Pressure filters

Pressure Filtration is the process of separating a suspended solid such as a precipitate from the liquid in which it is already suspended by straining it – under pressure – through a porous medium that can be penetrated easily by liquid. Pressure Filtration is used extensively in a range of industries including:

- Chemical manufacturing
- Pigments
- Mining
- Mineral processing
- Frac sand
- Aggregates
- Sugar beet processing
- Winemaking
- Beer making
- Metal/surface finishing

The liquid to be filtered is called the suspension or slurry. The liquid passed by the filter is called the filtrate. The solid material remaining in the filter is known as the filter cake. The filtrate – free of solids – is forced out of the filtrate manifold.

Choosing a Filter Media for Pressure Filtration

Micronics' pressure filtration experts recommend the use of woven filter cloth or non-woven, felted material such as needle punched felt, depending upon the application and operating conditions. The choice of media is critical to the performance of the filtration equipment. The filter cloth is the key foundation to excellent filter press operations. Improvements in particle retention (capture efficiency) may be achieved by utilizing filter cloth that has been expressly designed with consideration for both the yarn type (e.g., monofilament, multifilament, textured, spun) and the physical construction of the cloth (e.g., weave, weight, etc.)

Solids

Solids are the physical state of matter in which samples maintain their shape and size. Some highly viscous liquids, such as cold molasses, flow so slowly that they seem to retain their size and shape and thus appear to be solids. Solids exhibit a regular arrangement of atomic, ionic, or molecular particles. Solid objects have a crystalline structure. In contrast, the molecules of liquids are arranged irregularly. Liquids have no crystalline structure.

Liquids

Substances in the liquid state of matter are intermediate between the gaseous and solid states. The molecules of liquids are not as tightly packed as those of solids or as loosely arranged as those of gases. The densities of liquids are usually lower than but close to the densities of the same substances in the solid state. In some substances such as water, the liquid state is denser. Liquids are characterized by a resistance to flow, called viscosity. The viscosity of a liquid decreases with temperature and increases with pressure. Viscosity is also related to the complexity of the molecules constituting the fluid. For example, the viscosity is low in liquefied inert gases and high in heavy oils. A liquid can sometimes be heated above its usual boiling point. Liquids in that state are referred to as superheated. Similarly, liquids can also be cooled below their freezing point.

Filter press

An M.W. Watermark 800mm Filter Press

An **industrial filter press** is a tool used in separation processes, specifically to separate solids and liquids. The machine stacks many filter elements and allows the filter to be easily opened to remove the filtered solids, and allows easy cleaning or replacement of the filter media. Filter presses cannot be operated in a continuous process but can offer very high performance, particularly when low residual liquid in the solid is desired. Among other uses, filter presses are utilised in marble factories in order to separate water from mud in order to reuse the water during the marble cutting process.

Concept behind filter press technology

Generally, the slurry that will be separated is injected into the centre of the press and each chamber of the press is filled. Optimal filling time will ensure the last chamber of the press is loaded before the mud in the first chamber begins to cake. As the chambers fill, pressure inside the system will increase due to the formation of thick sludge. Then, the liquid is strained through filter cloths by force using pressurized air, but the use of water could be more cost-efficient in certain cases, such as if water was re-used from a previous process.

Types of filter presses

There are four main basic types of filter presses:

i. plate and frame filter presses,
ii. recessed plate and frame filter presses,
iii. membrane filter presses and
iv. (fully) automatic filter presses.

i. Plate and frame filter press

A plate and frame filter press is the most fundamental design, and may be referred to as a "membrane plate filter." This type of filter press consists of many alternating plates and frames assembled with the supports of a pair of rails, with filter membranes inserted between each plate-frame pair.

- Plates provide support to the filter membranes under pressure, and have narrow slots to allow the filtrate to flow through the membrane into the plate, then out into a collection system.
- Frames provide a chamber between the membranes and plates into which the slurry is pumped and the filter cake accumulates.

