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DEWATERING OF SLURRY FROM GEOTHERMAL PROCESS STREAMS

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ABSTRACT

In certain areas of geothermal resource production solids are produced from different processes such as precipitated solids from the dual flash crystallizer-clarifier process utilized in the Imperial Valley of California and elemental sulfur from the oxidation of hydrogen sulfide utilized at The Geysers facilities near Healdsburg, California. Many forms of apparatus using several methods of separating liquid from solids have been utilized to dewater these slurries; however, the complicity of the apparatus devices, the frequent consumption of several components in the apparatus, and the high cost of maintaining and operating that dewatering equipment have suggested that a new solution to the problem was needed. The Pneumapress™ Filter was developed as an economical and reliable solution to these problems with liquid/solids separation.

INTRODUCTION

Red Hill Geothermal, Inc. and Unocal Geothermal Division are currently producing 220 megawatts of electricity at peak capacity in the Imperial Valley of California using a dual flash crystallizer-clarifier process. Precipitated silica, a by-product of the Imperial Valley operations process, must be removed continuously from the system to maintain effective operation. The solids are removed at the clarifier underflow from a 224 degrees Fahrenheit stream containing approximately 33% by weight solids and approximately 30% dissolved salts.

Among equipment previously utilized to dewater underflow sludge are plate & frame and cavity filter presses, centrifuges, a sludge drying bed, vacuum trucks, horizontal plate filters, and horizontal diaphragm filters. A pilot Pneumapress™ Filter was tested at Unocal Geothermal Unit No. 3 to evaluate a new method of dewatering geothermal slurry. A substantial increase in production of solids and filtrate were readily apparent. After evaluating production results the Pneumapress™ Filter was found to increase the production of solids and filtrate per unit area tenfold in comparison with existing equipment in the same resource area. Laboratory results indicated the additional benefits of dryer filtered solids and improved filtrate clarity.

DEVELOPMENT OF THE PNEUMAPRESS™ FILTER IN GEOTHERMAL SERVICE

In the past the horizontal plate filter and the horizontal diaphragm filter have been the most attractive alternatives to dewater geothermal sludge. Benefits of utilizing horizontal plate filtration include uniform distribution of filtered solids and a large filter area. However, filter plate seals were not effective in preventing leakage of filtrate during the filtration cycle and the hot corrosive geothermal slurry limited the choice of materials utilized in the filters. Elastomer products used as gaskets, diaphragms, and chamber seals became consumables with a significant amount of manpower required for removal and replacement at regular intervals. Problems such as joint leakage, delamination, separation of components, and crushing of horizontal divider plates occurred in filter plates fabricated from laminated phenolic sheet stock utilized in the horizontal plate filter. Failure of elastomer diaphragms used to force the hot brine slurry through woven filter media occurred with the horizontal diaphragm filters at regular intervals requiring frequent replacement of the diaphragms. The diaphragm filters require a separate skid with reservoir for diaphragm fill liquid, pumping equipment, ejectors to remove fill liquid and retract diaphragm, bag filters, booster pumps, and other piping equipment to operate the filter.

A factor limiting solids and filtrate production with the diaphragm filter is the limited filter chamber volume that accommodates the elastic limit of the

