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WASTE MINIMIZATION WITH POROUS METAL BACKWASH FILTERS

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INTRODUCTION

Solid-liquid (S/L) separation [Ref. 1] is an area in the Chemical Processing Industry (CPI) where plant engineers and process designers are focusing considerable efforts on waste minimization. Driving pressures include increased profitability and compliance with newly enacted governmental regulation on waste disposal. Efforts are targeted at waste source reduction, process modifications that minimize waste, and increased reuse and recycling of process components. Separation equipment manufacturers have responded in a variety of ways, such as increasing separation efficiency, developing reusable filter media, eliminating filter aids, and reducing the liquid content of the solid waste. The majority of the equipment used in S/L separation employs sedimentation, centrifugation and pressure filtration techniques. Tubular backwash filters have gained increased acceptance in the CPI due to the use of a robust barrier for solids retention [Ref 2]. They also offer high flow capacity, good solids concentrating, and simplicity of operation.

This paper describes tubular backwash filters with renewable sintered powder porous metal media in S/L separation and how they benefit waste minimization. Application cases are given in CPI wastewater treatment, filter cake dewatering and closed-loop catalyst recovery.

POROUS POWDER METAL MEDIA

Tubular backwash filters described in this paper employ sintered powder porous metal media that has properties for minimizing waste in S/L separations. The all-welded design eliminates particulate bypassing at the end connectors of the filter element. High efficiency particle retention results from the pore size uniformity, as the pores are formed by sinterbonding size-controlled metal powders. The rigid matrix formed by these sintered powder particles imparts mechanical strength to the filter elements and prevents cake unloading at increased differential pressure, a phenomenon observed with less rigid media. The inert nature of stainless steel (SS) powder assures liquid purity during separation. For severe process conditions of high temperature or in corrosive environments, alloys like Monel®, Hastelloy® or Inconel®[i] are recommended.

Porous metal media are available in several discrete grades, ranging from 0.2 to 100 micrometer. The filtration characteristic and mechanical properties of the grades most commonly used in S/L separation are listed in Table 1.

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[i] Hastelloy® is a registered trademark of Haynes International, Inc.
Monel® and Inconel® are registered trademarks of International Nickel, Inc.

TABLE 1

MOTT CORPORATION POROUS 316L SS MEDIA PROPERTIES

Mott Micron Grade	***MFP[1] Size, µm***	***Min. Bubble Point[2], Inch H_2O***	***Min. Tensile Strength, psi***	***Wall Thickness, Inch***	***Pressure Drop[3], psi***
0.5	1.7	40.0	23,500	0.047	30.0
2.0	3.0	17.0	17,700	0.062	6.0
5.0	5.8	13.0	13,300	0.062	2.4
10.0	12.6	7.5	10,500	0.062	0.6

1. Mean Flow Pore per Coulter Porometer™
2. In IPOH per ASTM E128 modified
3. At 10 GPM/ft^2 water flow rate

HYPULSE®[ii] FILTERS

HyPulse S/L tubular backwash filters use a "static tube in vessel" design where all moving parts like pumps, valves and flow control devices are outside of the filter housing (see Fig. 1). The simplicity of this design allows completely enclosed operation which minimizes waste such as solids loss during cake removal or emissions of volatiles. The filter media is cleaned in place concurrently with the discharge of the collected solids at the end of a filtration cycle. The discharge is in the form of a pressurized gas-assisted hydraulic pulse utilizing a small portion of the filtered liquid to flush out the tubular filter elements and to eject the solids.

