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There is a wide choice of centrifuges on the market. However, to be able to select the most appropriate one for a specific process a thorough understanding of the various options is necessary. Thomas Broadbent & Sons Ltd, UK, explains, with particular reference to the pharmaceutical and fine chemicals industries.

Centrifuges: the Choice

Compared with other methods of solid/liquid separation, centrifugal processing provides a number of unique advantages. For example, they can be installed in a relatively small footprint, have a high washing capability, produce low cake moisture, achieve a high capacity throughput and provide the user with a totally enclosed, vapour-tight processing facility. However, when making the proper selection of a centrifuge for a particular application, it is important that the user's technical requirements are taken into consideration.

Technical Considerations

Prior to considering the various system options, it is important to clearly define the process. An accurate definition of the process is essential at initial briefings with the centrifuge supplier because subsequent screening tests and feasibility studies must be based on relevant data, rather than on vague and sometimes misleading assumptions.

Once the process is clearly defined, it is much easier to identify the variables which may effect the choice of process package. These variables include: percentage of suspended solids; volumetric slurry throughput; solids throughput; and required product consistency at the point of discharge.

Materials usually exit the centrifuge in either a powdered or granular form, although occasionally they can be discharged as a paste. Product consistency will to some extent dictate the method of materials handling and transportation.

Objectives

A potential user should clearly define exactly what they require the centrifugal process to achieve. For example, does the material require clarification, classification, degritting, thickening, dewatering, washing or separating and repulping, and is the process a solid/liquid, liquid/liquid or a three phase liquid/liquid/solid application?

Other considerations of equal importance are: g force; cake dryness; solids' level in discharge liquors; product temperature; viscosity; specific gravity; pH; and batch or continuous process.

The decision to use either a batch or a continuous machine depends on several factors. Unlike batch centrifuges, continuous machines are limited to a wash/solids ratio of approximately 10%, with only a short period allocated to the wash zone prior to the finish of the cycle. If, for example, the material to be processed has low residual impurities and a high washing requirement, the greater flexibility of the batch processing allows the necessary adjustment such as extended washes and longer residence times.

Particle size, distribution and shape are also important factors when determining separation capabilities, and whether a batch or continuous centrifuge is the best option. Generally speaking, materials of 45 microns and above that are relatively

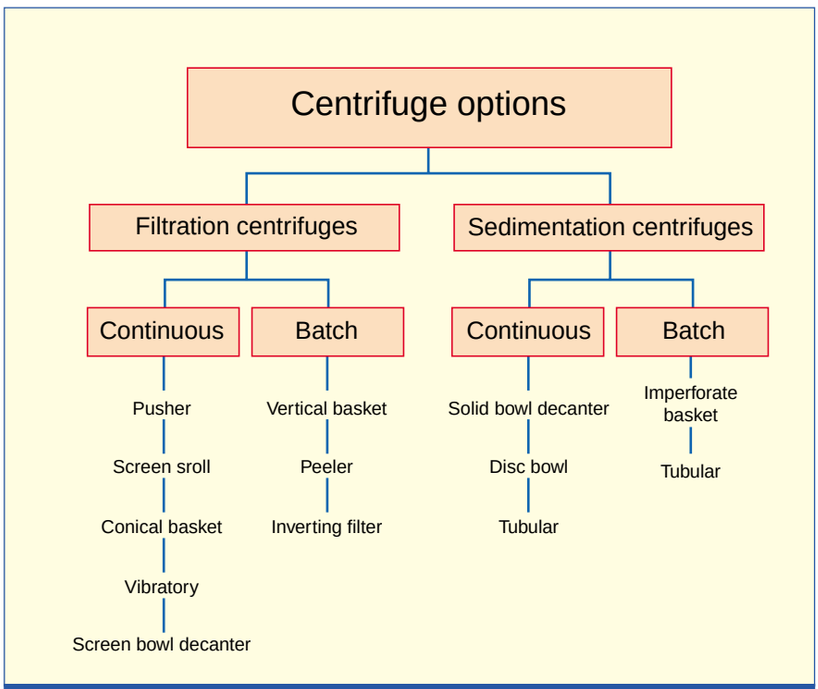

Figure 1: The different types of filtering and sedimenting centrifuges.