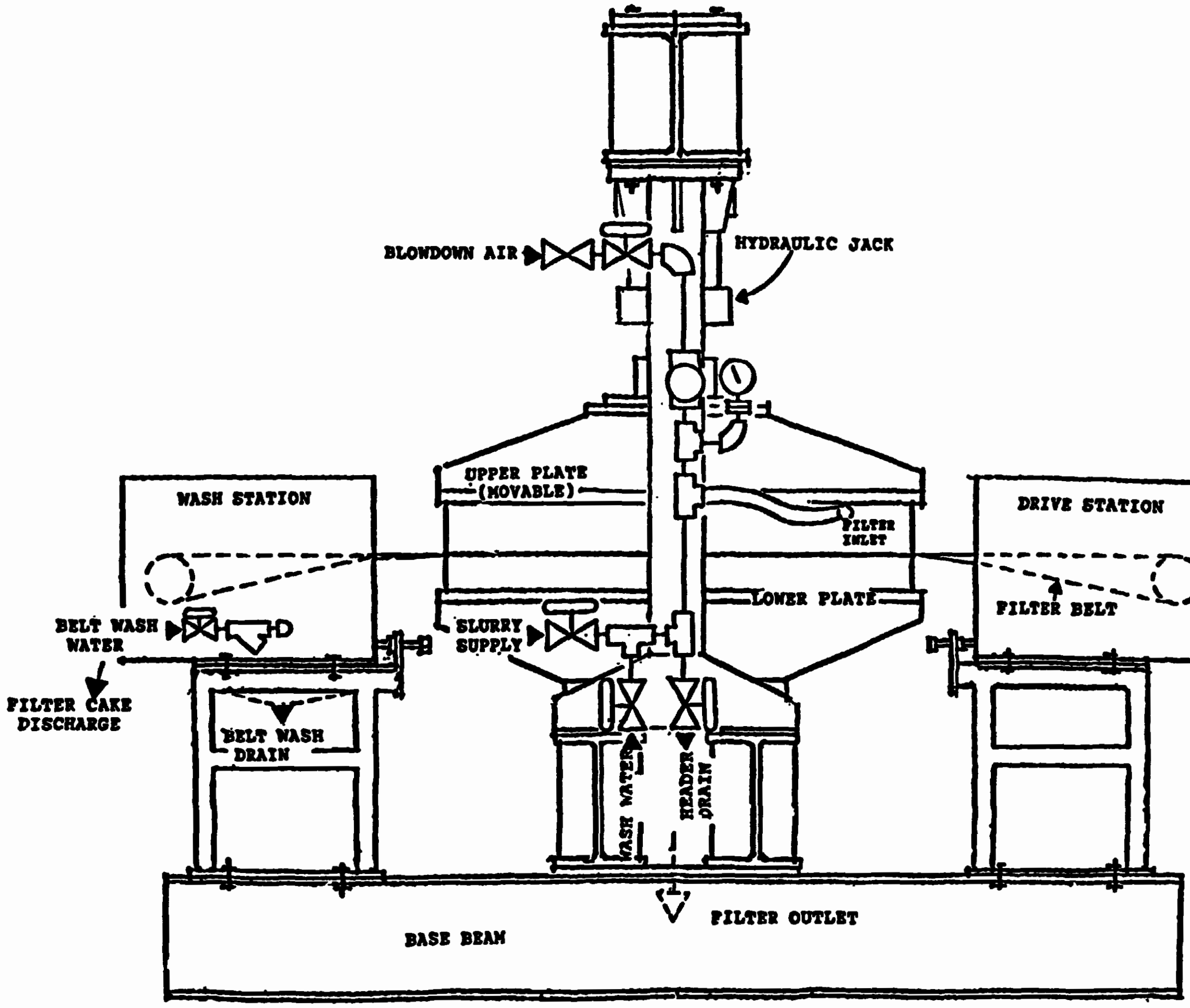


FIGURE 1. PNEUMAPRESS™ FILTER ELEVATION DRAWING

distended diaphragm in the filter chamber. The filter chamber with the retracted diaphragm is filled with slurry. After filling the chamber with slurry the diaphragm is hydraulically actuated to squeeze liquid from the slurry solids producing filter cake limited in size by the filter chamber volume that accommodates the distended diaphragm. Another factor limiting production is the time involved in each filtration cycle to fill and retract diaphragms and inflatable seals. Regular interruption to dewatering operations are required to replace squeeze diaphragms, contaminated diaphragm fill liquid in reservoir, and inflatable chamber seals. A typical diaphragm filter produced a 1" cake every 12 minutes when the filter was in good working order.

The limitations in production with the horizontal diaphragm filter were overcome with the Pneumapress™ Filter by eliminating diaphragms, inflatable chamber seals, and diaphragm fill and retract equipment thus eliminating the time to operate these devices during the filtration cycle. By eliminating the limited filter chamber volume that accommodates the squeeze diaphragm, optimum filter chamber volume can be utilized to substantially increase the volume of solids and filtrate processed per unit filter area. With a greatly reduced filtration cycle time and a substantial increase in the volume of solids and filtrate processed per unit filter area, the cost of solids and filtrate production utilizing the Pneumapress™ Filter is reduced to a fraction of the cost of production utilizing the horizontal diaphragm filter.

Separation of filter plate components utilized in the horizontal plate filter hampered dewatering operations and a wet 1" filter cake was produced every 20 minutes.
The problems with separation of filter plate components were overcome by using more suitable filter components fabricated from corrosion resistant alloys and incorporating design parameters better adapted to service the filtering application.

