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# A Simpler and More Cost Effective Solid-Liquid Separation for the Mining Industry

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ABSTRACT: This paper discusses new solid-liquid separation technology introduced by Pncumaprcss® Filter Corporation that addresses may of the limitations of conventional filler technology. The operating principle of this technology is outlined and a process How diagram provided. Two case studies of mineral applications are provided to demonstrate the effectiveness of this technology.

## I INTRODUCTION

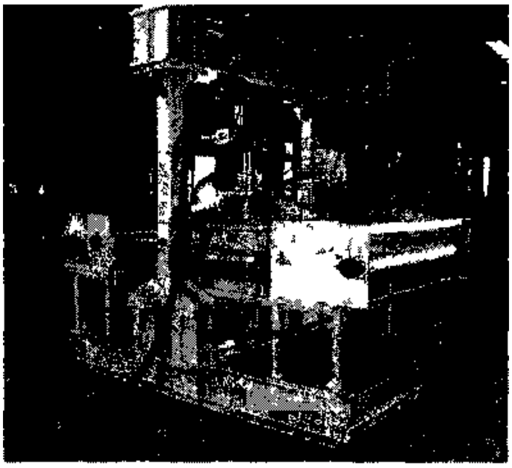
Cost effective solid-liquid separation technology is essential to the economical production of solids or filtrate in the chemical, food processing and mining industries. To achieve this, the plant engineer faces a wide selection of filter technology. The chosen technology should achieve the desired solids and filtrate properties, provide reliable operation as well as offer low installation, operating, and maintenance costs. Unfortunately, a great deal of the technology available today does not satisfy all of these requirements and a misguided decision may result in significant operating difficulties, high operating and maintenance costs, and a poor return on investment. This paper introduces a new technology that addresses these requirements and provides case studies from several applications where this technology has been successfully implemented.

## 2 CONVENTIONAL FILTER TECHNOLOGY

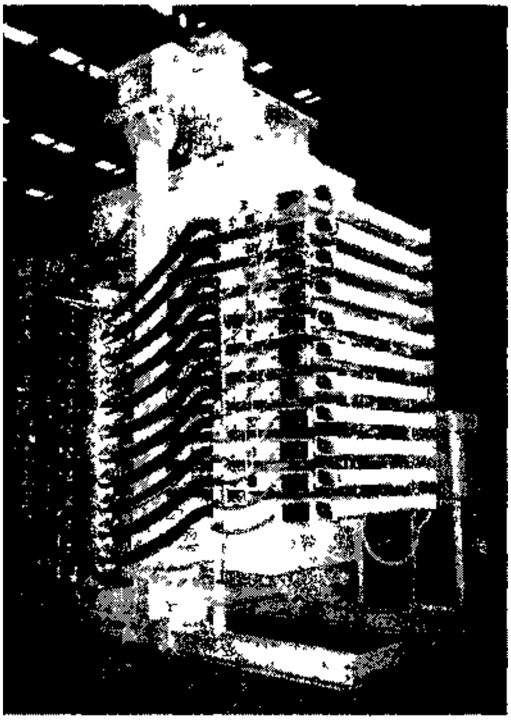
The most widely used conventional filter technology includes liker presses, vacuum fillers, centrifuges, low-pressure automatic pressure filters and high-pressure or mechanical expression automatic pressure filters. Conventional filter presses sutler Irom unavoidable labor costs and solids build-up removal problems that may result in leakage and damage. Despite attempts at automating filter presses, there remains the need for a great amount of operator intervention and large volumes of wash water to clean the filter media. Vacuum filters often produce high cake moistures, high solids content in filtered liquid and require large amounts of floor space and peripheral equipment. Centrifugal separation often requires high maintenance and expensive installation for the rotating equipment, inefficient washing or dewalering of solids, extensive structural and foundation support, large amounts of surrounding equipment, and large areas of floor space. Low-pressure coolant type automatic pressure filters have been limited in capacity and pressure differential for acceptable throughput and performance. High pressure or mechanical expression automatic pressure fillers arc very complex mechanically, have a multitude of expensive components and require intensive maintenance. Together, these limitations result in unscheduled downtime and loss of production.

## 3 NEW FILTER TECHNOLOGY

In order to address the limitations of conventional filter technology as outlined above, Pneumapress® Filter Corporation introduced a new series of high-pressure automatic pressure filters (APF's). The focus lor the design of the new high-pressure APF was to develop very effective filtration technology using mechanically simple and robust equipment available in a wide range of capacities. These filters are available cither as a Single Module Filter with only one filter chamber (figure 1.0) or as Multi Module Filter with multiple chambers (figure 2.0). A filter overview with operating sequence, process How diagram, process parameters and case studies are discussed in this paper to illustrate the filters effectiveness and simplicity.



