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Clarification and Filtration Part 3	عنوان المحاضرة باللغة الانجليزية
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محتوى المحاضرة

FILTRATION EQUIPMENT

Commercial filtration equipment is classified by the end product desired (filtrate or cake solids), by the method of operation (batch or continuous), by type of operation (non-sterile filtration, sterile filtration, centrifugation filtration, centrifugation sedimentation), but most importantly by the type of driving force (gravity, vacuum, pressure and centrifugation)

Gravity Filters

Gravity filters rely on gravity generated low operating pressure (usually less than 1.03×10^4 N/m²) and give low filtration rates unless very large surfaces areas are used, which limits their use on a large scale

However, these are simple and cheap, and are frequently used in laboratory filtration where volumes are small and low filtration rate is relatively insignificant. Gravity filters employing thick, granular beds are common in water treatment, where

clarification of water is done prior to deionization or distillation

Small-scale purification of water may use porous ceramics as a filter medium in the form of hollow “*candles*”. The fluid passes from the outside through the porous ceramics into the interior of the hollow candles

Various new gravity filter systems are available commercially such as cylindrical gravity filters, rectangular gravity filters, and hydro-clear gravity filters which utilize granular particles in a basin. Fluid streams pass through the basin and particles are physically and/or chemically captured by the media.

Vacuum Filters

These are employed on a large scale, but are rarely used for the collection of crystalline precipitates or sterile filtration. Vacuum filters are simple and reliable machines, and therefore have gained wide acceptance in the chemical, food and pharmaceutical industries. For large-scale operations, continuous vacuum filters are the most widely used.

Rotary Drum Filter

The rotary drum vacuum filter is divided into sections, each connected to a discharge head. Each filter unit is rectangular in shape with a curved profile so that a number can be joined up to form a drum. Each unit has a perforated metal surface and is covered with filter cloth.

The slurry is fed to a tank in which solids are held in suspension by an agitator. As the drum rotates, each section passes through the slurry and vacuum draws filtrate through the filter medium at the drum surface (*pick-up zone*).

The suspended solids deposit on the filter drum as a cake, and as rotation continues, vacuum holds the cake at the drum surface. This is followed by washing and further drainage in the drying zone. As the cake moves towards the discharge point, it may be scraped from the drum or it may be supported by strings until it breaks free under gravitational forces (*cake removal zone*).

The cake discharge may be done through a scraper, belt, roll or a string. Scraper discharge mechanisms will suit cakes that could be scraped readily and roller discharge mechanism are better for thixotropic cakes

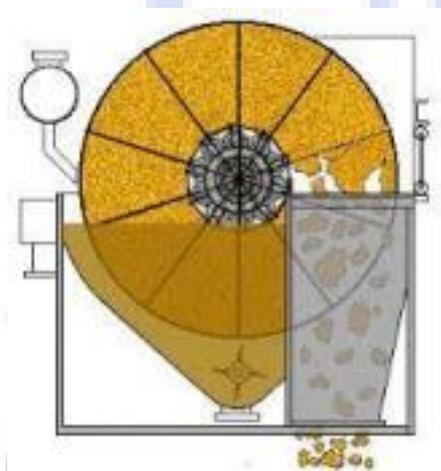
For solids that tend to block the filter cloth, a precoat of filter aids such as diatomaceous earth, perlite and cellulose is deposited on the drum prior to the filtration process

Precoat filters are generally used where a very high degree of clarity is required and solids content is very low (less than 2–3%) or where solids are sticky and would otherwise clog the filter cloth

Rotary Disc Filter

It consists of several discs, up to 15 in the larger machines, each made up from sectors which are clamped together to form the disc .

Each sector is connected to a vacuum system, compressed air, and appropriate receivers, in the correct sequence, by means of special rotating valve. The operation sequence of a disc filter is similar to a drum filter. The main feature of disc filter is less floor space and the lowest cost of filtration when compared to other vacuum filters.