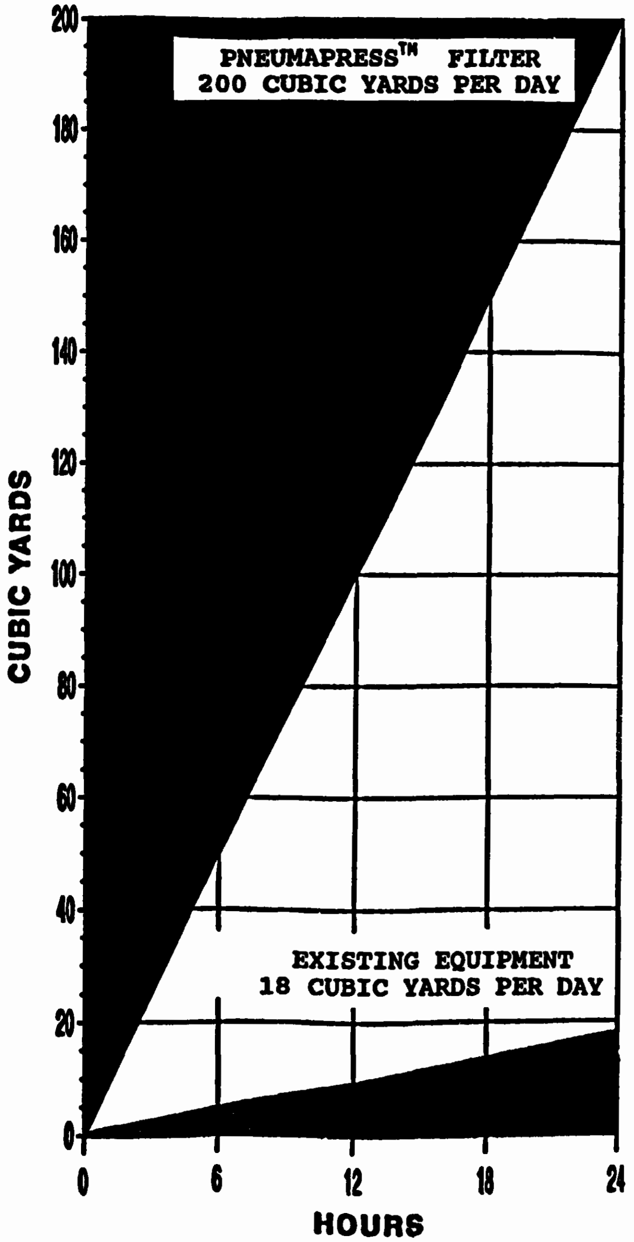


FIGURE 2. [1]SOLIDS PRODUCTION COMPARISON

[1]Figures are based on the productivity per unit filter area in operation.

The structure of the Pneumapress™ Filter is designed to provide effective distribution of pressure and resulting forces thus enabling the filter to withstand high operating stress. Filter structural components including filter plates do not require regular replacement or servicing. The filter chamber can accommodate unrestricted flow with optimum chamber depth to maximize molecular contact for effective washing of slurry solids. The reduced volume of wash liquid and reduced wash time required by the Pneumapress™ Filter reduces the time of each filtration cycle and improves the production rate per unit area providing additional operational cost savings.

Another benefit of the 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. This provides additional savings benefits by eliminating the cost of these items as well as manpower and interruption to dewatering operations to replace spent consumable items.

In order to adapt the Pneumapress™ Filter to the hot corrosive service and maintain structural integrity wettable filter components were fabricated with a corrosion resistant alloy using techniques that rid the structure of residual internal stresses, eliminate deformation while in service and prevent sensitization of the filter components. Eliminating specialized equipment, eliminating consumable components and related maintenance requirements, and adapting appropriate fabrication techniques using corrosion resistant alloys have enhanced reliability of the filter and greatly reduced the cost of plant operation.

PRINCIPLE OF OPERATION

A series of filtering steps are utilized to incorporate certain filtration principles that optimize the production of solids and filtrate. In the Imperial Valley, the Pneumapress™ Filter processes underflow from the clarifier separating precipitated silica solids from hot brine, washes dissolved salts from retained slurry solids in the filter chamber with wash liquid, and squeezes retained solids while compressed air forces liquid from the filter cake. The dry cake is then discharged into a tote box or conveyor belt.