Fıguıe l Sıngle Module Fıltcı



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## 4 FILTER OVERVIEW

A \ei> simple mechanical structuie is used to support the lıltei The stiuctuie consists ol two columns an uppei and lowei support beam and two base beams These components are illustrated in tiguies 10 2 0 and 5 0 Within the support structuie aie the filtei plate(s) and a single hydraulic cylinder The hydraulic cylmdei is used to open and close the filtei plate(s) and keep the plate(s) closed when the liltratıon pıocess is in pıogıess Each tiltei plate consists or an uppei *un* lowei chambei with two layeis ol l'iller media between the chambers Each filtei plate has its own individual lilter bell, belt drive system and belt wash system Piping to feed the filter is typically supplied as shown in figure 5 0 and the ti I tot ıs controlled using a PLC Filtei cakes are discharged into a cake icmoval system such as a mixing box conveyoi or tote box as shown it Fıguıe 7 0 A process flow dıagıam is shown in Fıguıe 6 0

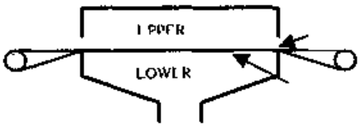
## 5 FILTER OPERATION

The tılreı cycle consists ot a sequence or lilteung steps that mcoipoiate certain hltiation principles to optimi/e the pıoductıon ol solids and filtrate

The séquence ol lillenng steps in a typical Pncumapress® lilter application wheie sluiry must be effectively washed and dewatered to pioduce substantially diy solids ıs descııbed below These steps aie illustrated in Figures 3 0 to 3 3

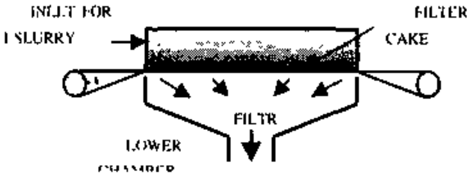
### *Step 1 - h die) Plaie Closı *

In Step 1, the upper chamber closes on a double layer of filtei media oi filtei belt that is supported by a grid on the lowei chambei



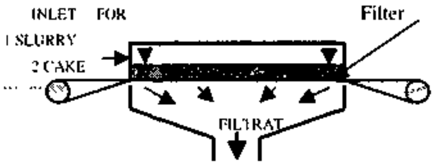
### *Step 2 - Sim ı \ Fill/Cake Wash*

In Step 2, shiny is pumped into the upper chambei ol the filtei plate (Figure 3 1 ) A filtei cake begins to loi m on the filtei belt as the solids are letained on the lılteı belt and the clean lillrate passes into the lower chambei ol the filtei plate and out ot the filtei The slimy lill pcnod oi duration may be controlled using time sluny picssuie, weight or a flow monitoring system The optimum slurry fill time or slurry inlet piessuic set point may be the fill time oi pressuie set point that pioduces the most solids or filtrate per cycle without a deciease in cake diyness oi loss ol wash liquid effectiveness Increased cake size and a double layer ot woven lilter media provide a ınoıe tortuous path loi the sluny, thus improving filtiate clanlv and minimizing pioduct loss Alter sluny fill is completed cakewash watei may be introduced and contiolled in the same mannei as the slurry fill



*Step 4 - Gas Squeeze*

In Step 4, compressed air or gas is introduced into the filter chamber to force liquid from the solids and to squeeze and dry the solids retained on the filter media (figure 3.3). As the air or gas enters the filter chamber it displaces the slurry and de-waters the solids that have formed on the filter media. No diaphragm or other squeeze mechanisms are used within the (liter chamber to dewater and dry the filter cake - the air or gas does all the de-watering and drying. A sufficient supply of compressed air used at optimum pressure differential results in decreased air use and very fast and effective dewatering.

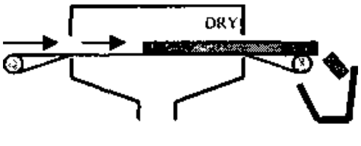


*Step* 5 - *Plates Open*

In Step 5, the filter plate opens and the newly formed dry filter cake is retained on the filter belt.

*Step 6 - Cake Discharge*

In Step 6. the final step of the filtration cycle, the filter bell advances and the dry filter cake is discharged into a mixing box, lole box or onto a conveyor belt (figure 3.3 and 7.0). As the filter belt advances, it is scraped and washed and a clean section of filter belt moves into the filter chambers in preparation for the next filter cycle. No operator intervention is required at any time during the filter cycle - the filler cycle is fully automatic.