Pressure Filters

Most of the pressure filters are batch operated but continuous filters are also available. However, owing to the difficulty in removing the cake they are mechanically complex and expensive so mainly used where the added value to the product is high. The filtration rate is influenced, in broad terms, by the properties of the slurry. The trend is that the rate goes up with increased pressure, coarser particles, particle

distribution with high uniformity, nonslimy or non-gelatinous solids, noncompressible cakes, lower liquid viscosity and higher temperatures

Plate and Frame Filter Press

The plate and frame filter press is the simplest of all pressure filters and is the most widely used



Filter presses are used for a high degree of clarification of the fluid and for the harvesting of the cake. When clarity is the main objective, a “batch” mode of operation is applied

As the name implies, the plate and frame filter press is an assembly of hollow frames and solid plates that support filter media

One side of the plate is designed for the flow of the feed. After passing the filter media, the filtrate is accommodated on the other side. The solids collect in the frames, and filtrate is removed through place conduits. In cake filtration, the size of the frame space is critical, and wide sludge frames are used

The filter press is the most versatile of filters since the number and type of filter sheets can be varied to suit a particular requirement. It can be used for coarse to fine filtrations, and by special conduit arrangements, for multistage filtration within a single press

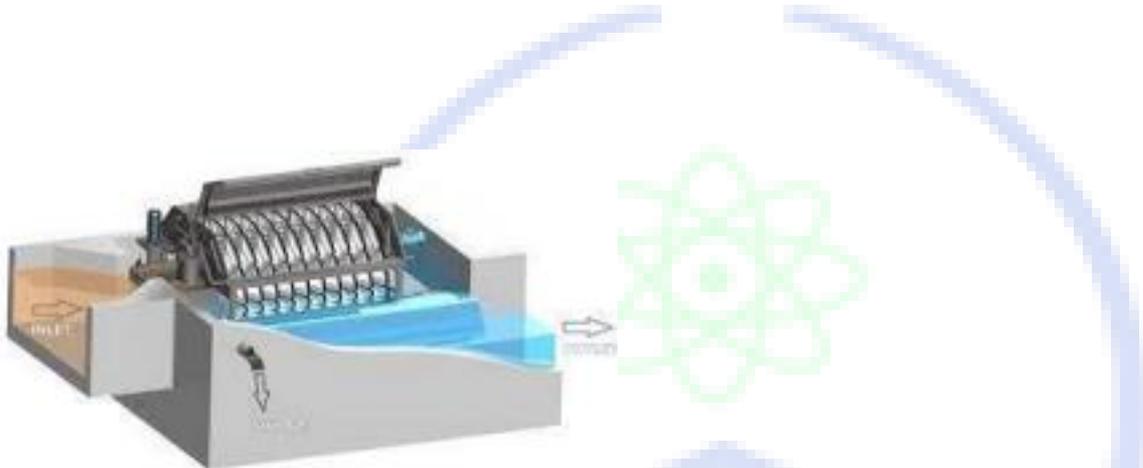
The filter press is the most economical filter per unit of filtering surface, and its material of construction can be chosen to suit any process conditions. Labour costs in assembly and cleaning are a primary disadvantage, and leakage between the plates may occur through faulty assembly

Disc Filters

The term disc filter is applied to assemblies of felt or paper discs sealed into a pressure case.

The discs may be preassembled into a self supporting unit, or each disc may rest on an individual screen or plate. Single plate or multiples of single plates may be applied. The flow may be from the inside outwards or outside inwards. The disc

filter overcomes some deficiencies of the filter press. Compactness, portability, and cleanliness are obvious advantages for pharmaceutical batch operations



Centrifugation Filtration

In filtering centrifuges, centrifugal force is used to affect the passage of the liquid through the filter medium. This type of filtration is particularly advantageous when very fine particles are involved. Whenever solids recovery is the primary goal, filtering centrifuges must be considered as an alternative to filtration

The advantages of the process are effective washing and drying. Residual moisture after centrifugation is far less than in cakes produced by pressure or vacuum filtration