The stack is compressed with sufficient force to provide a liquid-tight seal between each plate and frame, the filter membrane may have an integrated seal around the edge or the filter material itself may act as a gasket when compressed. As the slurry is pumped through the membranes, the filter cake accumulates and becomes thicker. The filter resistance increases as well, and the process is stopped when the pressure differential reaches a point where the plates are considered full enough. To remove the filter cake and clear the filters, the stack of plates and frames are separated and the cake either falls off or is scraped from the membranes to be collected in a tray below. The filter membranes are then cleaned using wash liquid and the stack is re-compressed ready to start the next cycle.

ii. (Fully) Automatic filter press

An **automatic filter press** has the same concept as the manual filter and frame filter, except that the whole process is fully automated. It consists of larger plate and frame filter presses with mechanical "plate shifters". The function of the plate shifter is to move the plates and allow rapid discharge of the filter cakes accumulated in between the plates. It also contains a diaphragm compressor in the filter plates which aids in optimizing the operating condition by further drying the filter cakes. **Fully automatic filter presses** provide a high degree of automation while providing uninterrupted operation at the same time. The option of the simultaneous filter plate opening system, for example, helps to realise a particularly fast cake release reducing the cycle time to a minimum. The result is a high-speed filter press that allows increased production per unit area of filter. For this reason, these machines are used in applications with highly filterable products where high filtration speeds are required. These include, e.g., mining concentrates and residues. There are different systems for fully

automatic operation. These include, e.g., the vibration/shaking devices, spreader clamp/spreader cloth version or scraping devices. The unmanned operating time of a fully automatic filter press is 24/7.

iii. Recessed plate filter press

A recessed plate filter press does not use frames and instead has a recess in each plate with sloping edges in which the filter cloths lie, the filter cake builds up in the recess directly between two plates and when the plates are separated the sloping edges allow the cake to fall out with minimal effort. To simplify construction and usage the plates typically have a hole through the centre, passing through the filter cloth and around which it is sealed so that the slurry flows through the centre of each plate down the stack rather than inward from the edge of each plate. Although easier to clean, there are disadvantages to this method, such as longer cloth changing time, inability to accommodate filter media that cannot conform to the curved recess such as paper, and the possibility of forming uneven cake.

iv. Membrane filter press

Membrane filter presses have a great influence on the dryness of the solid by using an inflatable membrane in the filter plates to compress remaining liquid from the filter cake before the plates are opened. Compared to conventional filtration processes, it achieves the lowest residual moisture values in the filter cake. This makes the membrane filter press a powerful and widely used system. Depending on the degree of dewatering, different dry matter contents (dry matter content – percentage by weight of dry material in the filter cake) can be achieved in the filter cake by squeezing with membrane plates. The range of achievable dry matter contents extends from 30 to over 80 percent. Membrane filter presses not only offer the advantage of an extremely high degree of dewatering; they also reduce the filtration cycle time by more than 50 percent on average, depending on the suspension. This results in faster cycle and turnaround times, which lead to an increase in productivity. The membrane inflation medium consists either of compressed air or a liquid medium (e.g., water).

Applications

Filter presses are used in a huge variety of different applications, from dewatering of mineral mining slurries to blood plasma purification. At the same time, filter press technology is widely established for ultrafine coal dewatering as well as filtrate recovery in coal preparation plants. The use of the filter press is very beneficial to plant operations, since it offers dewatering ultraclean coal as product, as well as improving quality of water removed to be available for equipment cleaning. Other industrial uses for automatic membrane filter presses include municipal waste sludge dewatering, ready mix concrete water recovery, metal concentrate recovery, and large-scale fly ash pond dewatering. Many specialized applications are associated with different types of filter press that are currently used in various industries.

Plate filter press is extensively used in sugaring operations such as the production of maple syrup in Canada, since it offers very high efficiency and reliability.

Optimum time cycle

High filtration rate can be obtained from producing thin cake. However, a conventional filter press is a batch system and the process must be stopped to discharge the filter cake and reassemble the press, which is time-consuming. Practically, maximum filtration rate is obtained when the filtration time is greater than the time taken to discharge the cake and reassemble the press to allow for cloth's resistance. Properties of the filter cake affect the filtration rate, and it is desirable for the particle's size to be as large as possible to prevent pore blockage by using a coagulant. From experimental work, flow rate of liquid through the filter medium is proportional to the pressure difference. As the cake layer forms, pressure applies to the system increases and the flow rate of filtrate decreases. If the solid is desired, the purity of the solid can be increased by cake washing and air drying. Sample of filter cake can be taken from different locations and weighed to determine the moisture content by using overall material balance.

