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

P. Costelloe
Pneumapress® Filler Corporation, Richmond, California, USA
Q. Kilavuz
Kilavuz Limited, Mersin, Türkiye

ABSTRACT: This paper discusses new solid-liquid separation technology introduced by Pneumapress® Filter Corporation that addresses many of the limitations of conventional filler technology. The operating principle of this technology is outlined and a process flow 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 leaker presses, vacuum fillers, centrifuges, low-pressure automatic pressure filters and high-pressure or mechanical expression automatic pressure filters. Conventional filter presses suffer from 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 moistrures, 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 dewatering 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 filters are 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 for 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 either 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 flow diagram, process parameters and case studies are discussed in this paper to illustrate the filters effectiveness and simplicity.
FILTER OVERVIEW

A simple mechanical structure is used to support the filter. The structure consists of two columns and two base beams. These components are illustrated in Figures 1 and 2.

FILTER OPERATION

The filter cycle consists of a sequence of filtration steps that incorporate certain filtration principles to optimize the production of solids and filtrate. The sequence of filtration steps in a typical Pneumapress® filter application where slurry must be effectively washed and dewatered to produce substantially dry solids is described below. These steps are illustrated in Figures 3 to 33.

Step 1 - Plate Close

In Step 1, the upper chamber closes on a double layer of filter media or filter belt that is supported by a grid on the lower chamber.

Step 2 - Slurry Fill/Cake Wash

In Step 2, slurry is pumped into the upper chamber of the filter plate (Figure 3). A filter cake begins to form on the filter belt as the solids are retained on the filter belt and the clean filtrate passes into the lower chamber of the filter plate and out of the filter. The slurry fill process duration may be controlled using time, slurry pressure, weight, or a flow monitoring system. The optimum slurry fill time or slurry inlet pressure set point may be the fill time or pressure set point that produces the most solids or filtrate per cycle without a decrease in cake dryness or loss of wash liquid effectiveness. Increased cake size and a double layer of woven filter media provide a more tortuous path for the slurry, thus improving filtrate clarity and minimizing product loss. After slurry fill is completed, cakewash water may be introduced and controlled in the same manner as the slurry fill.
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 flow diagram for the installation of a Pneumapress® single or multi-module filter is illustrated in figure 6.0. As illustrated in the process flow diagram, the 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 are 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 filter 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 filler chamber optimizes molecular contact between the cake wash and the filler 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 filler 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. 1: Removal of precipitated silica from a clarifier underflow
In the Imperial Valley of California a geothermal power generation facility uses a dual Hash, 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 tillers. 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.

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 Pne-
mapress® Filter and reduced the cost of operating the Geothermal Plant.

Calcium sulphate hemihydrate is processed in two forms, alpha-hemihydrate and beta hemihydrate. Alpha-hemihydrate is produced by the decomposition of gypsum in water at elevated temperature and pressure. It is used in specialty applications such as medical plasters and self-leveling compounds.

After 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 Pneumapress® filler using proprietary filtration technology developed specifically for alpha-hemihydrate was installed to replace the conventional dewatering technology. The installation of the Pneumapress® enabled the plant to dewater and dry the gypsum to 98.5% 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.
Filter Process Parameters

Typical Pneumapress® filler operating parameters are provided below. Actual operating parameters vary with each product being filtered.

| Individual Filter Plate Area | Plates are manufactured in 13 ft², 3 ft², 8 ft², 12 ft², 19 ft², 30 ft² (1.2m², 0.28m², 0.74m², 1.16m², 1.76m², 2.78m²) |
| Number of filter plates per filler | Fillers are available with 1 to 24 plates |
| Total filter area per filler | Filters are available in sizes of 13 ft² to 720 ft² (1.2m² to 67 m²) |
| Slurry capacity | Filters are available to process from 1 to 10,000 gpm (.22 m³/hr to 2,271 m³/hr) |
| Solids capacity | Filters may produce 1 to 250,000 lbs/hr of de-watered solids (.45 kg/hr to 113,000 kg/hr) |
| Operating pressure | Filters are available to operate at up to 360 PSI (25 Bar) |
| Updating temperature | Filters are available to operate at up to 400°F (204°C) |
| Filter cycle time | Cycle times vary from 30 sec to 5 mins |
| Materials of construction | Carbon Steel, Stainless Steel and many specialized materials |
| Flood space requirements | Smallest models require 30 ft² - largest 150 ft² (2.8m² to 14m²) |
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 be 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 filter also means adaptability to rapid advances in filter media technology. Technical advances in nitration media at Pneumapress® are used to 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 to retain competitive operations for the future, to utilize a Pneumapress® filter.