By this method the moisture content of a cake of coarse crystals can be reduced to as low as 3%., This facilitates the drying operation which normally follows

The process is widely used for separating granular products from liquors, but is less effective for concentrated slurries containing smaller particles

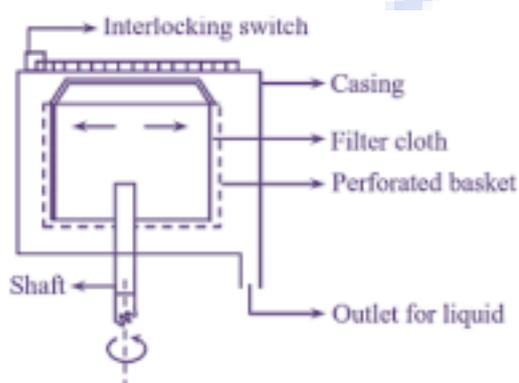
Perforated Basket

the device consists of a perforated metal basket mounted on a vertical axis by means of which it can be rotated at a speed of 20 to 25 revolutions per second

The cloth used to retain solids is often supported on a metal screen and the outer casing collects the liquid thrown out from the perforated basket by

centrifugal force

Baskets mounted are emptied by shoveling the cake. If, however, top suspension is used, the cake can be more easily withdrawn through traps in the base of the basket



Laboratory Filtration Equipment

Laboratory equipment catalogs offer a wide choice of funnels and flasks adaptable to pharmaceutical filtration studies

For gravity filtration, conventional glass percolators are applicable, in which case the bottom tube is covered with fibrous material. The filtering funnel is the most common of all laboratory filter devices. Filter paper is used with funnels. Sometimes, a plug of fibrous material may be used instead. Filter bags for laboratory use are made of fabric and are mounted for gravity filtration. The uncertainty of adequate clarification with *glass beads* or *sand* has restricted their use as gravity filters for certain operations in the laboratory.

Suction filters are greatly utilized in the laboratory. Usually, a conical funnel and the Buchner funnel are used for suction filtration, as are immersion and suction-leaf filters. Immersion filter tubes, also known as filter sticks, are generally used for small-scale laboratory operations.

Filter paper in circular form is the most common medium for laboratory filtrations. Filter papers are available in a wide variety of textures, purities, and sizes and are available for different uses. They may be circular (1 to 50 cm in diameter), folded, or arranged in sheets or rolls. Some of the special types of laboratory filter papers for pharmaceutical industry are:

- 1) Filter papers impregnated with activated carbon for the adsorption of colours and odours in pharmaceutical liquids.
- 2) Filter paper impregnated with diatomaceous earth for the removal of colloidal haze from liquids with low turbidity

Minimum laboratory equipment includes a plate and frame press, a membrane filter holder, and a single-element housing for disposable cartridges.

SPECIALIZED FILTRATION

Sterile/Aseptic Operations

Filtration may be used to clarify and sterilize pharmaceutical solutions that are heat-labile

Membrane filters have become the basic tool in the preparation of sterile solutions

A sterility requirement imposes a severe restraint on filter selection. All sterility tests are presumptive, and one must rely upon total confidence in the basic process, and economics becomes a secondary factor. Membranes with porosity ratings of 0.2 or 0.45 μm are usually specified for sterile filtrations. In this porosity range, membrane filters may clog rapidly, and a prefilter is used to remove some colloidal matter to extend the filtration cycle

The FDA allows the use of 0.45 μm filters only in cases of colloidal solutions in which 0.2 μm filters have been shown to clog very rapidly

High viscosity or abnormal contaminant levels are the primary restraints to the use of membranes, since an extremely large filtration area is needed for practical flow rates

Simple formulations such as intravenous solutions, ophthalmics, and other aqueous products may be filtered directly through membranes in an economical manner. Heat-labile oils and liquids containing proteins require pretreatment, e.g. centrifugation or conventional filtration, prior to sterilization filtration. The objective is removal of gross contamination that would rapidly plug the finer membranes