Possible heuristics to be used during design of the process

The selecting of filter press type depends on the value of liquid phase or the solid phase. If extracting liquid phase is desired, then filter press is among the most appropriate methods to be used.

Materials

Nowadays, filter plates are made from polymers or steel coated with polymer. They give good drainage surface for filter cloths. The plate sizes are ranged from 10 by 10 cm to 2.4 by 2.4 m and 0.3 to 20 cm for the frame thickness.

Filter medium

Typical cloth areas can range from 1 m^2 or less on laboratory scale to 1000 m^2 in a production environment, even though plates can provide filter areas up to 2000 m^2. Normally, plate and frame filter press can form up to 50 mm of cake thickness, however, it can be push up to 200 mm for extreme cases. Recessed plate press can form up to 32 mm of cake thickness. In the early days of press use in the municipal waste biosolids treatment industry, issues with cake sticking to the cloth was problematic and many treatment plants adopted less effective centrifuge or belt filter press technologies. Since then, there have been great enhancements in fabric quality and manufacturing technology that have made this issue obsolete.

Operating condition

The operating pressure is commonly up to 7 bars for metal. The improvement of the technology makes it possible to remove large amount of moisture at 16 bar of pressure and operate at 30 bars. However, the pressure is 4-5 bars for wood or plastic frames. If the concentration of solids in the feed tank increase until the solid particles are attached to each other. It is possible to install moving blades in the filter press to reduce resistance to flow of liquid through the slurry. For the process prior to cake discharge, air blowing is used for cakes that have permeability of 10^{-11} to 10^{-15} m^2.

Pre-treatment

Pre-treatment of the slurries before filtration is required if the solid suspension has settled down. Coagulation as pre-treatment can improve the performance of filter press because it increases the porosity of the filter cake leading to faster filtration. Varying the temperature, concentration and pH can control the size of the flocs. Moreover, if the filter cake is impermeable and difficult for the flow of filtrate, filter aid chemical can be added to the pre-treatment process to increase the porosity of the cake, reduce the cake resistance and obtain thicker cake. However, filter aids need to be able to remove from the filter cake either by physical or chemical treatment. In terms of cake handling, batch filter press requires large discharge tray size in order to contain large amount of cake and the system is more expensive compared to continuous filter press with the same output.

Washing

There are two possible methods of washing that are being employed, the "simple washing" and the "thorough washing". For simple washing, the wash liquor flows through the same channel as the slurry with high velocity, causing erosion of the cakes near the point of entry. Thus, the channels formed are constantly enlarged and therefore uneven cleaning is normally obtained. A better technique is by thorough washing in which the wash liquor is introduced through a different channel behind the filter cloth called washing plates. It flows through the whole thickness of the cakes in opposite direction first and then with the same direction as the filtrate. The wash liquor is normally discharged through the same channel as the filtrate. After washing, the cakes can be easily removed by supplying compressed air to remove the excess liquid.

Waste

Nowadays filter presses are widely used in many industries, they would also produce different types of wastes. Harmful wastes such as toxic chemical from dye industries, as well as pathogen from waste stream might accumulate in the waste cakes; hence the requirement for treating those wastes would be different. Therefore, before discharge waste stream into the environment, application of post-treatment would be an important disinfection stage. It is to prevent health risks to the local population and the workers that are dealing with the waste (filter cakes) as well as preventing negative impacts to our ecosystem. Since filter press would produce large amount of waste, if it was to be disposed by land reclamation, it is

recommended to dispose to the areas that are drastically altered like mining areas where development and fixation of vegetation are not possible. Another method is by incineration, which would destroy the organic pollutants and decrease the mass of the waste. It is usually done in a closed device by using a controlled flame.

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