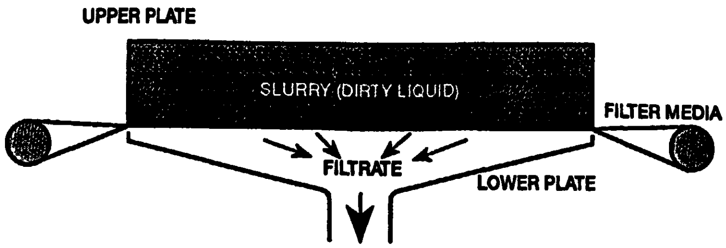
The sequence of filtering steps utilized with corresponding filter improvements is described below:

1. Filling of the filter chamber with geothermal slurry is controlled by time,

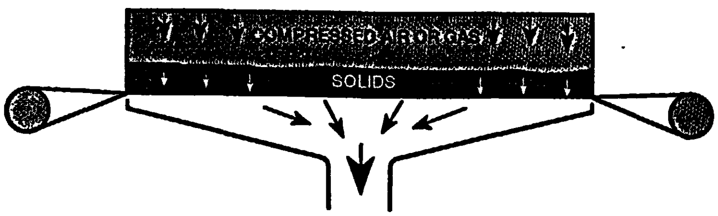
the optimum fill time being the fill time that produces the most dry solids per cycle without a decrease in cake dryness or loss of effectiveness of wash liquid. Note that increased cake size and a double layer of woven filter media provide a more tortuous path for the slurry thus improving filtrate clarity.

2. Wash liquid is then introduced into the filter chamber to wash dissolved salts from the retained slurry solids. With other filtration methods effective washing of dissolved salts from the slurry have been hampered by such obstacles as retracted elastomer diaphragms, structural components, and filter inlet and outlet components existing in the filter chamber which restrict optimum molecular contact. The design of the Pneumapress™ Filter chamber optimizes molecular contact between the slurry solids and the wash fluids. Changes in the filter cake and filtrate are being studied currently to measure the extent of the benefits in reducing the amount of wash liquid time

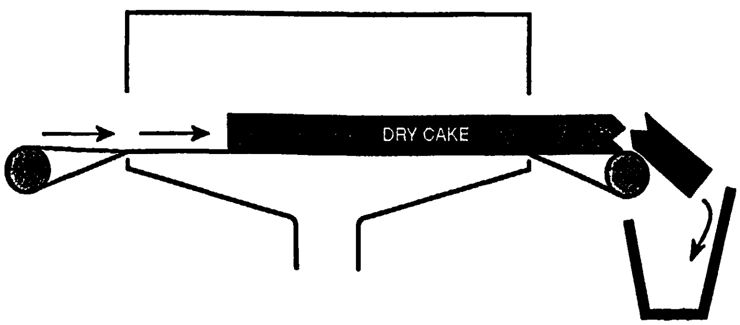
FIGURE 3. FILTER OPERATING PRINCIPLE



1. FILTRATION: Slurry is pumped into a filter chamber formed by lowering upper plate onto filter media. Filtered liquid is collected at the lower plate and is discharged through the filter outlet.



2. GAS SQUEEZE: Compressed air forces the liquid from solids retained on the filter media and dries solids "cake".



3. CAKE DISCHARGE: The upper plate is raised and the filter cake is discharged into a tote box or conveyor belt.

and volume.

3. Compressed air is introduced into the filter chamber to force liquid from solids and to squeeze solids retained on the filter media. A sufficient supply of compressed air used at optimum pressure differential results in a decrease of air use to a fraction of that used on equipment previously installed.

4. The final step in the filtration cycle is the discharging of the dry filter cake from the filter chamber into a tote box or conveyor belt.

Filtration cycles are automatically repeated with each filtration cycle being completed in 4 to 5.25 minutes depending on plant ancillary equipment and pumping rate.

APPLICATIONS IN SULFUR SLURRY DEWATERING

Work continuing in other geothermal applications includes the dewatering of Stretford sulfur slurry at The Geysers near Healdsburg, California where continuous oxidation of hydrogen sulfide to elemental sulfur and water is used to reduce corrosion and meet environmental standards. Pilot testing of the sulfur slurry resulted in a several fold increase in solids and filtrate production as well as substantial improvement in filtration variables such as solids content and filtrate quality. After evaluating filter performance a Pneumapress™ Filter is being considered to displace existing equipment.

CONCLUSION

Separation of liquid from solids in certain geothermal process streams is required to maintain proper operation of plant equipment and meet environmental standards. In comparing various methods of dewatering geothermal slurries the Pneumapress™ Filter is unprecedented in adapting successfully to geothermal service. Pilot testing of other geothermal applications shall continue in order to enhance geothermal resource production and reduce operating costs.

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