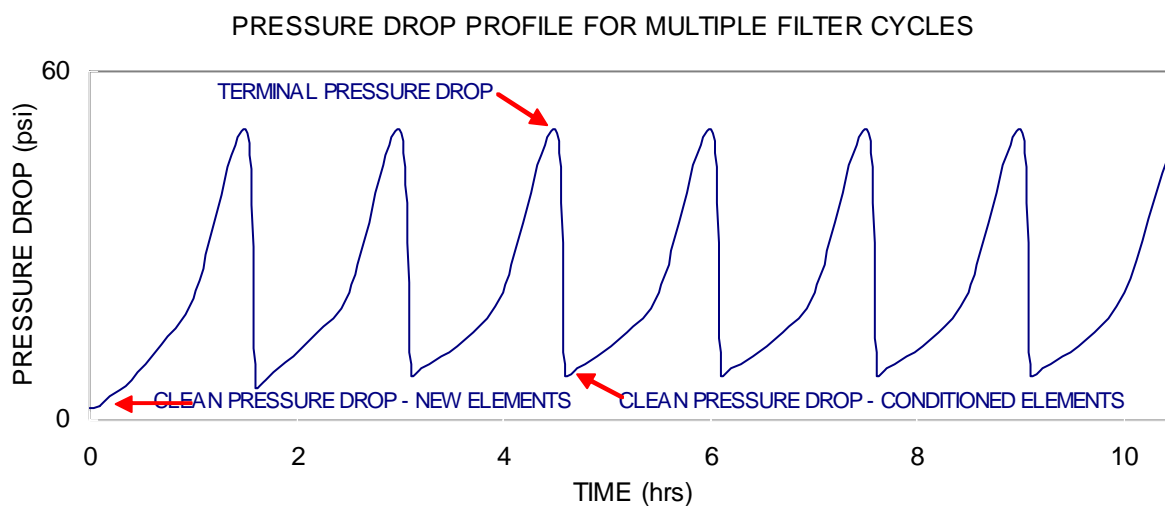
Mott's standard filter elements are constructed entirely of 316L stainless steel. Other alloys are available for severe process conditions. For refinery FCC slurry oil, carbon steel is typically used as the filter vessel material for operating temperatures up to 600°F.

Mott Precision Filter Media

There are many types of backwashable filters in the commercial marketplace in a variety of mechanical configurations. What truly distinguishes one from the other is the filter media used in the filter. Media selection is the key parameter for achieving the desired separation and for ensuring long operating life.

Mott precision porous metal filter media has controlled porosity and pore size that maximizes efficiency. For backwash filters to be successful over time, the media must provide the particle retention efficiency required and backwash clean cycle after cycle. Typical Mott filter cycle performance is shown by Figure 2.

Figure 2



Mott media, with its tightly controlled pore size, offers exceptional particle removal efficiency with minimal particle penetration into the media. The tightly controlled pore size and backwash operation of HyPulse LSI filters enable long operating periods between cleanings. Keeping the solids on the surface results in efficient backwashing and long filter element life. Most HyPulse LSI filters in slurry oil service are operating with their original elements, contributing to low operating costs.

Filter Mechanical Construction

The HyPulse LSI filter assembly is constructed for ease of service and operation. The filter vessel is cylindrical with standard ASME heads. A tubesheet is welded into the bottom of the vessel where the elements are installed with a 2 inch NPT thread. A high temperature thread sealer is used to seal the elements in the tubesheet. A stainless steel spider assembly is installed on top of the elements to maintain spacing. The flanged cover is sealed with Flexitallic gaskets.

The filter elements are 2 inch diameter, 80 inches long, each with an active surface area of 3.27 ft². The installation end has a 2 inch NPT threaded adapter to screw into the tubesheet. An installation tool is provided to screw in the elements.

Filtrate outlet nozzles are positioned both high and low on the vessel to allow for complete filtrate withdrawal and maximum product recovery. Additional nozzles are provided for auxiliary services and instrumentation.