After the filter cake is discharged, the filtration cycle is automatically repeated. Typical cycle times vary from less than one minute to several minutes, depending on the application. The operating principle of a single-module filter with one filter plate is virtually identical to that of a multi-module filter with a number of filter plates.

## 5 PROCESS FLOW DIAGRAM

A typical process How diagram for the installation of a Pneumapress® single or multi-module filter is illustrated in figure 6.0. As illustrated in the process How diagram, ihe installation of the filter is very simple and does not require complex peripheral equipment.

## 6 PNEUMAPRESS® ADVANTAGES

The Pneumapress® single and multi-module filters differ from conventional fillers in several ways. These key differences greatly enhance the effectiveness of the Pneumapress® filter by providing many operational advantages. Some of these advantages arc discussed below:

*Low Installation Costs*

Minimal structural installation requirements, minimal floor space requirements, simple assembly, few process connections and minimal peripheral equipment results in low installation costs.

*Low Maintenance Costs*

Because of the mechanical simplicity of the filler and the selection of components to ensure local availability for the end user, maintenance costs are minimized.

*Mechanical Simplicity*

Each Pneumapress® filter is designed and constructed with the objective of minimizing the number of components required. The filter uses a fraction of the mechanical components used on other filter equipment.

*Operational Simplicity*

Each filler is extremely simple to operate. The filter is completely automatic and no operator intervention is required at any time during the filter cycle. The filter may be operated from a control panel next to the filter or from a remote control point using a DCS or other control system.

*Reliability*

Because of the mechanical simplicity of the filter and the low maintenance required, filter reliability and minimum downtime is ensured.

*High Performance*

Very high throughput per unit of filter area is achievable because of the fast filtration cycles.

*Highly Effective Cake Washing*

The design of the filter chamber optimizes molecular contact between the cake wash and the filter cake. This ensures consistent cake wash results with a minimum use of wash waster.

*Isolatable Filter Plates*

The heavy-duty design and construction of the filter plates allows the individual filter plates of a multi-module filter to be isolated during production. This design also eliminates the risk of damage to the filter plates that results when process malfunctions create internal pressure differences within the filter.

## 7 CASE STUDIES

### *7.1 Case Study No. I: Removal of precipitated silica from a clarifier underflow*

In the Imperial Valley of California a geothermal power generation facility uses a dual flash, crystallizer-clarifier process to control solids precipitated as the geothermal stream cools. Precipitated silica solids must be continuously removed from the system to maintain effective operation. The solids are removed at the clarifier underflows from a 224°F stream containing approximately 33% solids by weight and approximately 30% dissolved salts.

Among equipment previously utilized to de-water underflow sludge were plate & frame filter presses, cavity filter presses, centrifuges, sludge drying beds, vacuum trucks, horizontal plate filters (low pressure APF's) and high-pressure mechanical expression filters (high pressure APF's).

In the past, horizontal plate filters (low pressure APF's) and expression or squeeze filters (high-pressure APF's) have been the most attractive equipment to dewater geothermal sludge. Benefits of utilizing horizontal plate filtration include uniform distribution of filtered solids and a large filter area. However, the hot corrosive geothermal slurry limits the choice of materials utilized in the filters. Elastomer products such as gaskets, diaphragms, and chamber seals became consumables requiring a significant amount of manpower for disassembly of the filter and removal and replacement of the consumable parts at regular intervals. Problems such as joint leakage, separation of components, and crushing of horizontal divider plates occurred with the low pressure APF. Elastomer diaphragms used to squeeze the hot brine slurry through woven filter media with the high pressure (mechanical squeeze) APF's failed at regular intervals and therefore required frequent replacement. Also, the diaphragm filters require a separate skid, reservoir and piping equipment for diaphragm filling and retraction.

A factor limiting production with the expression (mechanical squeeze) high pressure APF's is the operating cycle and configuration of the filter chamber. Due to the chamber configuration of the high pressure expression APF and non-uniform resistance to flow through the cake, effective cake washing to remove solubles required a large amount of wash water both increasing cycle time and water use. Another factor limiting production is the time involved to fill and retract diaphragms and inflatable seals (when used). A typical expression filter produced a filter cake every 8 to 12 minutes when the filter was in good working order. The Pneumapress® filter, which used shorter cycle times (2 to 4 minutes) combined with more effective solids and filtrate production, substantially outperformed the expression filter with much less filter area - see Figure 4.0.