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incompressible are highly suitable for separation by filtration. On the other hand, finer or more compressible materials lend themselves to separation by sedimentation.

Special Requirements

In the situation where it is essential that no cross-contamination occurs between batches, centrifuges can be installed with pre-programmable, validated, clean-in-place (CIP) washing systems, which also eliminate the need to open the casing between cycles for cleaning and maintenance. These machines are particularly suitable for use in applications in the pharmaceutical and fine chemical industries

Recommendations from pharmaceutical authorities such as the Food and Drug Administration (FDA), USA, have led to the introduction of stringent codes of practice that are rigidly enforced right across the international process industry. These recommendations in turn have created a need for centrifuge design to be validated, and have driven the development of machines that combine the very best of good manufacturing practice (GMP) and state-of-the-art programmable logic controls (PLCs). Also, where centrifuges are required to handle potentially explosive or flammable products, they can be installed with inert gas purging systems to ensure complete operational integrity. They can also be supplied with pressure tight systems.

Centrifuge Selection

Having clearly defined the process, i.e. objectives and required variables, it is now possible to proceed with selecting the type of centrifuge to meet the specified criteria. Broadly speaking centrifuges can be divided into filtration centrifuges and sedimentation centrifuges. Figure 1 highlights the different types of sedimenting and filtering centrifuges. Preliminary screening tests will quickly indicate the best option.

Sedimentation Centrifuge

Disc Bowl

The disc bowl type centrifuge operates at speeds of 3000 to 20 000 times gravity, providing a continuous clarification system that is suitable for materials with a solids content of 1-2 % or less. It is designed to separate either a solid/liquid or two liquid phases on a continuous basis. Solids settle on the wall of the bowl and are discharged either manually or automatically by intermittent opening of the bowl. The disc stack greatly increases the effective settling/clarification area, and the liquid and solid phases travel up or down the disc surfaces. The liquid discharges through one or more paring discs.

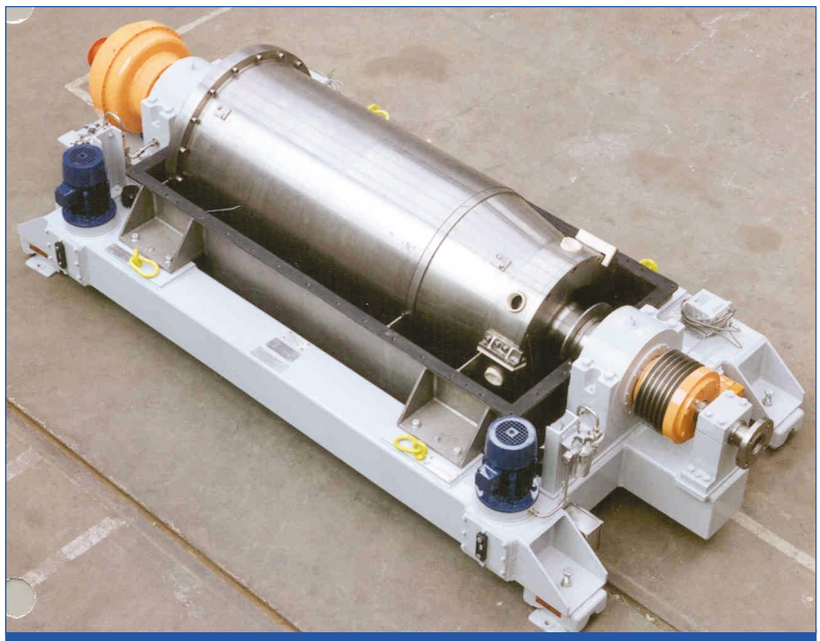

Figure 2: A 550 mm x 1375 mm titanium decanter for high temperature salt extraction

Horizontal Solid Bowl Decanter

Decanter centrifuges (Figure 2) consist of two horizontal concentric rotating elements contained in a stationary casing. The outer rotating bowl/element is tapered so that solids discharge from a smaller radius than the liquor. The inner element is a hollow hub screw conveyor with blade tips shaped to fit closely to the contour of the bowl.