The use of filtration to remove bacteria, particulate matter from air, and other gases such as nitrogen and carbon dioxide is widespread in the pharmaceutical industry. The following are some common applications employing initial gas filtration:

- 1) Vent filtration
- 2) Compressed air used in sterilizers
- 3) Air or nitrogen used for product and in process solution transfers and at filling lines
- 4) Air or nitrogen used in fermentation

Filtration should be the last step in processing, and the filter should be placed as close as possible to the point of use of final packaging. In serial filtrations, only the final unit needs to be sterile, but minimal contamination in prior steps increases the reliability of the total process. Sterile filtration should always be a pressure operation; a vacuum is undesirable since bacteria may be drawn in at leaky joints and contaminate the product

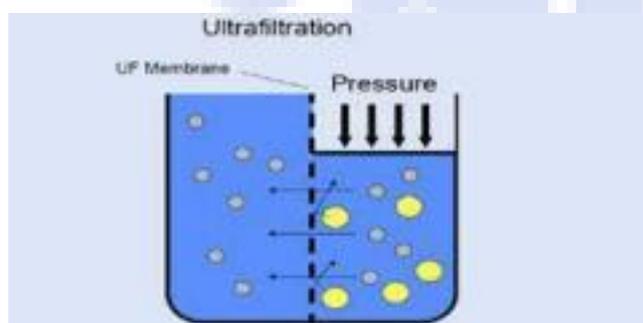
Membrane Ultrafiltration

Unlike conventional filtration, ultrafiltration is a process of selective molecular separation.

It is defined as a process of removing dissolved molecules on the basis of membrane size and configuration by passing a solution under pressure through a very fine filter. Ultrafiltration membrane retains most macromolecules while allowing smaller molecules and solvent to pass through the membrane

The difference between microfiltration and ultrafiltration is significant. The former removes particulates and bacteria; the latter separates molecules

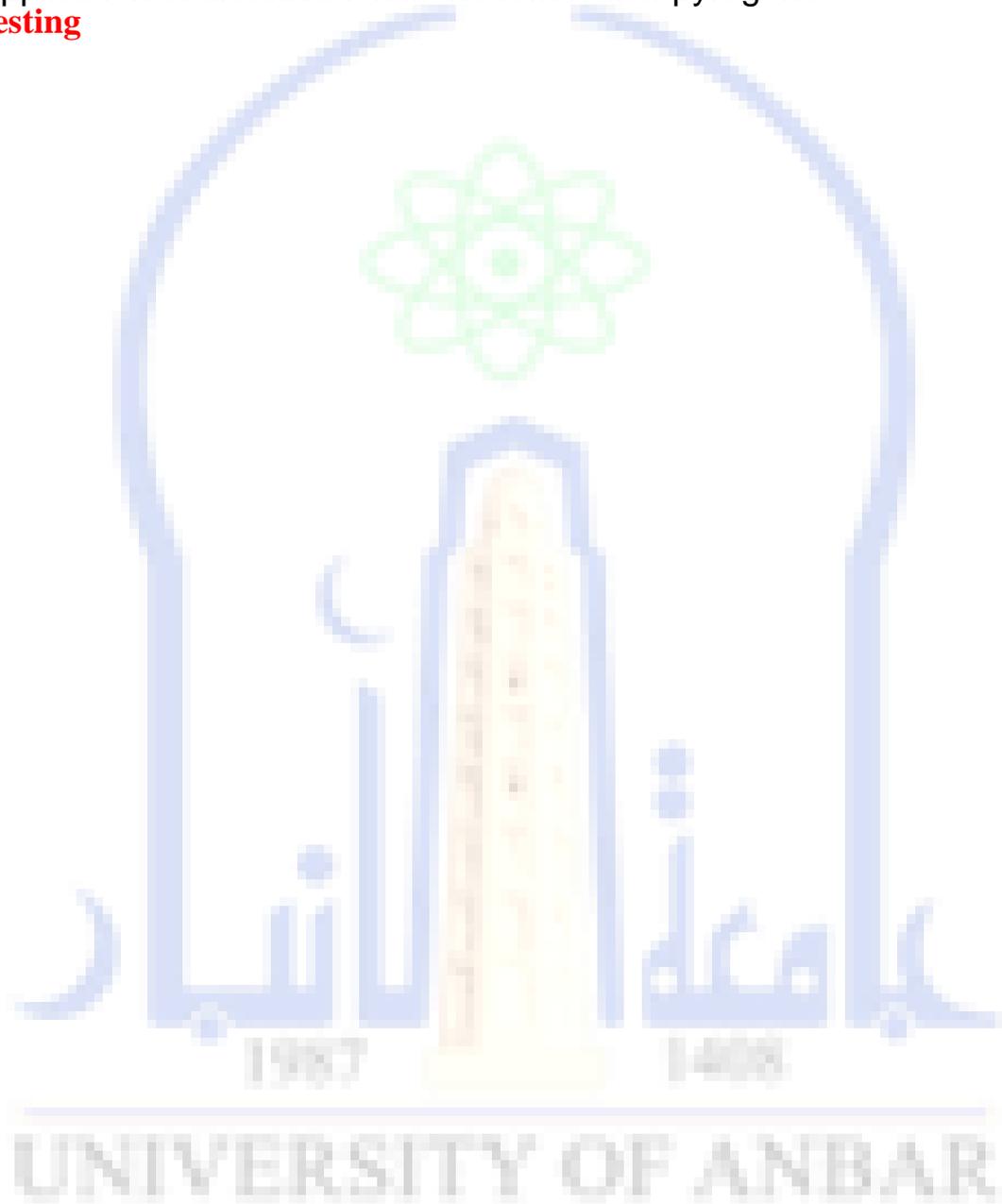
Separation of a solvent and a solute of different molecular size may be achieved by selecting a membrane that allows the solvent, but not the solute, to pass through. Alternatively, two solutes of different molecular sizes may be separated by choosing a membrane that allows the smaller molecule, to pass through but holds back the larger one