The limitations in production with the low pressure APF and expression high pressure APF were overcome with the Pneumapress® filter by eliminating diaphragms and expression mechanical equipment, inflatable chamber seals, and diaphragm fill and retract equipment. The problem of crushing filter plate components was overcome by using more suitable filter components and incorporating design parameters better adapted to service the filtering application. To accommodate the severe operating environment of the hot corrosive geothermal slurry and maintain structural integrity, welded filter components were fabricated from a corrosion resistant alloy using fabrication techniques that remove internal residual stresses from the structure, eliminate deformation while in service and prevent sensitization of the filter components. Furthermore, the filter structure is designed to provide effective distribution of the internal pressure and resulting forces, thus enabling the filter to withstand high operating pressures. The Pneumapress® Filter is also designed to accommodate unrestricted flow through an optimum chamber configuration to maximize particle contact in the filter chamber for effective washing of slurry solids. Another benefit of the Pneumapress® Filter is the introduction of technology to eliminate leakage of slurry and filtrate during filter operation without the use of consumables such as gaskets, o-rings or inflatable seals.

Eliminating specialized equipment, eliminating consumable components and adapting appropriate fabrication techniques using corrosion resistant alloys have enhanced the reliability of the Pneumapress® Filter and reduced the cost of operating the Geolhermal Plant.

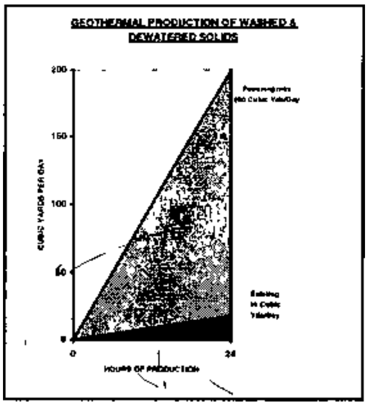


Figure 4 0 Geothernia1(Piocluction

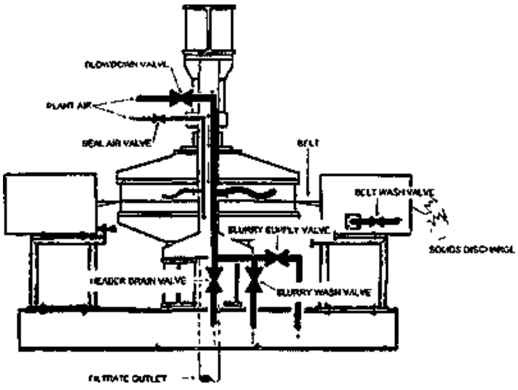
*7.2 Ca.sc• Study No. 2: Dewatering oj Gxpsum A Iphci-lieiiuhydrate Slurry*

Calcium sulphate hemihydrate is processed in two forms, alpha-hemihydrate /ind beta hemi-hydralc. TÏÏe~lIIpTra^emihydrate4s-rHV>d4iccd by the decomposition ot gypsum in water at «Jevated temperature and pressure. It is used in specialty applications such as medical plasters and sclfleveling compounds.

Aflei the conversion process from calcium sulphate to alpha-hemihydrate, the alpha-hemihydrate slurry must be de-watered and dried. Conventional technology used in this process included centrifuges -or pressure filtration followed by conveying to a drying system.

A Pneumaprcss® filler using propriety filtration technology developed specifically for alpha-hemihydrate was installed to replace the conventional dewatcring technology. The installation of the Pneumaprcss® enabled the plant to dewater and dry the gypsum to 98..W solids in a single step, eliminating the dryer, and improving the crystalline structure. This was significantly dryer than previously obtained using conventional technology.

Along with eliminating the operating costs of the dryer the overall process was greatly simplified. The de-watering process itself was simplified, the conveying system to the dryer was eliminated, the dryer was eliminated and the bag house associated with the dryer was eliminated.