Feed slurry is introduced into the conveyor hub by pump or gravity feed, and as this automatically accelerates to machine speed the slurry is delivered by centrifugal force into the rotating bowl via discharge ports, where solids settle through the liquor pool formed on the wall of the bowl. There is a slight differential speed between the rotation of the bowl and that of the conveyor, which permits the solids to be conveyed continuously along the bowl wall, out of the pool and up the tapered drying beach to solids discharge ports. The clarified liquor discharges continuously in the opposite direction through adjustable overflow ports.

Employed as a classifier, the solid bowl decanter centrifuge effects sharp cuts of solids in liquor suspension, and can be used to process materials between 1-50 micron in size.

Solid Bowl Basket

In general batch perforated basket centrifuges are now considered an obsolete technology. Other machines, such as solid bowl decanters have gained favour because of advances in their conveyor designs enable the processing of difficult to convey solids. However, there are exceptions to this, especially when relatively small volume materials are to be processed and where cycle times are not a significant factor.

Tubular

This type of centrifuge is designed as a solid tube capped at both ends, and is usually fed through a bottom inlet with two liquids that differ in their specific gravity. Of the two liquids, the heavier phase is concentrated against the wall of the cylinder, while the lighter phase floats against it. The two phases are separated by means of a baffle, which discharges them into two distinct flows. If solid feeds are processed in a liquid/solid or liquid/liquid/solid state regular cleaning is required, but if no suspended solids are present the process can be continuous.

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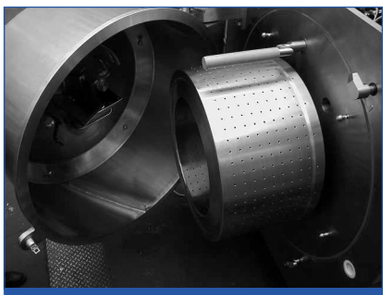

Figure 3: Broadbent's 800 mm diameter horizontal basket centrifuge for pharmaceutical production.

Filtering Centrifuges

Horizontal Basket Peeler

Two types of peeler centrifuge exist: a heavy duty chemical design and a GMP design. The peeler centrifuge offers both a filtering and decanting capability, and is particularly suitable for processing materials in the ultra-clean environment of the pharmaceutical and fine chemical industries. Machines have either perforated baskets and screened membranes for filtering processes or solid bowls for decanting. The centrifuge has a fully opening front-end casing (Figure 3), which allows safe operator inspection of the interior. It also posseses an automatic peeler knife mechanism for cake discharge, as well as the benefit of an effective 'heel' removal system - a feature that provides complete batch-to-batch containment and reduces the operating cycle by removing the separated solids at high speed.

High g forces and increased discharge speeds mean the peeler uses shorter cycle times, which can be adjusted to ensure a range of washing capabilities. It can be used for applications where the feed slurry has a low or fluctuating solids concentration.

Horizontal Screen Bowl Decanter

This type of decanter is operationally similar to solid bowl decanters, but is designed to provide additional washing efficiency and enhanced moisture removal in applications where crystalline materials are involved. The decanter operates in two stages, combining the clarification and sedimentation advantages of the solid bowl centrifuge and the dewatering benefits of an additional screen section.

Inverting Bag

The inverting filter centrifuge is an automatic, horizontal machine, incorporating an automatic unloading bag. The front and rear basket walls are stroked forward by a hydraulic piston to discharge the solids. The filter cloth is arranged as a cylinder, with the rear edge secured to the rear basket wall and the front edge to the basket shell at the front rim. As the piston moves forward, the cloth is turned inside out and the solids discharged in clumps into the solids collection housing. They are primarily used in the pharmaceutical industry and provide heel removal after each cycle, but are limited to smaller sizes and capacities.