The selectivity and retentivity of a membrane are characterized by its molecular weight cut off. It is difficult to characterize the porosity of an ultrafiltration membrane by means of precise molecular weight cut off. The configuration of the molecule and its electrical charge may also affect the separation properties of the membrane

Applications in the pharmaceutical industry are predominantly in the concentration of heatlabile products, such as vaccines, virus preparations, and immunoglobulins. Ultrafiltration also has been used to recover antibiotics, hormones, or vitamins from fermentation broths, to separate cells from fermentation broth, to clarify solutions, and to remove low-molecular-weight contaminants prior to using conventional recovery techniques. The most important application of ultrafiltration is the removal of pyrogens

Integrity Testing



FILTER SELECTION

In designing or selecting a system for filtration, the specific requirements of the filtration problem must be defined. The following consideration should be addressed before any assistance is requested from the manufacturers of filtration equipment

Once the purpose of the process has been determined, the selection of the filter medium can be made. For example, for a sterilizing filtration, a 0.2 μm pore size is used; for clarification, a plate and frame filter or woven-fiber filter may be used. In general, a pore size smaller than the smallest particle to be removed is selected. The filter medium should be compatible with the liquid or gas to be filtered. It is advisable to check the chemical compatibility charts provided by the vendors for selection of filter type. Filter type, cellulose, poly tetrafluoroethylene (PTFE), fiber, metal, nylon, may be selected based on the chemical resistance to the most aggressive ingredient in the liquid

Filtration surface area is calculated after the filter media, pore size, required flow rate, and pressure differentials are established

For a liquid having a viscosity significantly different from that of water (1 cp), the clean water flow rate is divided by the viscosity of the liquid in centipoises to obtain the approximate initial flow rate for the liquid in question

The broad span of pharmaceutical requirements cannot be met by a single type of filter. The industrial pharmacist must achieve a balance between filter media and equipment capabilities, slurry characteristics, and quality specifications for the final product. The choice is usually a batch pressure filter, which uses either surface or depth filtration principles.

Thank You