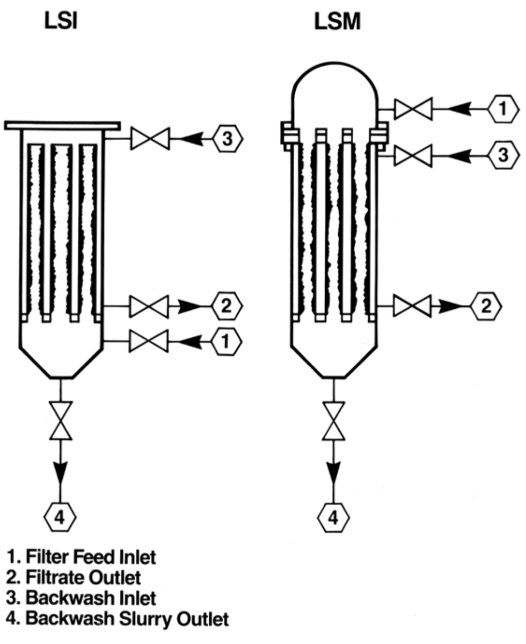


Figure 1: HyPulse Filter Options

[ii] HyPulse® is a registered trademark of Mott Metallurgical Corporation

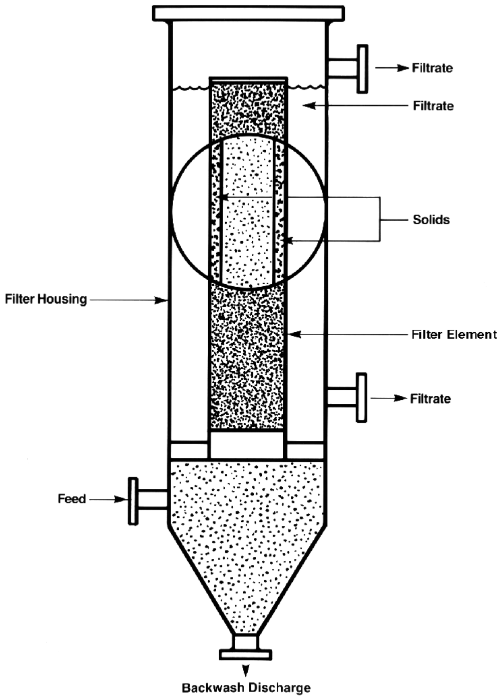


FIGURE 2: Design Schematic of HyPulse LSI Filter

HyPulse technology minimizes waste in three ways: first, the volume of the separated solids is reduced; secondly, the use of external fluid is eliminated; finally, the filter media is reused over many cycles. This reduces waste of the filtration media itself as well as product lost in the media.

The defining feature of the HyPulse® filters is the inside-to-outside flow of the process fluid with the collection of captured solids on the inside surface of the tubular filter element. The HyPulse LSI model with single open-ended elements used as a dead end filter is shown in Figure 2.

The benefits of inside-to-outside flow are (a) cake stability throughout the complete filtration cycle ensuring consistent filtrate clarity, (b) post-filtration cake washing with minimal consumption of wash liquor due to plug-flow type liquid displacement in the filter elements, and (c) cake de-watering by gas displacement of free liquid inside and outside of the filter elements. To minimize waste HyPulse® technology reduces solids contamination of liquid products, and minimizes loss of liquid products in the recovered solids.

APPLICATIONS

Case 1: Crystallizer tails polishing for waste water COD reduction

A porous metal backwashable HyPulse LSI filter was successfully applied on aqueous crystallizer tails polishing. This proved to be an economical solution to reduce a chemical oxygen demand (COD) problem in a waste water treatment plant. The problem was traced, in part, to fines carried over in the tails from the crystallizer. A rugged backwash filter was demanded because of the process conditions and the abrasive nature of the crystals.

The objective of the filtration was to capture the fines comprised of particles larger than 2 μm, and return them back to the crystal separator for zero waste operation and minimal waste water contamination. The solution to the problem consisted of a three-step process: particulate characterization; pilot plant testing; and design of a full-scale filter system. Particle size and filtration characterization were a problem to analyze because of process temperatures of 150 to 190°F and continued crystal growth once a sample was removed from the crystallizer. A fully automated pilot filter was installed at the plant to determine feasibility and suitability in application. Specific scale-up parameters to be determined were: porous media grade, cake properties, and backwash requirements; optimum location of the filter in the process system; and where best to recycle the recovered particulate matter. After successful field testing, scale-up was performed and full size filters installed.

The continuous flow of crystallizer tails with 1.5 weight percent of solids was handled with an automatic triple filter system, with two filters simultaneously on filtration and the third being regenerated or on stand-by. Process conditions of aqueous 2% nitric acid (HNO_3) at up to 190°F required all 316L SS materials of construction. The original elements have been working for more than six years with multiple daily blowbacks.

This is an example of COD waste reduction at the point-of-origin instead of treatment at the end of the pipe where the contaminants are diluted and more expensive to treat. The effective removal of the crystals by filtration reduced the COD. Zero waste operation produced added value in crystal yield.

Case 2: Solids waste minimization in synthetic lube production
A manufacturer of synthetic lube upgraded the product purification step with a tubular backwash filter. Objective of this step was the removal of 1 to 2 weight percent of lime, activated carbon, catalyst fines, and traces of metal oxides and silicas. A single HyPulse® LSI filter replaced two filter presses that required frequent replacement of paper filter media and produced so-called hot drips on the floor during cake discharge. Manual cake removal limited feed temperature with the presses to 150°F. The fine nature of the solids present in the feed also required the addition of filter aid which increased the waste to be disposed of in an incinerator.

Pilot testing on-site with a single element HyPulse tubular filter provided excellent filtrate clarity in the first pass. A further advantage was the capability of the SS media to filter at 300 to 350°F, in contrast to cooling of the feed stream prior to the filter presses required by the temperature limitations of the paper media. The filter presses required an additional manual cleaning step.