Pusher

This type of filtering centrifuge not only operates on a continuous basis, but also provides particularly long residence times. Solids are retained as a cake on a wedge wire basket from where it is transported by an oscillating pusher mechanism in the direction of the solids discharge. Feed solids can be granular, crystalline or fibrous, and relatively incompressible. They should also be free-draining with a low aspect ratio and an average particle size of 200 microns.

Scroll/Screen

The scroll/screen centrifuge consists of a horizontally driven scroll conveyor, which revolves at an optimum differential speed within a rotating conical basket. Solids separation from the mother liquor is achieved by the action of centrifugal force, operating at high g force, while discharge takes place via the inclination of the basket and the differential speed of the scroll. At the point of separation, solids are conveyed forwards by the scroll to discharge at the widest open-end of the filter basket, with the filtrate passing directly through the screen.

This type of centrifuge can be equipped with automatic scroll speed adjustment to accommodate changing process requirements, which completely eliminates operator intervention and process downtime. Scroll/screen machines have excellent washing capabilities and can be used for solids/liquids separation, where feed materials have high particle sizes, i.e. 50 microns or above. A unique feature is its ability to separate both floating and sedimenting solids.

Vertical Basket

A selection of feed, wash, spin and plough speeds are available, either by electrical inverter or hydraulic drives, which make modern basket filtering centrifuges very adaptable in the processing of a wide range of slurries and chemical compositions. These batch machines produce exceptionally dry cakes and have two

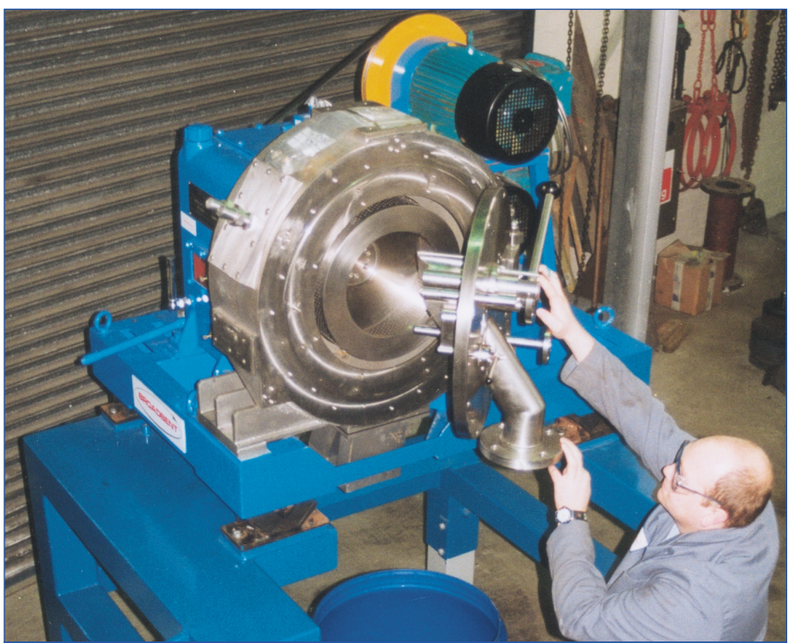

Figure 4: Broadbent's mobile, centrifuge test facility for the pharmaceutical and fine chemicals industries.

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major advantages – the capability to efficiency wash cake solids using the minimum wash fluids, and the ability to discharge the separated solids at low basket speed, ensuring negligible breakage of delicate crystals. The extracted mother liquor and wash liquor are easily segregated at separate stages of the batch cycle.

During operation, slurry is fed through the top opening of the basket which normally operates at a reduced speed. Depending on the type of slurry being treated and/or machine type the feed is either introduced directly into the basket via a tangential pipe or a 360° distributor cone. The feed rate and/or basket speed are adjusted so that the feed rate matches the filtration rate as the slurry covers the basket wall, forming an evenly distributed cake. Following the washing cycle, dry spinning commences at a much higher speed. Subsequent to this the cake is discharged either manually or automatically using a traversing plough back at a lower rotational speed.