This simple arrangement has proven to be an extremely reliable configuration that allows modification of operating parameters to maximize the process benefit of the filter installation. The versatility of the design allows for customization of process operation for maximum economic benefit. Figure 3, below, illustrates a large filter assembly.

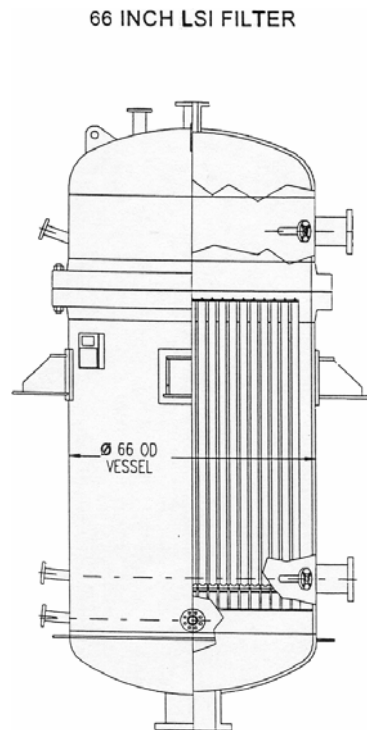


Figure 3

PREVIOUS FCC SLURRY OIL FILTER INSTALLATIONS

Mott has designed and installed slurry oil filtration systems with 24, 36, 42, and 66 inch HyPulse LSI filters. These include single vessel installations operating on a continuous basis with an interruptible flow, and duplex or triplex filter system operating on a continuous basis. One filter operates online, one is on standby, and one is a spare used during maintenance periods. These filters operate on a simple cycle of filtration and backwash with an occasional flush with Light Cycle Oil. They have operated reliably and effectively since 1993.

RECENT ADVANCEMENTS

When a major refinery approached Mott with a requirement for a high flow, high efficiency filter for FCC slurry oil, the scalability of the Mott HyPulse LSI filter provided the obvious choice. The high flow requirement was satisfied by selecting a filter of sufficient size to contain the required number of filter elements. The high efficiency particle removal requirement was met with the proven Mott precision porous stainless steel media. Pilot filter testing confirmed all operating parameters. The required filter was 66 inches in diameter and is capable of processing in excess of 10,000 BPD slurry.

The requirement for a continuously operating process was satisfied by a Mott triplex filtration system, which included a backwash receiver. The normal operating mode has one filter on line, one on standby, and one as a spare. Given the reliability of Mott filters, extended cycle times were obtained by running two filters simultaneously, but staggered in cycle time, with the third filter being on standby for utilization when one of the online filters requires backwashing. All three filters are employed in the filtration cycle to make maximum utilization of the available surface area.

For maximum operating efficiency, product oil is purged from the filter housing and is replaced with LCO for backwashing. This is completed without loss of solids during the fluid exchange, one of the features of the HyPulse LSI design.

This filter installation represents a major enhancement of HyPulse filter technology in both the scale of design and operating efficiency. The system operation takes advantage of every design feature of the HyPulse LSI filter, resulting in maximum economic benefit to the refinery. As noted earlier, Mott's customer realized the benefits of the HyPulse LSI design and promptly selected an identical system for a second refinery.

A review of the system's process conditions, filtration requirements, design specifications, and operating results is summarized below:

PROCESS CONDITIONS AND REQUIREMENTS

Process Fluid:	FCC Slurry Oil
Gravity, API:	-1.0
Process Rate:	More than 10,000 BPD
Slurry Solids Concentration:	1,000 ppm
Product Solids Concentration:	Not to exceed 50 ppm
Operating Temperature:	450-550°F
Operating Pressure:	50-130 psi
Minimum Cycle Time (Interval between Backwashes):	2 Hour

PROCESS CONDITIONS AND REQUIREMENTS (cont'd)

Filter Backflush Liquid:	Light Cycle Oil
Operation:	Continuous with maximum interchangeability between the filter vessels. Backwash solids to a receiver tank with LCO.