TABLE 2

SYNTHETIC LUBE POLISHING: COMPARISON OF FILTER PERFORMANCES

	FILTER TYPE	
	PLATE & FRAME	***TUBULAR BACKPULSE***
Filter Media	Disposable Paper/Cloth	Re-usable Powder Metal
Filtration Temperature	≤150°F	≤350°F
Cake Removal	Manual	Automatic
Filter Aid	Yes	No
Weight % Solids in Cake	37.7	43.6

A significant breakthrough was achieved when filter cake dewatering was evaluated. The MOTT HyPulse LSI filter produced a drier cake than the filter press. The liquid content of the discharged solids was reduced by one-fifth; adding two benefits: (a) increased yield of polyol esters and (b) significant improved charging of the waste solids to the incinerator. Elimination of filter aid material and filter paper reduced ash content of the incinerated solid waste. A performance comparison of the two filters is shown in Table 2. The payback for the complete $400,000 tubular backpulse filter upgrade including site modifications and change of associated equipment was estimated to be 18 months in this application.

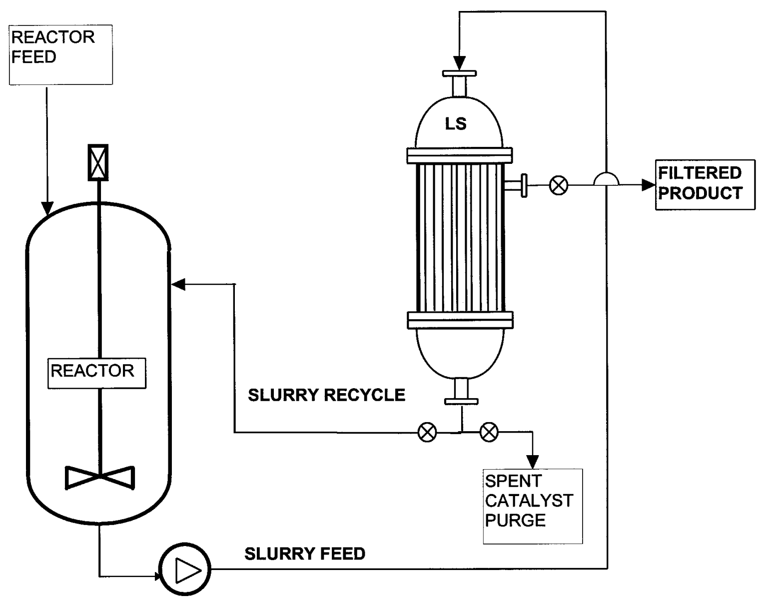
Case 3: Integrated closed-loop catalyst recycle

The S/L separation in this case concerns the retention of fine suspended catalyst particles (0.5 - 100 µm) from a continuous flow, stirred tank reactor (CSTR) where an isomerization reaction is carried out at closely controlled pressure and temperature. In the past, in-tank filter candles covered with either felt or cloth socks were used to retain the catalyst particles. With a typical media life of four weeks sock replacement would require frequent CSTR shutdown. The sock media also allowed fine attrited catalyst to pass requiring secondary back-up filters.

The proposed HyPulse Filter design remedied several aspects of waste: the frequent disposal of primary in-tank filter socks as well as secondary filters; the loss of catalyst associated with the media exchange and disposal; and loss of product. Further process efficiencies were expected by minimizing the waste of raw materials due to product yield reversal when catalyst leaked into downstream operations. Finally, the elimination of frequent shutdown of operations for in-tank sock exchanges would lengthen the active life of the catalyst.

Based on laboratory testing, the customer decided to recover the catalyst outside of the reactor. This afforded both steps, i.e. reaction and separation, to be operated at their respective optimal conditions. A single HyPulse® LSM type filter was installed in a loop around the reactor, as shown in Figure 3.

FIGURE 3: HyPulse LSM Filter For Integrated Closed-Loop Catalyst Recycle



The HyPulse LSM filter utilizes double open-ended porous metal filter elements (see

Figure 1). A portion of the reaction slurry entering the filter from the top is continuously filtered by inside-to-outside flow to maintain residence time in the reactor-filter loop aggregate. Slurry exiting from the bottom of the filter is recycled to the reactor (see Figure 3). The recirculation is set at a rate such that the filter cake thickness in the elements is dynamically controlled without need for filter shutdown.

Additional discussions of this novel technology which has advanced catalyst filtration with CSTRs are presented in Refs. 3 and 4. The specific waste minimization experience in this application has been: the novel HyPulse LSM significantly increased the catalyst life due to in-process recycling, high solids retention ($\leq$ 0.01 PPM of suspended solids in filtrate) increased feedstock conversion, and the porous sintered powder metal media reliability eliminated filter media waste.

REFERENCES

[1] Svarovsky, L. (edit.), 1979, “Solid-liquid Separation,” Butterworth

[2] Mayer, E., 1988, Filtration News, 24-27, May/June 1988

[3] U.S. Patent No. 4,552,669 (Nov. 12, 1985), R. Sekellick, assigned to Mott Metallurgical Corporation

[4] Julkowski, K. J., Mayer, E., Paper presented at American Filtration & Separations Society Conference, Minneapolis, MN, April 29-May 2, 1997: “Catalyst Recovery from Continuous Flow Reactors with Mott HyPulse LSM Filters”