Given the correct feed conditions, feed speed and filter cloth, basket centrifuges can dewater solids from 1-10 000 microns. They can also be fully sealed and purged for safe operation, and on fully automatic operation operators do not come in physical contact with the product.

Vibratory

In this centrifuge, which can attain throughputs of up to 350 tonnes/hour, solids are retained by a sieve and transported by axial vibrations greater than the rotational speed of the centrifuge. They are highly suitable for processing high throughput products that are easily dewatered to the required moisture content.

Conclusions

Selecting the most appropriate centrifuge for a specific duty is a detailed and fairly complicated process. A basic understanding of what is currently available and what considerations must be taken into account prior to making the a selection have been highlighted in this article. Figure 5 provides a general guide, based on particle size and feed slurry solids content, which is of use when making an initial selection. However, it is strongly advised that potential centrifuge users consult manufacturers at the earliest stages of process design.

Centrifuge Test Facility

Pharmaceutical and fine chemical companies can now assess on-site the effectiveness of centrifugal separation on a scaled-down production, prior to committing to a major capital investment.

Broadbent is offering potential customers the opportunity to use a purpose-built, 350 mm diameter, GMP peeler centrifuge (Figure 4) mounted in a steel frame for ease of transportation and handling, to evaluate a wide range of operational performance data including the required g force and achievable cake dryness for any given process.

At any time during the trial, the cycle can be interrupted to check the shape, compaction, cracking or migration of the processed solids, and thereby allow corrective action to be taken prior to continuing the next cycle. The pilot plant also incorporates a CIP system to reduce product contamination between batches or products. A particular benefit to users that work with materials which are expensive, difficult to process or require lengthy production cycles, is that the pilot centrifuge only requires small quantities of feed stock.

According to Broadbent, this facility enable numerous on-site evaluating tests to be carried out within a short period of time, reducing man hours and costs when compared with full-scale production.

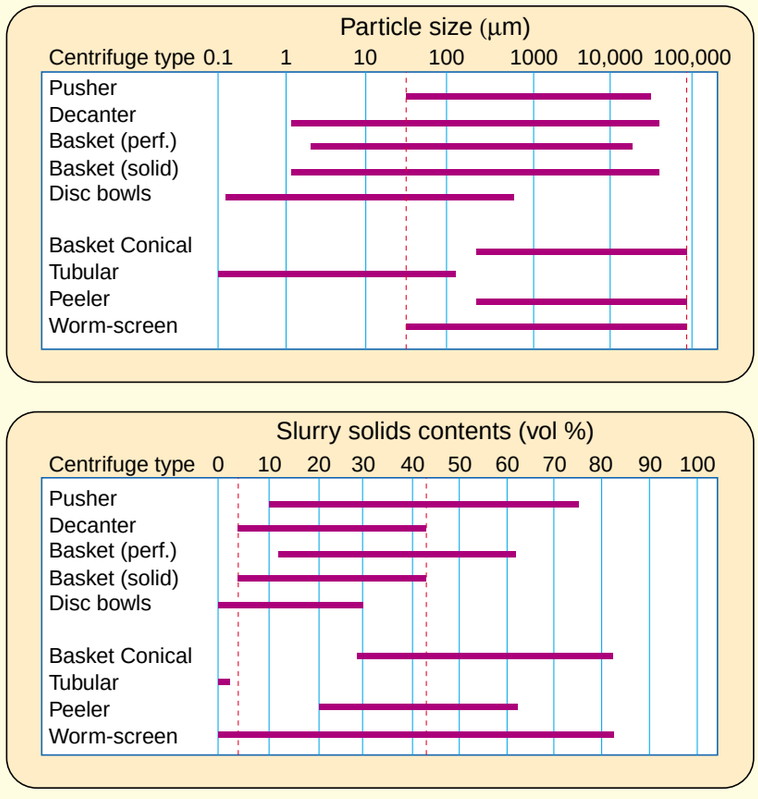

Figure 5: Simple centrifgue guides based on particle size and solids content.

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