FILTER SYSTEM DESIGN SPECIFICATIONS

A Mott HyPulse LSI filter system consisting of three 66-inch LSI filters and one 96-inch backwash receiver was selected to meet the specified requirements. Each filter is capable of handling the full process flow and meeting the requirements of 2-hour intervals between backwashes. Mott's precision filter media delivers the required product quality. The scope of supply was a complete filter system, including all interconnecting piping, valves, controls and instrumentation. System design specifications are as follows:

Filters:	Three (3) HyPulse LSI Filters, Model 846680-421-2-0.5
Vessel Diameter:	66 Inches
Design Conditions:	300 psi at 600°F
Maximum Available Pressure Drop:	100 psid
Operating Cycle Pressure Drop:	30-60 psid program adjustable
Filter Elements:	2-inch diameter by 80 inches long, 316L stainless steel
Control Valves:	Actuated Eccentric Plug
Instrumentation:	Rosemont Smart Transmitters for pressure, level, and temperature
Flow Measurement:	Orifice meters
Process Control:	PLC communicating to the refinery DCS

OPERATING RESULTS

Filtrate Quality

The filter system has consistently delivered product solids concentration well below the required maximum.

Filter Cycle Time

With low viscosity resulting from high slurry temperatures, and high cycle pressure drop of 60 psid, filter cycles between backwashes exceeded 4 hours with one filter online at full flow rates, and more than 16 hours with two filters online.

Process Efficiency

With long cycle times, the efficiency of recovered product as a percentage of feed slurry exceeds 99.8%. For every 1000 barrels of filtered product slurry, only 2 barrels are lost to the backwash.

Cycle time is affected by the oil viscosity, operating filtration flux rate, and rate of solids to the filter. Since the filter loads to a certain solids level under prescribed conditions, the filtration cycle can change with these variables.

Filter Pressure Drop

Clean pressure drop (i.e. pressure drop seen after a backwash) has been very stable at under 3 psi, indicating that the filter media is being cleaned effectively by the backwash. The dirty filter pressure drop is program adjustable up to the design limit of 100 psid. The typical cycle pressure drop is set for 60 psid for routine operation to reduce wear and tear on the equipment.

The unique HyPulse LSI design provides for high pressure drop capability that significantly extends the filter cycle time. The precision pore size filter media is designed to work at these pressures without plugging due to particle penetration. In actual operation, inadvertent pressure drop excursions as much as 40% above desired operating limits have had no effect on the filter, the media, or subsequent filter cycle performance.

CONCLUSIONS

The Mott HyPulse LSI has performed from startup beyond the requirements and expectations of the customer. The mechanics of the system have functioned very well with few corrections required. This latest installation is one of a series of successful HyPulse LSI applications that continue to demonstrate state of the art filtration with Mott filters.

MOTT HYPULSE LSI FILTERS IN FCC SLURRY OIL INSTALLATION LIST

Year	Customer	Bbls/day	# of HyPulse Vessels
1990	BP Oil, Toledo, OH	4000	1
1993	Clark Oil & Refining (formerly BP), Lima, OH	3500	1
1993	BP Oil, Grangemouth, UK	2200	3
1997	Confidential (USA)	>10,000	3
1997	CNPC/Hubei, China	860	3
1997	Confidential (Europe)	>10,000	3
1999	SINOPEC/Shengli, China	1000	2
1999	CNPC/Hubei, China	500	3
2000	Petrochina / Dagang Refinery, China	2060	2
2001	Sinopec / Tianjin, China	945	2
2001	Petrochina / Fushun, China	945	2
2000/02	Petrochina / Jilin, China	500	2/2
2002	CITGO Petroleum / IL	7000	3
2003	Sinopec / Qilu China	1715	2
2003	Slovnaft / Slovakia	1000	2
2004	Petrochina / Yumen China	1545	2
2004	Sinopec / Jingmen China	1030	2
2004	Sinopec / Cangzhou China	2060	2
2005	Petrochina / Lanzhou China	4300	2
2005	Petrochina / Daqing China	1545	2
2006	Petrochina / Jinzhou China	3770	2
2007	Petrochina / Soralchin Algeria	515	2