Figuie 5.0 Single Plate Filler Showing Piping Layout

# *PNEUMAPRESS* Process Flow Diagram

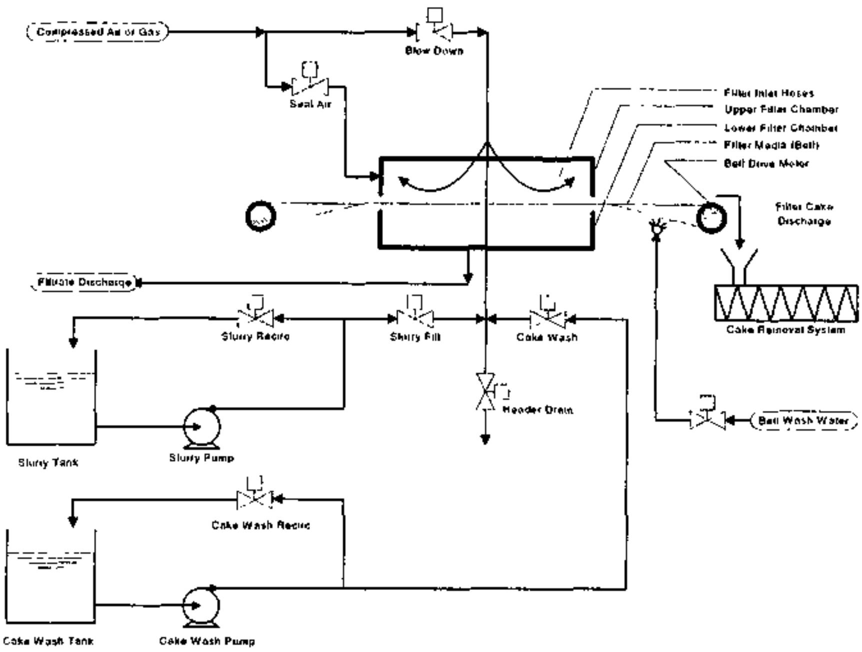
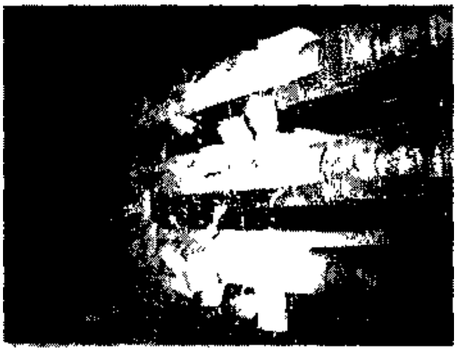


Figure 6.0 Process Flow Diagram

## Filter Process Parameters

Typical Pneumapress® filler operating parameters arc provided hclow. Actual operating parameters vary with each product being filtered.

| | |
|---|---|
| Individual Fıllei Plate Area | Plaies are manufactured in 1.3 ft$^{:}$. 3 ft$^{2}$. 8 ft$^{2}$. 12 ll$^{2}$. 19 ft$^{2}$. 30 It$^{2}$ (.12m$^{2}$. 28m$^{2}$. .74m$^{2}$. 1.Urn$^{2}$. 1.76m$^{1}$. 2.78m$^{2}$) |
| Number of filter plaies per fillei | Fillers are available with 1 to 24 plates |
| Total tıltei area pel liltei | Fılteıs aie available in sues of 1.3 ft" to 720ft$^{2}$ (,12m$^{2}$ lo67 nr) |
| Sluu y capacity | Filters are available to process from 1 to 10.000 gpm (.22 m'/hrto2.271mVhi) |
| Solids capacity | Filters may pioduce 1 to 250,000 lbs/hr of de-watered solids (.45kg/hr to ll.3.000kg/hr) |
| Opciating pressure | Filters are available to operate at up to 360 PSI (25 Bar) |
| Updating temperauue | Filters are available to opeiate at up to 400"F (204"C) |
| Fıltei cycle tune | Cycle times vary from 30sec to 5mms |
| Matenals of constiuction | Carbon Steel. Stainless Steel and many specialized materials |
| Flool space requiicments | Smallest models require 30ft"- largest 150ft$^{2}$ (2.8m$^{2}$ to 14m$^{2}$) |



Figuie 7 0 Filter dike Dıscluıge

## 8 OPERATING BENEFITS AND SUMMARY

Because the Pneumapress® filters are simple, versatile, and almost free of consumable items, they can be suited to many applications, including specialized applications such as processing corrosive and/or high temperature streams. The filters produce dry and uniform solids, high quality filtrate and are simple to operate and maintain. Very dry (up to 98.5% solids) can he produced, which can reduce or eliminate dryer requirements. Containment of toxic gases or volatile materials can be controlled with the simple design. Steam or non-reactive gas may be used to displace liquids from solids to prevent oxidation or avoid reactive mixtures during separation.

Versatility of the filler also means adaptability to rapid advances in filter media technology. Technical advances in nitration media at Pneumapress® arc used lo produce dry cake, effective cake washing, clean filtrate and high filter media cycle life. The filter is adaptable to the most efficient filter media suited for each application.

The result of using the Pneumapress® filter to displace existing equipment simplifies operations, reduces floor space requirements, simplifies CIP and greatly increases efficiency in separating solids and filtrate.

The impact of the single and multi-module Pneumapress® filters in reducing operating and production costs will motivate many cost conscience companies, who want lo retain competitive operations for the future, to utilize a Pneumapress® filter.